Utilization of Research Results on Forage and Agricultural By-Product Materials as Animal Feed Resources in Africa

PROCEEDINGS OF THE FIRST JOINT WORKSHOP
HELD IN LILONGWE, MALAWI
5–9 DECEMBER 1988

by the
PASTURES NETWORK FOR EASTERN AND SOUTHERN AFRICA (PANESA)
and
AFRICAN RESEARCH NETWORK FOR AGRICULTURAL BY-PRODUCTS (ARNAB)

edited by
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Editors

O P E N I N G   C E R E M O N Y

PREAMBLE TO THE MEETING

Ben H. Dzowela
Workshop Organising Secretary
ILCA, P. O. Box 46847, NAIROBI, Kenya

We the organisers, A.N. Said and myself, take pleasure in welcoming you to Lilongwe, the venue of this year's joint ARNAB and PANESA workshop on the theme "Utilization of research results on forage and agricultural by-product materials as animal feed resources in Africa". We look forward to having useful discussions with you individually where possible and more especially with other participants in the course of the coming week.

The theme of this year's workshop has special significance to African crop-livestock agricultural production systems. The introduction of new, high-yielding cultivars of wheat and rice in the early 1960's led to dramatic increases in food production in many developed countries. This phenomenon, often referred to as the "Green Revolution", gave rise to a widespread optimism that similar "revolutions" could be achieved in most commodities. Since then, however, few other such widespread and dramatic increases in productivity have actually been achieved in the tropics and subtropics in spite of the many efforts of national and international agricultural research institutions. According to a recent IDRC report (Crop and Animal Production Systems Programme Report, June 1988), many of the research-generated technological packages in the tropics and subtropics of Africa have not been adopted by the majority of farmers because:

a) most of the farmers are small-scale who are economically rational and generally only willing to adopt innovations they consider to be advantageous;
b) most of these small-scale farmers live in highly unpredictable environments, where input and marketing infrastructures are often unreliable;
c) most of them cannot simply take risks;

d) all too often, research objectives are based on the preconceptions of scientists who have little appreciation of the real problems of small-scale farmers; and
e) in some cases the technological packages are in a language not easily understood by the farmers.

Some useful research, nevertheless, has been conducted in the African countries represented here. Because the small-scale livestock producers in the tropics and subtropics have limited resources, low input technologies particularly the use of legumes, shrubs and trees that can fix nitrogen, alone or in combination with grasses, have received a good deal of research resources allocation in national and international centres. The improvement of the present feed resource base, native pastures and rangelands has also been given priority especially where land is not a serious constraint in the semi-arid environments. Where land is a main constraint in the high potential tropical and subtropical plateaux and highlands, the research emphasis has centred on the use of high-yielding grasses and legumes for cut-and-carry management using less trees and shrubs as forages.

Attention to research has also been given to agricultural by-products which are an important feed resource in many animal production systems in developing tropical and subtropical African countries. With the decline and degradation of grazing lands through overgrazing and the expansion of arable cropping, agricultural by-products have become increasingly important. The use of farm-produced by-products (stovers, straws, bean and ground nut haulms and house hold offals) and of agro-industrial by-products as animal feed is an efficient and ecologically sound use of feed resources.

Technologies have been developed in national and international research centres in forages and agricultural by-products in Africa. It is for this reason that the theme of this workshop has been especially chosen to take stock of how the results of this research are being utilised by the majority of African farmers, small-scale/smallholder farmers, in improving the efficiency of their production systems.

Shortfalls in the utilisation of these research results have been experienced by the majority of farmers in Africa. As scientists we should, through the workshop, be able to modify research strategy to enable us to better serve the farming community. We have every hope that this will be done in the course of the workshop week.

The workshop theme has been subdivided into four sessions, namely:

Session I: Research Review on Utilisation of Feed Resources

Session II: On-farm Feeding Systems

Session III: Feed Resources Evaluation

Session IV: Technology Testing, Evaluation and Adoption

This subdivision has arisen primarily from the enormous diversity of the types of research that has been done in Africa. We are confident that together, in spite of this diversity, we shall come up with useful discussions, sharing of experiences and with recommendations that are likely to redirect us in our efforts to improve the sustained yields and output of livestock production systems.

Address to the opening session of the First Joint ARNAB/PANESA workshop on "Utilization of research results on forage and agricultural by-product materials as animal feed resources in Africa". Lilongwe, Malawi

J.C. Tothill

ILCA, Addis Ababa

Honourable Minister of Finance, Your Worship the Mayor of the city of Lilongwe, Mr. Chairman and Principal Secretary, Distinguished guests, Ladies and Gentlemen Colleagues.

It gives me great pleasure to welcome you to this first joint workshop of the African Research Network on Agricultural By-Products (ARNAB) and the Pastures Network for Eastern and Southern Africa (PANESA). I would like to convey to you our thanks to the Government of Malawi for the courtesy they have extended to us by hosting this meeting. This is actually the second time Malawi has graciously hosted the annual workshop of ARNAB, but the first time for that of PANESA.

At this meeting there are more than 80 delegates from 24 countries from West, East and Southern Africa.

This, the first occasion of these two networks holding a joint meeting, recognises the common bond between them in representing interests and activities in crucial areas of feed resources basic to the nutrition of livestock. We see these resources as the vital elements which link livestock and crop production which is such a basic characteristic of the predominantly smallholder farming systems of Africa.

For this meeting we come to Malawi because it provides us with well-developed examples of these smallholder systems, where not only exemplary progress has been made in improving production but also where considerable potential for further development is recognised, and with this, an environment of receptivity to research and development.

We welcome the Malawi government's generosity and foresight in allowing its scientists to participate and contribute so freely in our activities and deliberations. With this commitment to continuing such support we can, through networking, effectively enlarge the critical mass of scientific manpower and activity for both individual countries and for the region, by bringing the totality of the scientists of many regions together and, in collaboration, their skills and ideas to bear jointly on the problems of these regions. Through discussions and the planning of collaborative research between themselves and other national and international scientists, its subsequent execution with financial help from interested donors, its interpretation both on a regional and a national basis, research effectiveness can be substantially increased. Thus in addressing the problems of the region, instead of having a handful of scientists, we have a large body of scientists.

Networking is a powerful tool in promoting this type of collaboration in:

- information exchange (newsletters, meetings);
- training (courses, participation, interactivity);
- collaborative research (peer joint planning and review).

Development of collaborative research

Both PANESA and ARNAB are now at the critical phase of developing their collaborative research programmes, PANESA at the point of implementation and ARNAB at the proposal formulation stage.

This has led to a considerable involvement of the active membership in planning meetings for the development of research protocols which address:

- The problems that the national scientists perceive as important for researching

- Ways in which these problems can be addressed more effectively by a collective approach to planning, implementation and interpretation
- How the international research centres fit and can collaborate in these developments

This has required the continued participation of most o the active members in order to bring these plans to fruition. Having accomplished this we anticipate the participation will broaden out to reach the younger up-coming scientists. The network must follow a path that at the same time leads to a collegial spirit of collaboration, communication and peer criticism without becoming an "old-boys club".

The activities of the network will largely be centred around:

1. General meetings or workshops, such as this one, held regularly, where presentation and discussion of mature research is carried out. These annual meetings are also th Annual General Meeting at which the office bearers of the Steering Committee are elected to represent the membership in matters of policy and activity developments and directives to the Coordinator, thus an important channel of information between the national scientists and the international centres.

2. Research planning and review meetings where the coordinatec research plans of the network are formulated, results presented and discussed and a regional basis for interpretation of the results developed.

3. Training courses which provide opportunities to develop specific skills e.g. PANESA's seed production course in Zimbabwe in 1988.

ILCA's Network activities

Since the last general workshop meeting of PANESA in Arusha, Tanzania in May 1987 and of ARNAB in Bamenda, Cameroon in October 1987 the main activities of the networks have been:

- Presentation of Phase II funding proposals to the Donor (International Development Research Centre of Canada) just approved for ARNAB and that of PANESA being considered.
- Collaborative Research Planning Meetings for PANESA:

- September 1987, Nairobi - proposal developed and submitted to SPAAR (Special Programme for African Agricultural Research) in October 1987 and donor identified

- September 1988, Addis Ababa - research protocols formulated for implementation during 1988-89

- First Joint Steering Committee Meeting PANESA-ARNAB, May 1988.

- PANESA Seed Production course, Zimbabwe, June 1988

ILCA'S other developments are:

- The likelihood of ILCA opening a regional facilitation office in Harare to coordinate the developing collaboration within SACCAR for the SADCC countries as well as to complement the activities of other international centres such as ICRISAT and CIMMYT.

- The establishment of a Forage Seed Production Unit at ILCA (Debre Zeit):

  - to boost intermediate seed production;
  - develop adaptive research in seed technology;
  - carry out training and technical development;
  - establish regional production and training sub-centres.

- The likely emergence in 1989 of a Feed Resources Network in West Africa based on initiatives of national scientists, ILCA, CIAT and IEMVT.

Finally we commend to the Honourable Minister

- The outstanding work of the coordination of the networks - Dr. Dzowela for PANESA and Prof. Said for ARNAB.

- The invaluable work of the Steering Committees who are the voice of the membership and "ground truth" for our work.

- The Donors, particularly IDRC, but also OAU/IBAR and potentially the Italian Government for research implementation.

- The membership for their hard work and enthusiasm.

Honourable Minister, I thank you on behalf of us all for your gracious presence and the honour of having you open this meeting.

STATEMENT BY JACKSON A. KATEGILE
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The Honourable Minister, L.J. Chimango, Minister of Finance of the Malawi Government. I wish to introduce IDRC to those who do not know it. The organisation was established by an act of the Canadian Parliament in 1970 with a mission to assist in the promotion of indigenously determined social and economic advancement of the developing regions of the world, with particular focus on the poorest peoples of those regions. Within this mission, IDRC has two principal objectives.

- First to support research of direct relevance to third world development and having direct demonstratable links to the poor, and

- Second, to assist developing countries to build indigenous research and research-supporting capacity mainly at the national and regional levels.

IDRC focusess its activities in six main areas of

- Agriculture, food and nutrition sciences
- Communication
- Earth and Engineering sciences
- Health sciences
- Information sciences and
- Social sciences

The Agriculture, Food and Nutrition Sciences (AFNS) Division's mission within the centre is to contribute to agricultural development through specific research and research-supporting activities. A number of participants here come from countries and institutions which receive IDRC support and I need not elaborate on the types of support which you are already familiar with. I would, however, like to elaborate on

IDRC support to networks. Projects supported by the Crop and Animal Production Systems are often linked in networks based on the discipline and commodities. In order to facilitate the interactions, IDRC supports coordinating units based in international centres or regional centres. Of specific interest here are the two sister networks, PANESA and ARNAB. A series of workshops supported by IDRC led to the creation of PANESA with the main objectives of facilitating the exchange of information, and germplasm, training, and technical back-up. In 1981, AAASA and ILCA established the African Research Network for Agricultural By-Products (ARNAB). A series of workshops, partly funded by IDRC, in various African countries stressed the need for extra financial support for ARNAB. In 1984, IDRC provided a grant to ILCA to coordinate the network and additional funds have been made available in 1988. A major aim of ARNAB is to develop standard evaluation methodologies, standard terminology for accurately describing by-product feed and on-farm study methods. Noteworthy also is that IDRC gives high priority to dissemination of research results. On the average, 2 to 5% of the project funds are now allocated to publications and dissemination of research results.

The current joint workshop by the two networks is in recognition of the fact that both networks are aiming at finding alternative solutions to the common problem of livestock feed shortages which the livestock keepers face in Africa. I am certain that you will seise the opportunity to exchange information and experiences.

Mr. Chairman and the Honourable Minister, let me briefly address the theme of this workshop. In choosing the theme of the workshop, I believe that the organisers had reason for this selection. The present scenario is typified by having centres of excellence and areas of non-development. The centres of excellence include:

- Research Stations
- Universities/Colleges
- Large Farms
- Pockets of modern aariculture in rural areas

The other side are the areas of undeveloped agriculture which is common in the bulk of rural Africa. The two subsectors are very different as there is a large gap between the technologies used in the research stations, universities and the commercial sector and the rudimentary technologies practised by rural farmers. Expectedly, the same agricultural output/livestock production differ by the same magnitude if not more. The reasons for these differences are many: However,

- the researcher has his own reasons
- the extension worker has his own story, and
- the farmer has his own view on the "ivory towers" and his own environment. Among the causes for the low adoption rates of the researcher-generated technologies, the following are considered to be most important:

1. Poor dissemination of research results to the farmers. Here we find that the majority of the farmers in Africa

   - do not know the existence of the research stations as they have no direct access to these
   - African farmers have no access to the esteemed journals through which researchers communicate their research results.
   - The flow of information from researchers to extension workers is slow due to weak/poor linkages between research and extension systems. Each is an empire by itself.

2. Inappropriateness of the developed technologies for the farmers.

The majority of the researchers do not make a deliberate effort to understand the environment in which the African farmer lives. The environmental aspects include:

(a) Physical-rainfall, soil conditions, temperatures, and altitude. This is usually considered by the researcher to fit the technologies

(b) Economic - labour, costs, availability of inputs, availability of credit, marketing channels and disposal of incomes.
(c) Social - social structures, family structures, settlement patterns, education/literacy and farmers' aspirations and motivations
(d) Cultural environment - preferences, religion, beliefs, taboos and tastes

The economic, social and cultural factors influence the decision of farmers to adopt new technologies. Experiences demonstrate clearly that farmers accept technologies which improve their occupation and raise the levels of living e.g. coffee, cocoa, tobacco, milk production and horticulture.

It is certainly gratifying to see that an increasing number of researchers are recognising the importance of the socio-economic and cultural environment in designing research programmes which are aimed at developing appropriate technologies and testing the technologies on-farm. I trust that this forum will deliberate the issue at length and come up with specific recommendations on strategies for increasing the extent of two-way communication with farmers to enhance the utilisation of research results.

Address to a Workshop on Utilisation of Research Results in Forages and By-Products Animal Feed Resources in Africa

K.O. Adeniji
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Mr. Chairman, Honourable Minister for Finance, Hon. L.J. Chimango, Your Worship the Mayor of the City of Lilongwe, the District Party Chairman, Distinguished Delegates, Ladies and Gentlemen,

On behalf of the Secretary General of the Organisation of African Unity (OAU), H.E. Ide Omarou, it gives me great pleasure to welcome you to a Workshop on "Utilisation of Research Results in Forages and Agricultural By-Products Animal Feed Resources in Africa". The OAU is indeed honoured to have been invited to co-sponsor this workshop which is of immense importance to our programme of work in IBAR.

When our office was established in 1951, it dealt only with all aspects of epizootic diseases in Africa. In 1960, the functions were expanded to include other conditions of ill health of physiological, nutritional and genetic origin. It was not until 1970, when the functions were further expanded to embrace animal production activities that my section started to function. The main objectives of IBAR as from then on are:

1. To coordinate the activities of all the Member States of the OAU in the field of Animal Health and Production;
2. To collect, collate and disseminate information in all aspects of Animal Health and Production amongst Member States;
3. To initiate and execute projects in the disciplines of Animal Health and Production;
4. To liaise with the appropriate authorities of Member States, regional groups, inter-governmental and international organisations

Animal feed resources in Africa have received attention in IBAR. We started by attempting to assess the feed potential in Africa but before we could gather enough information for compilation and publication an international organisation (FAO) came up with a publication which contained all the data we had collected. We were however consoled by the fact that the idea originated from IBAR.

The range areas of Africa form a natural resource which is of vital importance in the development of livestock particularly beef animals. In one of the OAU meetings on animal health and production, a trans-national joint action on rangelands development in Africa involving IBAR and other international organisations was recommended. IBAR working alone impressed on Member States of the OAU to control grazing and allow enough time for natural revegetation, develop water through sinking bore holes and constructing dams for people and livestock in the range areas; revegetate the rangelands through various means including seeding etc., organise livestock marketing to ensure reasonable offtake; and introduce legislation to enable the enforcement of the above measures and of course control animal diseases.

Agricultural production in many countries of Africa over the past two decades is now better organised as more and more development plans give priority to food production for domestic use. As a result large track are being mechanised with resultant increases in the number of agriculture - based industries. However, large quantities of these agro-industrial by-products and crop residues available in Africa which could be used for animal feeding either go to waste or are under-utilised. In Sudan, a survey on agro-industrial by-products and crop residues indicated the availability of 4.5 million tonnes and that the energy present in these products could satisfy about 9% of the maintenance requirements of the national herd. In Cameroon, it was reported that cottonseed meal, an agro-industrial by-product and the major protein source, has promoted efficient growth when fed to non-ruminant and ruminant livestock. In the Ethiopian highlands, approximately 80% of feed resources are provided by crop residues and stubble grazing (mostly of straws of teff, barley, wheat and sorghum). In Kenya and Tanzanian highlands, the thriving small-scale milk production depends substantially on by-products such as bean haulms and maize stover as feed. In Nigeria and Senegal, agricultural by-products and crop residues are also widely used. Practically, in all countries of Africa where inventories of agricultural by-products have been conducted, large quantities are found. In some countries it has been shown that without the availability of crop residues, cattle will survive the long dry season only with poor condition. These products should be considered as a very valuable feed resource and could often constitute a basic component of less expensive rations for livestock.

IBAR is aware that a lot of research and experimental work has been done on the chemical and feeding properties of agricultural by-products but there is lack of knowledge of the effect of these feedstuffs on the performance of animals when used in practical situations and applying different feeding systems. In order to improve the efficiency of utilisation of the ration, more detailed investigation is also needed on the digestion, absorption and metabolism of some of the less well known but locally available by-products. IBAR therefore, proposed a project to be executed by the Agricultural Research Institutes (A.R.I.) of Member States of which the main objective is to improve the status of animal nutrition and hence the performance of the animal by promoting the use of locally available agro-industrial by-products and crop residues and therefore provide feeding techniques to the farmer.

The project proposed was approved by the Council of Ministers and Heads of States Meeting in Addis Ababa in 1985 - CM/Res.997 (XLII). Consequently, IBAR informed Member States to draw up project proposals on locally important by-products for funding. The response was very encouraging and contracts are in the process of being concluded with some countries. As more funds become available, other countries will benefit from the assistance provided by IBAR.

IBAR's decision to join the African Research Network for Agricultural By-Products (ARNAB) stems from its main objectives of strengthening and developing an African Network in support of research on the utilisation of agricultural by-products and crop residues through collaborative research. The title for this workshop is of particular interest to the OAU and the outcome will be of tremendous assistance in IBAR's programme of work on the utilisation of agricultural by-products and crop residues in livestock feeding.

I should add that the OAU's ministerial conference on animal resources in Africa has approved our membership. ARNAB workshops being annual events, IBAR will endeavour to continue to cosponsor the workshops for as long as the network is in existence.

The OAU is happy to be associated with the workshop and wish the participants successful deliberations.

Thank you for your attention.

Speech by Honourable L.J. Chimango, MP, Minister of Finance, Malawi

Mr. Chairman,

Your Excellencies, Members of the Diplomatic Corps, the District Chairman of the Malawi Congress Party, Honourable Members of Parliament, Your Worship the Mayor of the City of Lilongwe, Distinguished Delegates, Ladies and Gentlemen.

I am grateful to His Excellency the Life President, Ngwazi Dr. H. Kamuzu Banda, for directing that I may open this workshop. It is an honour and a privilege for me to have the opportunity to officiate at this inaugural function of the workshop on the "Utilisation of Research Results on Forage and Agricultural By-Product materials as Animal Feed Resources in Africa". To you all distinguished delegates, welcome to Malawi. I am privileged and delighted to extend this welcome on behalf of His Excellency the Life President, Ngwazi Dr. H. Kamuzu Banda, who is also the Minister of Agriculture. We are delighted to have you here.

The subject of your workshop is a very challenging and important one. The Government of the Republic of Malawi attaches very high importance to workshops of this nature, particularly at this time when our continent is faced with food production problems, when Africa is struggling to attain sustainable food and nutrition security at the farm level, at the national level, at the regional and at the continental level.

You who have gathered here, representing various organisations and institutions in Sub-Saharan Africa. You have come to discuss an important subject, a subject that affects livestock productivity in our respective countries. It is generally recognised that the biggest challenge to animal production is under-nutrition of animals. This is a serious problem during the dry period. It is more so in those countries experiencing an unimodal rainfall pattern. A lot of animals fail to produce to their maximum genetic potential of those livestock products, such as meat, milk and traction. I might add that these are products which countries strive to be self-reliant in. The cause for the deficiencies is resources shortage. This is therefore a challenge to us all.

The vast majority of our population on the continent live in traditional settings. They keep livestock and graze them in the dambos and open grazing spaces. Traditional feed resources, the customary grazing lands, however, continue to be threatened by the opening up of land for cultivation as human populations increase. Overgrazing, leading to degeneration of vegetal cover, and the drought conditions that the continent has experienced of late, have made the situation worse. It is imperative, therefore, that alternative feed must be explored in the form of forages and agricultural by-products.

In Malawi, our scientists are making pasture intervention efforts. The aim is to boost feed resources, of the smallholder livestock farmer both quantitatively and qualitatively, through the integration of improved forages in maize crop production systems.

Maize and groundnuts are the major food crops in Malawi. It is not surprising, therefore, that maize stover is the most abundant crop residue. Groundnut tops are second in importance. These are widely used for in site grazing and stall-feeding of cattle. The stall-fed cattle are also given maize bran as the main supplement whilst cottonseed cake and leucaena leaf meal are sometimes fed with the maize bran.

In our country the smallholder farmers who raise both crops and cattle have the potential to utilise crop residues. In addition, small-scale zero grazing commercial livestock production, based on one to four dairy cows or steers, is practised. One has to add, for our Kenyan colleagues, that here "zero" grazing is used in its classical sense. Zero grazing is, in fact, already popular in Malawi. This is so because of immediate cash benefits from the sale of milk or fattened cattle. It is also because of the large quantities of organic manure produced in the feeding pens. The manure produced is widely used in the production of crops such as tobacco and maize. The production of milk and high quality beef from grade dairy cows and fattened steers respectively makes a tremendous saving on imports of animal products by the country.

So much research information has been generated in some Sub-Saharan countries, notably: Zimbabwe, Nigeria, Kenya, Tanzania, Ghana, Cote d'Ivoire, Uganda, Ethiopia and here at home in Malawi. However, only a very small proportion of this research information is actually being used by farmers, especially those in the traditional sector that produce the bulk of the animal products. Probably the technologies embodied in this research information are not appropriate for this group of producers. If the results are technically adaptable, then the information must be in a language that our farmers may not understand. Possibly also, the infrastructure for adoption of these technologies is non-existent or not fully developed. Whatever the problem, it is now time for a break-through.

The importance of livestock cannot be over emphasized. Indeed it is a well known fact that livestock is an essential aspect of human existence and a very essential fuel of industrial development.

I, therefore, urge you to discuss the papers thoroughly so as to come up with recommendations that will be directed at meeting the needs of ordinary farmers, particularly the smallholder. Furthermore, I hope that you will take full cognizance of the socio-economic and environmental constraints which face the African farmer. In so doing you will come up with ideas which can easily be translated into action by the target populations. This will not only enhance your professional capabilities but will also help to improve the quality of livestock and the nutritional and economic status of farmers in your respective countries. Africa today depends upon the scientist who has initiative. To prosper our people must benefit from the innovative scientist who is capable of generating relevant and practical technologies. We have hope therefore, in you. I trust that you will deliver the goods in your respective endeavours. We wish you well.

At this point, I would like to express our gratitude to the workshop organisers. I mention in particular Professor Said of the African Research Network for Agricultural By-Products and Dr. Dzowela of the Pastures Network for Eastern and Southern Africa. We also appreciate the financial assistance made available by the International Development Research Centre of Canada and the Organisation of African Unity. Without these the International Livestock Centre for Africa and the Inter-African Bureau for Animal Resources, would not have been able to co-sponsor this workshop.

Distinguished delegates, you have a very busy schedule, I do hope, however, that you will have an opportunity to visit the surrounding countryside to see for yourselves results of the efforts that Malawi is making in the field of agriculture, in general, and animal production in particular. Our efforts in the fields are commendable but we are also the first to concede that more could be done to enable more farm families to open up. This the Malawi Government is committed to doing.

It is the wish of His Excellency the Life President that you should feel free to go anywhere you like. You are free to talk to anyone you like. So feel free to do so because you are among friends here. Should your commitments permit, you are free to extend your period of stay. In any case, we hope to see you again, you and your families, in Malawi on holiday.

Once again, I am very pleased to welcome you and we feel greatly honoured to be your host.

Distinguished delegates, ladies and gentlemen, I declare this workshop officially open. Thank you very much.

Keynote address: The Institutional and Research Factors that Affect the Optimisation of Research Results Use

Professor C.A. Onyango
Vice Chancellor for Academic Affairs,
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INTRODUCTION

The theme of this workshop is "Utilisation of Research Results in Forages and By-Products Animal Feed Resources in Africa". I believe that the various papers which will be presented during the workshop will focus on specific aspects of the theme. I was requested to deal with what I consider to be a broad area of concern to researchers in general, and while addressing my comments to the topic I was assigned, I hope I will make reference to what may be considered relevant to the theme of the workshop.

I would like to start my remarks by reflecting on the concept of research.

Creative thought is of great significance in today's society; Many advances which we accept as commonplace without thinking of their origin, arose from the abilities of individuals to perceive a certain problem and think of an original solution to it (Olive, 1962). This is what constitutes research. Dominowski (1980) defines it as a complex problem solving activity, "the perfect study" an ideal to be sought after rather than attainable achievements.

Generally therefore, research is a systematic way of seeking out answers to questions. Such answers may be abstract and general as is often the case in basic research, or they may be highly concrete and specific as is the case in demonstrative or applied research.

The basic definition gives us an opportunity to note one important point before going any further, and that is the fact that positive research results are by no means an adequate measure of the value of research. If for instance, a study has been carried out systematically, thoroughly and using sound and appropriate methodology, a contribution has been made towards expanding knowledge even though the findings from the study may be as yet inconclusive. We are aware that studies which may apparently appear to be unsuccessful, like in the case of what led to the discovery of penicillin, sometimes lead to an unexpected but nevertheless very useful information, or by their own nature form the basis for further investigation on a larger scale, with even more defined research technique. We are well aware that any amount of controversial research results generally lead to a greater intensity to verify the results which subsequently expand or clarify existing knowledge. In recent years, controversial statements made by certain researchers regarding the origin of the dreaded disease AIDS made it possible for others to try and prove the statements wrong, and thank God we know that there is no scientific proof to associate the origin of the disease with Africa or the green monkey found in its tropical forests. Research as we can see has its own built-in mechanisms for self checking and verification, even if in some cases this may be time and resource consuming.

The topic of my discussion is "The Institutional and research Factors which Affect the Optimisation of Research results". The dictionary definition of optimisation (to optimize) implies making the best use of taking; the best value of something. The implication of the above statement for this workshop is that we are/or may be sometimes not making the best use of research results; and that this is due to institutional and research factors. Whereas I will address myself to these factors, let us not assume that there are no other factors besides those which relate specifically to these two areas.

Institutional factors affecting optimisation of research results

The term "institution" here refers to an organisation or an organised system through which or in which research is carried out. The organisation may be social, economic, political or scientific. It may be public or private. It may also be local or, national, international or multi-national. Specific organisations I have in mind include such bodies as research or experiment stations, teaching/research institutions such as universities, colleges and university research farms, international research bodies such as IDRC, ILCA, ICRAF, ILRAD, ICIPE and so on. There are several problems of optimisation of research results which relate to these organisations.

Organisational Objectives may impinge upon the optimisation of research results. Take, for example, a university whose main function is to teach and award diplomas and degrees to its students. In a university, a lot of research is presumably done towards awarding Masters or Doctorate degrees. The professional academics who guide students and who also do their own research publish most of the result in reputable scientific journals. Apart from conducting and directing "brilliant academic" research, they aim to gain academic promotion and recognition among the peers. The rest of the research ends up in university libraries and archives. Many research organisations have no formal mandate to disseminate their results for day to day or immediate use. They therefore neither engage personnel for such activities, nor put any funds into it, unless prompted to do so. Kenyan universities for instance were recently challenged to be interested in solving problems which the public face. One main contribution Nairobi University has recorded is through the Rhizobia research project (providing a cheap organic fertilizer to the farmers) and current efforts to develop cheap housing for urban people. But the rate of dissemination is very low. Many research stations without clearly defined objectives may experience similar problems. This is why I think we are aware of a lot of good research gathering cobwebs in shelves at research stations.

Research programmes should be adequately coordinated and lack of this may result in poor optimisation of research results. In research stations for instance, research may be carried out without the farmers in mind. This lack of focus on a target group may lead to results which are not appropriate for optimum utilisation. University post-graduate research programmes experience this problem. Conservation on the part of those who direct research make it difficult especially for young researchers to tackle problems which may have immediate utility and even when they obtain utilisable results, it may not be spread for reasons stated above.

Institutional bias also plays an important role in the realisation of the research results. In one way, bias towards a certain direction or a certain discipline helps the researcher to produce exhaustive and up to date research results. However, it is disadvantageous towards the end results in a number of ways. First, the narrowness in focus, where the researcher is not exposed to other aspects of the same discipline. For instance it is important for an economic geographer to know something in medical geography. The two areas may be inter-related and can supplement each other. Reliance on economic geography without reference to certain aspects of medical geography may affect the research results in the sense that the arguments may be narrower and without sound basis for justification.

Second, most of the records used by researchers are products of self-reporting by different researchers and institutions.

Reports, especially those in the public sectors are written from a certain institutional standpoint as well as the biases of the author who may be bound by circumstances to please his institution. There are two overall effects of institutional bias on the optimum utilisation of research results. One, there is often lack of adequate recognition of what should be done. Institutions are often reluctant to promote a viable innovation due to lack of commitments. Two, they will also commit very little inputs (efforts) in such endeavour.

Perhaps the most important areas to consider is research funding. Luck of adequate finance or financial resources not only affects the institutions' ability to carry out research, but also the diffusion of research results. I have already given the example of research results being shelved in research stations. But much worse can happen. Often situations arise where raw data, meticulously collected, cannot be analysed due to lack of funds. Even the material which is already analysed may not be written up due to lack of such simple things as paper and duplicating facilities. Consequently the results may not be released for public consumption.

Universities in particular find it extremely difficult to convince government treasury to fund them for research. If one were to look at any university budget in Africa, one would hardly find a line item for research, and where it is included, the amount allocated is likely to constitute a very small percentage of the total budget. There is often nothing for disseminating any information.

Research stations or centres are not spared this problem. Their budgets often fall far too short of what the expectations are and limit their capacity to communicate any results through extension.

Lack of qualified research personnel is another institutional factor affecting the utilisation of research results. The forerunner of this problem is low salaries, lack of promotion and lack of recognition to qualified and well-trained researchers who very readily resign their positions to join better-paying organisations. The result is that in many research stations you find people without adequate research techniques and hence relatively poor research output. We can cite the case of Kenya where manpower has been constantly depleted from the National Agricultural Laboratories, NAL, National Research Stations, NARS Kitale and Katumani, resulting in the subsequent importation of (as it were) researchers from outside. The recent efforts by government, in providing a better scheme of service to researchers is intended to stem this tide, and in my opinion, is a step in the right direction. Shoddy research carried out by incompetent individuals is of no use to anyone.

The role of supervisory personnel may be connected with research utilisation in two ways. First, in institutions which have no qualified researchers to supervise the research undertakings, the quality of research and results are bound to be poor. The converse is true where the quality of supervision is good.

Research undertaken in research stations must have good supervision for the quality and pace to be maintained. In the universities, there is at least a greater collaboration among peers and mediocre research can be improved through peer criticism and the system of external assessment for student research projects. In experiment stations which have no affiliation to university systems this self or peer criticism may be totally lacking and efforts should be made to avoid it. Secondly research supervisors may have what I would like to term supervisory overload. This may be more common in universities than anywhere else. Researchers based in universities are also expected to teach students. If they take on teaching as well as research, their time must be carefully divided between the two functions. The number of students an individual supervises will invariably affect the quality of his research. Often research suffers more than the teaching in the case of overload, and we are certainly well aware of the extended and frustrating periods post-graduate students take to earn their degrees due to lack of adequate supervision resulting from staff overload. These researchers often have very little linkage with extension, and in the event of time constraint they are bound to carry on with the research or teaching without communicating their results for public utilisation.

Facilities play an important part in the optimisation of research results. Reference has already been made to the problem of financing which affects the acquisition of research facilities and materials. Research institutions often have limited transportation which they can use to implement on-farm research. The problem may be even more acute at universities where research competes with teaching and other adminstrative requirements for transportation. Lack of library and reference facilities in institutions greatly affects the research process. This hampers the speed at which researchers can make reference to other people's findings, which in turn they can utilise. Research stations or universities hardly have adequate facilities for diffusing their messages. The traditional role of a researcher is "to do research" and this is more so in Africa where basic facilities, transport, seed, fertilizer, communication equipment is available on a very limited scale. Where research results exist in libraries without being applied or referred to, they are unaccessible and incomprehensible to many ordinary people. Even the shelfing systems, the delivery methods, hours of access, and the fact that there are few instruments to read the available material, acts to the disadvantage of many prospective users of already well documented results.

The wholesome attitude towards research and reward system by institutions to researchers may have adverse effect on the utilisation of research results. This could be partly due to lack of incentives to good researchers. Universities for instance, insist on comprehensive list of research and publication and yet hardly provide adequate funding for research. Research stations on the other hand hardly reward any good and valuable research since they are restricted by Government promotional red tape. Researchers without a good system of reward may tend to do very little. They also tend to leave vital projects unfinished, thus setting back research which could otherwise solve pressing problems.

Conflict of priorities between institution and individual researcher may impinge upon the quality and utilisation of research. International organisations in particular release funds on condition their priorities and methods are followed. Often this restriction does not give adequate consideration to local problems about which local researchers are concerned. Thus the focus of research being carried out may be irrelevant to the local scene. When researchers concentrate on and achieve results which are not appropriate to the local scene, the results may not be applied. Conflict also relates to what is wanted and by whom! Farmers are not often consulted and they do not participate in determining the research priorities. They may as a consequence stay away from utilising research results.

Social Constraints may also create a problem to research. Good research requires adequate planning, vigorous use of correct methodology and critical unbiased analysis and interpretation of results. Good results may not be utilised due to poor methods of dissemination which are at variance with the socio-cultural practices of the intended clients. Methods of disseminating and communicating research results is important to consider in the utilisation of the research results. Research institutions tend not be charged with the responsibility of disseminating their findings to the public for use. This activity is generally expected to be carried out by extension services. The implication is that the extension services must first of all interpret the research results correctly and secondly find the correct medium to spread it among the users. The various media used for such purposes include demonstrations, on-farm trials, publications and various other communication channels. Whenever any of these media is not correctly used, the message contained in the results is generally lost. It is therefore important to have the correct personnel, the right facilities and to us the appropriate methodology to disseminate research results. This is the only way of attempting to guarantee the utilisation of the results.

Research factors affecting the optimisation of research results

In addition to the institutional factors, there are also various research factors which need to be considered in discussing the optimisation of research results. These factors cannot be overlooked, for they involve the actual process leading to the research results.

Identification and choice of a research problem plays an important role in the realisation of research results. Once a research problem to be investigated has been identified, other research procedures can easily follow. Failure to state the problem adequately is the first step in failure to carry out a project unless the problem is explicity stated.

We are aware, that stating a research problem adequately is often a problem especially for young inexperienced scientists. Many of them in their enthusiasm initially want to tackle a very wide scope of work, and when advised to limit their work (like often happens in the case of postgraduate students), they feel very discouraged. The reality of the situation only rears its head when the researcher realises that there are many variables to contend with and he does not know how, or have the capacity to handle them. The underlying question is however, who states the problem? Why can't farmers be involved in participation to identify the research problem. Assumptions are often made about their lack of knowledge, but yet they recognise their problem.

Objectives and Scope of the research relate directly to the statement of the problem and are affected by or affect it.

A researcher may find himself in a situation where there is limited resources, time and other facilities. The scope of his work therefore becomes automatically affected. Failure to state the objectives clearly and precisely may lead to wastage of time. Once stated well, the objectives give the researcher a sense of direction, knowing what to look for, where and when. Failure may also lead the researcher into giving false information in the results. In stating the objectives and scope of the research, appropriate assumptions or hypotheses must also be made. This enables the researcher to eliminate any conflicts, and hence, carry out an investigation whose results are valid and reliable. But for purposes of utilisation, research should also relate to what may have impact on society. It must also be economically beneficial, and finally those who can disseminate the results should be clearly stated.

Once the objectives are stated, it is important for the researcher to identify appropriate method to investigate the problem. The design of the research is important and the researcher must understand it fully. Whether experimental or non-experimental design is chosen, the researcher must be in a position to understand and follow his chosen method fully. We are cognizant that each research design has its own peculiar strength and weakness for application in given situations. An appropriate design leads to correct and utilisable situations. If these results are applicable in a particular case (i.e. technologically speaking) they can be utilised. This applies also if the results have a superior utility to what exists. Researchers should therefore aim at bringing about technological as well as social change.

Traditionally, research results are processed using simple instruments, "paper and pencil" as it were. But scientific research has grown with technology, and now researchers have to use highly technical instruments to analyse their data. Very often instruments for research are lacking, and therefore there are delays in both the actual research as well as in the analysis of research data. I am particularly having in mind computers and computing facilities including software. In the case of many of us in the developing world, there is the problem of technological backwardness where even when the technology is at hand, we can hardly use it readily. Many of us can hardly type (a very simple skill) our raw data into a computer. Worse still we cannot write simple programmes suitable for our research work. When the publication of research findings is delayed, the utilisation also becomes limited. Technology is always becoming better. Research should be completed in time and should be aimed at solving existing (real life) problems which farmers recognise.

The manner of writing and reprinting, especially the choice of words in giving the research findings, may have adverse effects. Typing errors and ommission of certain important facts can go along way to affect the findings.

Researchers have a tendency to write in detailed scientific jargon. Whereas this is understood and useful to their peers, the common users (e.g. farmers) may require additional and simple interpretations or translations; something scientists either do not have time to do, or interest to carry out since it "dilutes" their level of ability and thus reduces their level of recognition by peers.

The role played by other researchers especially supervisors and collaborators in similar research is very important. Supervisors are expected to ensure that the correct procedures are followed and that the researchers keep to ethical practice. Collaborators provide a mechanism through which a researcher counterchecks his procedures and results. It gives one an opportunity for comparison. Assuming there is successful co-operation and collaboration among researchers, results can be verified quickly and released for use. Unless a system of verification is insured, research results may not be released in time.

There are a few other factors of research which I would like to mention.

Social , Political and Cultural Influence may also affect the optimisation of the research results i.e. on certain occasions people write what is likely to be favoured by their upbringing and that of their audience.

Patience and careful attention to the experimental design (Curtis, 1976) is desirable. Occasionally some researchers are impatient and end up doing the experiments in a hurry. This leads to tempering with instruments and thus interferes with research results.

Ethical issues could also affect the optimisation of the research results i.e. there are some researchers, especially those who choose interviewing as a methodology towards accomplishing the research results, who involve the respondents without asking them whether or not they wish to participate. Sometimes, some investigators have withheld from their subjects certain information about the research in which they were taking part. Furthermore some researchers force people to participate, or deceive the participants. The researchers even lead the research participants to commit acts that diminish their self-respect. Consequently the participant may withhold certain important and beneficial information that would be important to the research results. The subsequent results from such research, even when utilised, are not realistic.

CONCLUSION

In conclusion, I would like to emphasize that whereas we consider both institutional and research factors to affect the optimisation of research, the cardinal point is that research, if it is to be useful must be geared towards existing practice or intended practice.

In the university we carry out a lot of theoretical research which, even though adding to new scientific knowledge, has no immediate application in people's daily lives. Similarly at research station level some of the research carried out has no immediate application.

It is, therefore, necessary for researchers to consider seriously the development of applied research, as opposed to basic research. They should utilise existing knowledge from basic research to develop appropriate problem-solving projects. As often remarked, "we should not spend too much time trying to re-invent the wheel, but rather to make the wheel carry out various functions for us".

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SESSION 1: RESEARCH REVIEWS ON UTILISATION OF FEED RESOURCES

UTILISATION OF PASTURE RESEARCH RESULTS IN TANZANIA

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ABSTRACT

Tanzania has behind it more than 40 years of pasture research experience and yet this experience has had little impact on pasture production and utilisation in the main livestock areas. Indeed, it is now recognised that pasture inadequacy is a bottleneck in livestock development programmes in the country.

Constraints within the pasture research and extension establishment seem to have largely limited the effectiveness of research. In particular, the lack of a clear national pasture research and development strategy, the lack of overall co-ordination and appraisal of extension service have all combined to militate against the formulation of viable improved pasture innovations and their adoption by the livestock industry. Contributory factors have included the existence of unsuitable grazing systems, poor livestock management, unavailability of pasture seeds and a poor farm input-output infrastructure.

INTRODUCTION

Grasslands are a major feed resource in Tanzania. They occupy about 51% of the total land area (FAO, 1967) and have supported millions of wild and domestic animals over the years. Ruminant livestock populations have been estimated at 12.1 million head of cattle, 5.5 million goats and 3.6 million sheep (Min. of Agric., 1984). It seems likely that these grasslands will, for quite a long time to come, continue to support these animals in terms of feed requirements both for maintenance and production. However, if they are to meet the demands imposed by a growing livestock industry in the country, they must be managed and utilised in a way that ensures the production of large quantities of high quality forage. This, inevitably, involves research which has to generate improved pasture systems to the majority of the livestock keepers. It is estimated that 99% of the ruminant population thrives mainly under the traditional systems of management. The traditional sector is characterized by communal grazing practices which do not encourage the use of improved pasture technology.

The livestock industry in Tanzania has contributed much less to the monetary economy of the country in comparison with the cash crops (Anon, 1984). Early efforts at improving production from the country's vast livestock resource concentrated on livestock disease control and genetic improvement. It has now been realised that further improvements in production can be achieved by increasing the quantity and quality of the feed available to the animals.

This paper examines the scope and main shortcomings of past pasture research and development programmes and the development of the traditional livestock sector.

PAST PASTURE RESEARCH AND DEVELOPMENT

In Tanzania pasture research dates back to the 1930's and was pioneered by such scientists as French (1938) and Van Rensburg (1952), Staples (1937) among others. Investigations that have been carried out since then and their evaluations are well documented (Mehta, 1973; Mehta, 1974; Rwebangira, 1978; Lwoga et al., 1984) and the following is only a summary of the past work. On the whole, much information has been accumulated in seven main areas including:

a. Pasture plant species occurence, adaptation, productivity, establishment and suitability for pasture in various areas of the country. Such work was undertaken in the humid to sub-humid areas (Naveh, 1966; Naveh and Anderson, 1967; Hopkinson, 1970); the sub-humid to semi-arid areas (Walker, 1969a; Van Voorthvize, 1971), and the semi arid areas (Owen and Brzostowski, 1967; Wigg, 1973). The major parameters studied included persistence, dry matter yield, resistance to grazing, drought resistance and quality. Other evaluation trials were carried out by Lane and Lwoga (1978), Mukurasi (1978) and Myoya (1980). The results have been summarized by Lwoga et al. (1984) on the suitability of grasses and legumes for pasture establishment in their various ecological zones in the country. Pasture establishment methods have not been dealt with in detail in Tanzania. The few workers who have conducted trials on this are, Northwood (1978) and Rukanda and Lwoga (1981). These workers have proved the effectiveness of minimum cultivation techniques with or without the use of herbicides, when introducing legume species on natural pasture in the sub-humid areas.

b. Grazing systems on rangelands: studies on stocking rates in subhumid ecological zones were carried out by Staples (1938), Walker and Scott (1968), Broatch (1970), Lugenja and Kajuni (1979) while those on grazing systems (rotational, continuous, deferred and their combinations) were done in sub-humid to semi-arid areas by Staples, (1937), (1945), Walker (1968), and Walker and Scott (1968). Walker and Scot (1968) concluded that combinations of rotational and deferred grazing gave better results than any of the other systems used singly.

c. Response of grass pastures to fertilizer application. The use of mineral fertilizers on natural pastures was tried by Evans and Mitchell (1962), Anderson (1965, 1968), Walker (1969b), Hendy (1975) and Lwoga (1981). The use of mineral fertilizers on natural pasture has been shown to improve both the yield and the quality of forage in various parts of Tanzania, but moisture stress reduces drastically the yield response in low rainfall areas (Lwoga, 1981).

d. Chemical composition and nutritive value of various grass, legume and browse species: Earlier studies, which evaluated chemical composition and in vitro digestibility, were conducted by French (1939; 1941; 1945; 1950; 1957), Van Rensburg (1956) and more recently by Kidunda (1988). Most of their results showed that plant species differed in their chemical composition and that the crude protein, minerals and vitamins contents decreased with advanced stage of growth while that of the crude fibre (lignin, hemicellulose and cellulose) increased with advanced stage of growth. The legumes were superior to the grasses in terms of crude protein content.

e. Vegetation communities and classification of vegetation within the country: Investigations on range ecology and vegetation survey include those by Phillips (1930), Greenway (1933), Scott (1934), Pieler (1952), Walker (1974) and Kahurananga (1979). The results of some of these workers formed the basis for the production of various vegetation maps of Tanzania and East Africa as a whole.

f. Bush control in natural pastures : Different methods of bush control were also investigated. Biological methods, mainly by the use of goats (Hornby and Van Rensburg, 1948), fire (Staples et al, 1942, Van Rensburg, 1952; 1958) and by mechanical means Brzostowski, (1960) were conducted in Central Tanzania. However most of the results in bush control have not been published in widely circulated journals.

g. Forage conservation : There have been few studies on forage conservation and their utilisation in Tanzania. Some early experiments (French, 1938; 1939; 1956; 1957) evaluated the feeding value of various grass hays and silages. Recently, Urio (1977), Kategile (1979) and Edeslsten and Lijongwa (1981) did experiments on the utilisation of crop residue to improve livestock nutrition during the dry season. These workers proved that crop residues could be used to improve livestock nutrition especially during the dry season.

CURRENT PASTURE RESEARCH

Currently pasture research is mainly undertaken by the Tanzania Livestock Research Organisation (TALIRO) which was formed in 1981. The organisation has various research stations representing the different ecological zones within the country. Such stations include Mpwapwa Livestock Production Research

Institute, Kongwa Pasture Research Station, West Kilimanjaro Research Centre, Malya Research Centre and Tanga Livestock Research Centre. Sokoine University of Agriculture (SUA) and Uyole Agricultural Centre (UAC) are two other institutions which are also actively engaged in pasture/forage and other feed resources research. Current research is on:-

i) Introduction and evaluation: a) Introduction and evaluation of pasture species for oversowing in natural pastures and undersowing with cereal crops in the semi-arid areas of Central Tanzania. The initial screening is done on station and later on-farm for the most promising species.

b) Screening of temperate and sub tropical and multipurpose browse species for adaptation to southern highland conditions for on-farm integration with cereals.

c) Legume forages incorporation with fodder grasses for smallholder dairy farmers in the Kilimanjaro highlands

d) Screening of tropical and sub-tropical forage grasses and legumes for adaptation to the coastal humid zone

ii) Pasture establishment a) Legume/grass mixtures for improvement of both the quality and quantity of the pastures

b) Effect of different N-fertilizer levels on the yield and quality of established pastures

c) Oversowing of legumes into natural pastures in Central Tanzania as a method of pasture improvement

iii) Nutrition: a) Dry season feeding in central Tanzania as an integrated system approach

b) Dairy feeding systems using crop residues in the Kilimanjaro highlands. Research is also done on the nutritive value, methods of treatment, utilisation and costs of transportation of the crop residues

c) Use of Leucaena leucocephala and other multipurpose trees as sources of feed during the dry season

iv) Range: Range monitoring, improvement by sod seeding, grazing management and bush control methods at Kongwa Pasture Research Station

IMPACT OF PASTURE RESEARCH

Although a great deal of effort has gone into pasture research over the years, there has not been much corresponding progress in pasture development in the major livestock areas in the country. On the contrary, it appears that expanding arable cropping and better veterinary services (with consequent increased livestock survival) in these areas have tended to lead to deterioration of forage resources over the years (Lwoga, 1979).

On the local scene, improvement of livestock productivity through better pastures has been recorded mainly under research and government institutional conditions. Some of the private farms in the northern and southern highlands of Tanzania have also benefited from research and improved pasture technology. This section however, comprises less than one percent of the national herd (FAO, 1967).

Clearly, past pasture research has not had much impact on pasture development in the country. The most important aspects of this problem are as follows:-

Lack of national objectives, co-ordination and integration

Lack of co-ordination between various research stations was an important organisational defect. Researchers were not much informed on the type of projects other stations had apart from information through annual reports, most of the reports were circulated late or not circulated at all.

Lack of well defined objectives that encompassed national priorities in pasture research and development was another short-coming. In the absence of such guidelines, projects were selected on an ad hoc basis with little consideration because pasture researchers were expatriates. Thus, a considerable proportion of past research work was of a short-term nature which is of rather limited value unless extended to actual grazing conditions.

Another consequence of the lack of well defined national objectives in pasture research was poor integration. Thus, in most cases each researcher planned and carried out his own projects in isolation, and the plant was separated from both the soil and the animal. Problems that confront the livestock farmer are of a multi-faceted nature. Tackling any of these problems requires a strategy in which all facets of the problem are simultaneously brought under intensive scrutiny to generate information that can be used to assemble an effective package of innovations.

One more consequence of the lack of a national strategy on pasture research and development is that in some areas, projects have been completed without publication of the results; and in other cases, projects which started more than ten years ago have been going on without periodical reviews.

Manpower situation

Manpower engaged in various pasture and range activities has, for a long time, been inadequate. In a survey of pasture and range activities in Tanzania, Edye and Boudet (1975) reported a total of 2 Tanzanians and 13 expatriates engaged in this field while the estimated total stood at 85 specialists.

It is therefore apparent that the total manpower falls short of the estimated requirements by a large margin especially in pasture research. The situation does not seem to have changed much today. More recently, Lugenja et al. (1984) reported that out of twenty (20) pasture personnel, 7 were engaged in pasture research, 4 in teaching and research while 9 were in extension and production services. With such a meager personnel position, little can be accomplished in pasture research and development.

Another aspect of the manpower situation in pasture/range activities appears to be the low morale among staff. Pasture research and pasture development in general have been so much ignored that the technicians posted to work in the pasture establishments count themselves as unlucky and lost.

Research funds

In the long past pasture research was, no doubt, strongly supported financially. However, the situation seems to have changed dramatically in the recent past. In the Ministry of Agriculture and Livestock Development funds allocated have been too small to even maintain on-going projects. In a number of African countries international research organisations have put substantial resources into pasture research, but this has, invariably, been conditional to the active participation of local government and the presence of clear research objective. It is not clear whether the Ministries involved have, in the past explored possibilities of securing assistance for pasture research from international research and funding agencies.

Extension service

Frequent communication between the farmer, extension and research workers is essential if worthwhile pasture research results are to be finally adopted by the livestock industry. In Tanzania, there seems to have been too few workers in Agricultural Extension Service sufficiently competent to advise farmers on pasture/range development (Rwebangira, 1978). Even where there has been such workers, their interaction with pasture researcher (through seminars, workshops or conferences) has been minimal.

Mention should be made of researchers who have established direct contacts with farmers, and of farmers who have sought and received advice from researchers directly. In general, however, efforts by researchers to deal directly with farmers have frequently been frustrated by lack of both funds and transport. Even where such problems did not exist, only a small proportion of farmers is likely to benefit from this service. It is also worthy mentioning that even the initiated Radio programmes on range management are likely to have little impact unless supported by a vigorous extension service.

A diploma course in Range Management has been going on at Livestock Training Institute (LITI), Morogoro since 1975 but, it seems, very few of the graduates join the extension service (most of them are employed on parastatal ranches and dairy farms).

Pasture utilisation systems

Three main pasture utilisation systems can be identified in Tanzania namely ;-

a. total nomadism in semi-arid areas with cattle keepers moving with their animals in search of suitable forage (as is still the case in Maasailand, to a significant extent);

b. semi-nomadism, with cattle keepers permanently settled, but trekking their animals to distant grazing and watering areas; and

c. ranching and dairying on land owned by associations, village, corporations, or private individuals.

Under system (c) improved pasture innovations can be (or have been) successfully introduced. under system (a) and (b), however, successful introduction of improved pasture technology requires considerable prior ground work, in particular, by way of monitoring human and stock mobility within affected areas, (ii) changing the traditional values and life-styles which emphasize the maximum number of livestock possible, and (iii) provision of adequate extension and veterinary services.

The changing of cattle keeper's values from regarding wealth in terms of cattle numbers to assessing cattle in monetary terms is the starting point towards an appreciation of the desirability of improved pasture technology. It is only after this change has taken place that the traditional livestock keeper is likely to co-operate willingly in schemes involving destocking; the replacement of the traditional communal land tenure system with recognised holdings by individuals, villages, cooperatives or co-operations; controlled or restricted movement of livestock and planned use of water and pasture resources. Evidence (Peterson, 1976; Stokes, 1976) suggests that there has not been much change in the values in the main livestock areas in Tanzania.

Availability of farm inputs and input-output delivery channels

The adoption of improved pasture innovations provided by research almost always involved the purchase of various items including machinery, fertilizer, pasture seed, fencing requisites, pipes, troughs and veterinary chemicals. In particular, plentiful supplies of good pasture seed and fertilizers at reasonable prices are vital. Shortage of pasture seed has, however, been a major limitation to pasture improvement in Tanzania (Lwoga, 1976) even though large quantities have been imported from Kenya and Australia (Rwebangira, 1978).

Several research stations and parastatal livestock farms have been producing (uncertified) pasture seed, but lack of funds has, apparently, stifled the development and expansion of this important activity (Rwebangira, 1978). A well organised, national pasture seed production programme is urgently needed to solve the problem of seed shortage.

Just as vital (to the adoption of improved pasture innovations) is the availability of inputs, the channels for the delivery of both these inputs to remote farms and farm products to their final destinations. The importance of this factor is, perhaps, better known in relation to crop production in Tanzania (e.g. late deliveries or lack of fertilizers, pesticides and seeds, lack of storage space for cereal harvests, lack of lorries to ferry cotton to ginneries etc). There is evidence that poor input-output delivery channels are an important constraint in livestock development projects in the country (Stokes, 1976; Mwakatundu and Mpatwa, 1977; Chikaka and Foote, 1978).

For a pasture research and development programme to have a positive effect on the livestock industry and thus, on the country's economy, there must be a corresponding programme aimed at developing the necessary infrastructure including roads vehicles, stock routes, storage facilities, processing plants, distribution and retail facilities for the livestock market; and facilities for exporting surplus livestock products and importing supplies.

POSSIBLE OBJECTIVES AND PRIORITIES

Our own view point is that planning a pasture research and development programme for Tanzania has to take account of variability in Land potential in the various parts of the country so as to avoid unnecessary duplication of experiments. In this respect, the ecological classification scheme (land classified into ecozones) of Pratt and his co-workers (Pratt et al 1986) would provide a useful basis (and is used in the suggestions made below). Account has also to be taken of the fact that the best lands in the country will continue to be used for the production of food and cash crops. Thus, the main thrust in pasture research and development has to be directed to areas of marginal crop production potential.

Ecozones II and III

These areas receive, on average, more than 750 mm annual rainfall. They are of high agricultural potential, most of the land being under permanent and arable crops, or under forest where topography does not permit cultivation. Though livestock keeping (especially dairying) is an important activity, forage shortage is a problem of increasing magnitude due to the expansion of cultivation into areas that were available for grazing previously.

Prospects for pasture expansion are bleak, and increased pasture production will depend largely on intensification on existing pastures. Objectives and priorities for pasture research and development should include the following:-

a) development of suitable fodder crop species
b) development of stable grass/legume pasture system
c) development of suitable conservation methods
d) development of suitable fertilizer recommendations
e) development of suitable grazing systems on natural and sown pasture
f) pasture seed production
g) use of agricultural by-products and farm wastes as livestock feed
h) improvement of soil fertility and soil erosion control through the development of suitable crop-pasture rotation systems and development of efficient N-fixing legumes (both indigenous and exotic).

Ecozones IV and V

These areas receive, on average 750 mm or less annual rainfall. They comprise the main beef cattle and wildlife areas and, in the central and northern regions, have been subject to considerable overgrazing. Though, on the whole, they are of low crop production potential, arable cropping has been expanding rapidly with the aid of tractor and oxen plough cultivation

The following should be among the objectives and priorities for pasture research and development:-

a) Production of adequate quantities of high quality forage for livestock throughout the year.

i) development of suitable grazing systems (taking into account pasture productivity and optimum stocking rate)
ii) development of suitable bush control method
iii) development of suitable forage conservation methods
iv) introduction of suitable legume and browse species into natural pasture
v) evaluation of suitable indigenous legume and browse species in natural pastures
vi) use of irrigation to produce high quality feed especially for dairy animals
vii) commercial pasture seed production

b) Soil moisture and seed production

i) development of suitable grazing systems
ii) reseeding of denuded areas with suitable grass and legume species
iii) development of suitable crop-pasture rotation systems

c) Improvement of soil fertility in areas of mixed farming through:

i) development of suitable crop - pasture rotation systems
ii) development of efficient N-fixing legumes that can be incorporated in crop farming systems.

In all types of econzones there is a strong case for assembling and conserving gene pools of potentially valuable indigenous grasses and legumes. These would provide material for pasture breeding and seed production projects.

5.3. More funds should be made available for pasture research. The government will remain the major source of such funds but it is conceivable that international organisations and agencies may be ready to give assistance if research objectives are defined, programmes prepared and an effective machinery for their execution is established.

5.4. Extension capability should be strengthened by:

a) increasing the number of staff with adequate training in pasture/range management, especially at diploma level

b) improving communication between research, extension and farmers through seminars, inter-institutional exchanges and visits and

c) alleviating obstacles that generally hamper the effectiveness of the extension service in the country (e.g. poor transport)

d) a vigorous recruitment and training programme should be undertaken to establish a multidisciplinary team of competent research staff in the country. An effective team would need to include ecologists, botanists, plant breeders, veterinarians, agronomists, soil scientists, animal nutritionists and social economists. These can work well when a pasture research institute is established, in which salaries and other employment conditions are sufficiently attractive to obtain and hold well qualified scientists. As conclusive results from pasture programmes require several years in experiments, a stable staff situation allowing continuity of research effort is necessary.

CONCLUSION

Although a great deal of effort has gone into pasture research and development over the years, this has had little impact on pasture production and utilisation among the livestock keepers in Tanzania. The major shortcomings were: lack of clear natural pasture research and development objectives, co-ordination and integration, inadequate manpower, lack of research funds and poor extension service. The situation was aggrevated by the existence of unsuitable grazing systems, poor livestock management, unavailability of pasture seeds and a poor farm input-output infrastructure.

Recent developments are, however very encouraging and auger well for the future of pasture research and development.

a. A farming systems approach which focusses on the farmers in given ecological zones has now been adopted in pasture/livestock feed research. Examples of this approach include a number of on-going projects at Mpwapwa Livestock Research Institute, Sokoine University of Agriculture and Uyole Agricultural Centre.

b. Researchers have better opportunities to meet and exchange ideas within and outside the country through participation in professional associations and networks such as Tanzania Society of Animal Production (TSAP), Tanzania Veterinary Association (TVA), Pasture Network for Eastern and Southern Africa (PANESA), and African Research Network for Agricultural by-products (ARNAB).

c. The funding is better now than in the past, in particular with regard to collaborative research projects within Eastern and Southern Africa through, International research agencies (e.g. IDRC) and regional pasture/livestock feeds networks (e.g. ARNAB and PANESA) encourage participation in regional collaborative research projects for which they provide "seed" funds and training opportunities.

d. There is now a core of indigenous researchers in pasture/livestock feeds and the staffing situation is likely to improve with time.

e. The decision by TALIRO to establish a national pasture research institute is a welcome move. There is no doubt that the institute will, when fully established, provide a major thrust in the research and development of pastures and livestock feeds as a whole.

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UTILISATION OF AGRICULTURAL BY-PRODUCTS FOR VILLAGE AND COMMERCIAL PRODUCTION OF SHEEP RATIONS IN GHANA

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ABSTRACT

Sheep constitute a significant proportion of the ruminant livestock population in Ghana. There is a growing interest in the raising of sheep in backyards among urban dwellers, but their major problems is the availability of feed as their animals are not allowed to roam and graze freely as is done in the village.

The agricultural by-product feeds available in Ghana include cereal and legume straws, corncob, cocoapod husk, coffee pulp and peels of yams, cocoyams, plantains and cassava. The nutritional problems encountered in the utilisation of these by-products, the treatments needed to improve their nutritional values and the economics of feeding to sheep have been discussed. The other major problems associated with the use of these by-products are bulking, transportation, storage and processing.

In the villages, in the southern parts of the country, it is suggested that grazing animals should be supplemented with peels. In the villages in the northern parts of the country, the feeding of cereal and legume straws should be encouraged. In the cities it is suggested that commercial feed mills should prepare diets from these by-products for sale. There is also the need to improve the growth rate and feed conversion efficiencies of the local breeds of sheep if they are to be raised intensively in the towns and cities.

INTRODUCTION

Sheep constitute about 42.67%, on numerical basis, of the ruminant livestock population in Ghana (Veterinary Services Department, Min. of Agric., Ghana, unpublished data). The rate of increase in the population of sheep is reported to be higher than that of any other species of ruminant livestock in the country (3.4% for sheep 1.2% for goats and 1% for cattle, (Veterinary Services Department, Min. of Agric., Ghana, unpublished data). Apart from being a source of meat, sheep are also the choice animals for sacrifices to gods and stools and for appeasing elders when they are offended by their juniors.

There is at present a growing interest in raising sheep in backyards by urban dwellers. The major problems of these backyard farmers is availability of feed. Unlike the backyard poultry farmers in the towns and cities, the backyard sheep farmers have no access to commercially-prepared feeds since no feedmill prepares sheep feeds for sale. They have to buy cut grasses and household offals such as cassava peels to feed in confinement these animals as the municipal authorities do not permit free roaming of sheep as is done in the villages.

Since the costs of sheep feeds prepared from concentrates such as cereal grains will be very prohibitive, attempts are being made by some researchers in the country to formulate sheep rations based mainly on agricultural and industrial by-products.

The aim of this paper is to discuss some of the prospects for and problems encountered in attempting to use agricultural by-products in rations for sheep in Ghana.

AGRICULTURAL BY-PRODUCT FEED RESOURCES AVAILABLE IN GHANA

Some of the agro-industrial by-product feed resources available in Ghana and their nutritive values are shown in Table 1. The industrial by-products are: wheatbran, dried brewers (spent grains from the breweries), oilseed cakes, copra, cottonseed cake and palmkernel); pito mash (spent grains from the brewing of local beer, pito) and maize bran. These by-products are used greatly in the rations of non-ruminants. The oilseed cakes are produced in the rations of ruminants, as there is not enough for making rations for non-ruminants.

The agricultural by-products which could be used in the rations of sheep are rice-bran, sun-dried poultry manure, coffee pulp, cocoapod husk, peels of cassava, plantain, cocoyam and yam, cereal and legume straws and corncobs.

With the cereal and legume straws and corncobs, the major limitations are their low digestibilities due to lignification of their cell walls which form the bulk of the materials. Apart from cowpea straws (for crude protein), they are also low in crude protein, water and most likely some essential minerals. The straws are also deficient in Vitamin A.

El-Naga (1987) reported of improvement in nutritional value of straws with supplementation of minerals, vitamins and nitrogen. El-Naga (1986) also obtained improvement in intake of straws with hydration. It is also believed that cereal straws are more efficiently utilised when supplemented with green forages (Mbatya et al, 1983). The actual constituents in green forages which help to improve the utilisation of cereal straws are not known. These cereal straws also respond to alkali treatment. Since sodium hydroxide is an expensive product in Ghana, lee (an affluent from the manufacture of soap) or woodash solution could be used to treat these straws as has been shown in Table 1 for corn stover. Varietal differences in digestibilities exist in cereal and legume straws (Tuah et al, 1988) and good quality straws could be used for feeding.

Table 1: Nutritive values of some agro-industrial by-products which could be used in sheep rations in Ghana

By-product	DM%	% Crude Protein (DM basis)	IVDMD* Untreated	IVDMD 5% NaOH treated	IVDMD Lee treated	IVDMD 10% wood ash solution treated
Cassava peels	27.9	5.71	62.95			
Plantain peels (Apentu)	19.8	10.64	76.03			
Yam peels (White)	17.70	11.21	61.58			
Rice straw ITA 230	93.40	4.36	46.78	65.82		
Corn stover (Dobidi)	92.74	5.04	51.13	62.03	75.38	63.25
Cowpea straw TVX 1948 OIF variety	90.58	13.31	54.18			
Cocopod husk	89.50	7.60	41.37	41.56		
Coffee pulp	90.56	8.8	33.07	33.72		
Sun dried poultry manure	91.66	14.77				
Copra cake	90.90	22.80				
Cottonseed cake	91.42	35.43				
Maize bran	86.86	12.73				
Rice bran	91.96	7.47	68.27	72.96		
Wheat bran	86.50	17.77				
Dried brewers spent grain	93.37	18.29				
Corncob	93.27	3.20	35.60	68.90		
Palmkernel cake (sun dried)	91.1	16.91				
Cocoyam peels	17.62	9.56				

* IVDMD = In vitro dry matter digestibility

Coffee pulp has low *in vitro* dry matter digestibility and does not respond to alkali treatment (Tuah and Ørskov, 1987; Table 1). It is high in lignin (about 27%) (Tuah and Ørskov, 1987). It contains about 5% condensed tannins. It, however, has the advantage of stimulating appetite in sheep (Tuah *et al*, 1985).

Cocoapod husk has to be dried quickly; otherwise it grows mouldy and loses all the digestible carbohydrates. At present it is dried electrically. The energy cost of obtaining one metric tonne of dried cocoapod husk is about 400 litres of oil (Gibb, 1975). The efficiency of using solar driers should be tested and if successful they can be adopted for use by small-scale farmers and the state - owned large cocoa plantations.

The peels of yams, plantains and cassava (and perhaps cocoyam for which no figures are available) are more digestible than the straws, corncob, coffee pulp and cocoapod husk (Table 1). They are most likely low in lignin. The cyanide content of the local varieties of cassava peels are not high but if there is the need to reduce it further, this can be achieved by fermenting the material before drying (Osei and Duodu, 1988). The crude protein contents of these peels, apart from cassava, are high and compare with that of tropical grasses (8% for grass hay, Akinsoyinu and Adeloye, 1987).

Poultry manure has to be dried before it can be stored for any appreciable length of time. When using poultry manure, copper toxicity and urinary calculi (in males) may occur. On the University of Science and Technology livestock farm, however, even layer manure has been fed to sheep for about seven months without any problems. The Djallonke breed of sheep may not be very sensitive to these disorders.

Corncob has low *in vitro* dry-matter digestibility but it responds to alkali treatment. It is bulked in the villages after shelling of corn.

Feed intake, performance and feed costs of production using some agro-industrial by-products and grass in sheep diets in Ghana.

Tables 2 and 3 contain feed intake, performance and feed costs of production of animals fed various diets containing some agro-industrial by-products, maize and dried grass. These trials were conducted on the livestock farm of the Department of Animal Science, University of Science and Technology (UST) Kumasi, Ghana.

In experiment 1 (Table 3) the costs of kilogram gain were ¢870.25 and ¢512.05 for diets containing 60% and 45% cocoapod husk respectively. For the diet containing 66% dried grass the cost per kilogram gain was ¢942.48.

In experiment 2 (Table 3) the cost per kilogram gain ranged from ¢437.12 to ¢555.34. There was no maize in any of the diets and the rations were formulated to contain mainly agricultural by-products.

These figures demonstrate clearly the advantages agricultural by-products have over dried grass. In fact in the city of Accra, 1kg DM of cut grass costs ¢133.3. If feed conversion efficiency (FCE) is about 20kg feed/kg gain as was for the diet containing 66% dried grass (Table 2) then the cost per kilogram gain would be ¢2666.6. If FCE is about 10kg feed/kg gain then the cost per kilogram gain would be ¢1333.3.

The FCE is however, most likely more than 10kg feed/kg gain. It is at least about 15kg feed/kg gain and the cost of kg gain would be ¢1999.5. Akinsoyinu and Adeloye (1987) in Nigeria obtained a FCE value of 14.61kg feed/kg when they fed a diet consisting of 66.6% grass hay and 26.6% maize to Djallonke sheep. If diets based mainly on agricultural by-products are cheaper than cut grass (which people buy in large quantities in Accra) why are agricultural by-products not being used in diets for sheep in the urban areas? The market exists for the sale of these feeds.

Problems associated with the utilisation of agricultural by-products in sheep diets in Ghana

Apart from the nutritional problems discussed earlier when discussing the types of agricultural by-products available in the country, there are other problems. The first of these is perhaps the lack of interest on the part of feedmillers to produce sheep diets as most of the by-products are not found in the cities where the commercial feedmills are located.

The cereal straws, apart from rice, are scattered on the farms after harvesting the grains. They have to be bulked and transported to the villages and stores. There are no machines in the villages to process those straws for incorporation in diets for ruminants. There are no sources of non-protein nitrogen to be added to the straws as all the poultry farms in the country are located near the big towns and cities and no urea is imported. Cocoa pod husk, as indicated earlier, ought to be dried quickly to retain its digestible carbohydrates and it is found on the cocoa farms where animals are not allowed for fear of damage to trees and fruits. Transporting the fresh husk to the villages for drying is almost impossible.

US$1 = Cedi 250 (but fluctuates); ₵ = Cedi

Table 2: Ration composition, growth rates, cost per kg feed (as is basis), feed conversion efficiency (F.C.E) and cost per kg gain of animals fed diets containing different levels of cocoa pod husk and dried grass.

Ingredients	1	2	3	4	5
Cocoapod husk	-	15.0	30.0	45.0	60.0
Dried grass (<u>Panicum</u> <u>maximum</u>)	66.0	49.25	33.25	20.0	6.0
Corn	7.25	14.0	19.0	21.25	25.25
Dried brewers-spent grains	25.0	20.0	16.0	12.0	7.0
Bone meal	1.0	1.0	1.0	1.0	1.0
Sodium chloride	0.5	9.5	0.5	0.5	0.5
Trace mineral-vitamin premix	0.25	0.25	0.25	0.25	0.25
Cost/kg of feed (Cedis*, as-is basis)	39.60	38.88	37.72	36.29	35.29
Daily gain in weight (g)	22.42	35.51	43.55	46.65	20.72
Cost/kg gain (cedis)	942.48	654.35	574.85	512.05	870.25
Kg feed/kg gain (F.C.E as-is basis)	23.80	16.83	15.24	14.11	24.66

* 232 Cedis = 1 US$

Table 3: Ration composition, growth rates, cost per kg feed (as-in basis), feed conversion efficiency (F.C.E) and cost per kg gain of animals fed diets containing different levels of cocoa pod husk and sodium hydroxide-treated corncob.

Ingrediets	Diets 1	2	3	4	5
Cocoapod husk	-	20.0	40.0	60.0	80.0
Sodium hydroxide treated corn cob (10%)	65.4	49.4	32.0	16.0	-
Sun-dried poultry manure	19.0	15.0	12.4	8.0	3.4
Wheat bran	15.0	15.0	15.0	15.0	15.0
Common salt	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	-	-	-	0.4	1.0
Trace mineral-vitamin premix	0.1	0.1	0.1	0.1	0.1
Cost/kg of feed (as-is basis; cedis)	31.34	29.94	28.05	26.88	25.81
Daily gain in weight (g)	31.15	45.21	40.69	28.98	26.70
Kg feed/kg gain (F.C.E. as-is basis)	17.72	14.60	16.56	19.71	20.25
Cost/kg gain (cedis)	555.34	437.12	464.51	529.80	522.65

Suggested solutions

Villages: In the southern parts of the country especially in the forest belt the dry season is not very severe and animals rarely lose weight. Sheep and goats are also allowed to graze freely in the villages and they are not kept intensively. They are housed only in the night.

The farms where crops are grown are also far away from the villages and the people keep animals only as a "hobby" as they are basically food and cash crop farmers. They are not motivated to spend time and money on these animals as they are not their main sources of income. They may therefore not be interested in transporting agricultural by-products from their farms to feed animals but they may be interested in transporting them to the villages for sale. It is suggested that the animals are fed with fresh peels of cassava, yams, cocoyam and plantains every morning before the animals are allowed to go out to graze or in the evenings when they are brought into their barns for the night.

These people eat these foodstuffs every day and there will be no problem obtaining the peels. Where a neighbour has no animals, his/her peels could be collected by another fellow for feeding to his/her animals.

In the northern parts of the country the dry season is more severe and lasts a longer period of time than in the forest belt. The people also have great interest in raising animals as the animals contribute greatly to their incomes. Their farms are also not very far away from the villages. The farmers could be motivated to feed agricultural by-products from their own farms but will not be prepared to buy feeds from commercial feedmillers. They will be prepared to transport the straws to the villages.

The straws could be treated with wood ash solutions to improve their nutritional value. The use of green crops as supplements could be undertaken if drought-tolerant leguminous trees and shrubs such as _Acacia_ _sp_. are planted.

It may also be necessary to provide simple machines (similar to corn mills found in some villages in the country) for shredding straws before feeding to animals. Legume straws which have higher nitrogen contents than cereal straws should be incorporated in the diets.

The Extension Services Department of the Ministry of Agriculture should be strengthened to advise farmers on the proper treatments and feeding of straws and other agricultural by-products.

Cities

In the cities, peels of cassava, plantain, cocoyam and yams could be bought from the chop bars and the garri factories by commercial feedmills. These have to be washed to reduce soil contamination before drying in the sun. They would then be ground and incorporated in diets. Poultry manure could be collected from the poultry farms, sun-dried and later used. Dried cocoapod husk could be bought from the large estate cocoa plantations and also from small-scale cocoa farmers. Cereal and legume straws, and corncobs could be bought from large scale farmers and also from small-scale farmers if they are willing to transport them to the villages. Already, rice straw is baled by some large-scale farmers for sale. These cereal straws and corncobs could be treated with wood-ash solutions and dried. The formulations of the diets, should be based on results of experiments conducted in the research institutions.

Dried brewers-spent grains, wheat bran, maize bran and rice bran could be bought to be used in the diets.

Feeds prepared with these ingredients could then be sold to backyard farmers in the urban areas.

There is also the need to improve the performance of sheep kept in the backyards in the urban areas. The local breed, the Djallonke, has a very slow growth rate (about 20-50g/day). Under village conditions, since no expenditure is incurred in their feeding, this slow growth rate may not pose a great problem. In the urban areas since people are going to invest in housing and feeds, it is necessary to increase the productivity of the animals. If a crossbreeding programme is to be instituted, then the breed selected should have the good attributes which the Djallonke has (high fertility, high prolificacy, and big gut size) in addition to having fast growth rate and high feed conversion efficiency.

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DISSEMINATION AND UTILISATION OF RESEARCH TECHNOLOGY ON FORAGES AND AGRICULTURAL BY-PRODUCTS IN KENYA

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ABSTRACT

Agricultural research is an essential service to the livestock industry in Kenya. This is seen in the planning, execution of research programmes and in the promotion and adoption of research results and recommendations. Effective research on forages and agricultural by-products can only be measured in terms of its contribution to the solution of problems faced in the national development. Research should start with identification of farmer's problems and opportunities, develop and test appropriate technologies under farmer's conditions and conclude with solutions that would enable farmers to increase their income.

Generation, dissemination and utilisation of appropriate technology depend on interdisciplinary team approach, organised into an interacting and cohesive group involving researchers, extension workers and farmers. There is need for strong research-extension-farmer linkages in order to develop and test suitable and adaptable technology that will increase production. A lot of pasture and agricultural by-products research has been carried in Kenya for many years and substantial amount of results and technologies developed and recommended to farmers. Not all these research results and technologies have been adopted by Kenyan farmers.

This paper will attempt to look at the past and present research and extension service organisation, their linkages and the efforts made by these agricultural services in the dissemination and adoption of the vast wealth of research technologies available in Kenya. The paper will also discuss an on-farm research approach as an effective means of dissemination, utilisation and adoption of research technology.

INTRODUCTION

Kenya is an agricultural country because more than 80% of the population depend on Agriculture and Livestock production for subsistence, employment, income and other basic needs. With the present annual human population growth of 3.8 - 4.0% , it has been estimated that annual production increase of 5.5 and 8.8% for meat and milk respectively are needed in order to maintain the present per capita consumption for these products at least through 1990 (Ministry of Livestock Development, 1980). All experts, whether agronomists or economists, agree that increased agricultural and livestock production remain the principal and indispensable way of responding to the challenge of the rapidly growing human population.

The main objective of Kenya's Livestock Development Policy is to intensify livestock production in order to:

a) Provide sufficient animal protein for adequate nutrition for the people and the surplus for export.
b) Alleviate poverty through creation of income generating employments at all stages of livestock production and
c) Increase production of the necessary raw materials of livestock products for the agro-industries.

With the rapidly growing human population, arable land has undergone drastic sub-divisions and fragmentation and is now very limited in highly populated areas. It is evident that increased livestock production can only be envisaged as a result of growth in return from land already under cultivation rather than bring more new land under cultivation. In fact, it has been estimated that the present land under pastures and animal production in high potential areas will decrease at a rate of 3.2% per annum due to more land being taken under subsistence crop farming.

Livestock research therefore aims at searching for more productive and high-yielding forage crops, utilising of agricultural by-products, developing appropriate technologies for efficient utilisation of these products for increased livestock production. The immediate goal of forage and livestock research is to stimulate production under given farmers' situations.

Livestock research and extension services are the two most important services necessary in technology development and dissemination of research results to farmers for increased livestock production. The extension services provide not only the technical information and skills, but also co-ordinate complementary services like input supply, credit and marketing - all required to remove various production constraints to the improved utilisation of farmer's resources. Kenya government is strongly committed to improving and strengthening both the agricultural research and extension services so that better production technologies can be developed, disseminated and utilised by farmers. The Government is also committed to improving other important complementary services necessary for the adoption of the developed technologies (Republic of Kenya, 1981; 1986).

RESEARCH TECHNOLOGY GENERATION

The agricultural sector of Kenya is normally divided into three sub-sectors; small-scale, large-scale, and pastoralists. Most small-scale and large-scale producers are located in the medium and high potential agricultural land occupying approximately 18% of Kenya's land surface. Pastoralists and nomads occupy the arid and semi-arid range areas which cover about 80% of land surface (Senga, 1976).

Although pasture research work in Kenya started way back in 1908, it was not until 1940 that systematic research started when Edwards recognised the need and subsequently defined the major ecological zones of Kenya and suggested that pasture research be carried out in a series of stations covering the major zones where 90% of the population lived (Edwards, 1940). The past and current trend of pasture research work has been discussed (Said, 1985). Prior to Independence, technologies were mainly developed to address problems of large settler farmers following subdivision and fragmentation of some of the large-scale farms. Consequently, research need for the small-scale intensive farmer was quite different from that under the extensive production system that was and is still being practiced to some extent i.e. large hectarages, mechanical operations, hay-pasture farming, large amounts of farm residues, fodder conservation practice, access to information and finance.

In response to the changes in the farming systems and the need to re-direct the country's livestock production to be more responsive to the needs of specific farmers, research work has been carried out in various Research Centres (Said, 1985) and various technologies and recommendations formulated for farmers. Past research achievements have been discussed and some of the publications stemming from the work have been given by Orodho (1983). A lot of research results and technologies have been produced in the form of recommendations (National Agricultural Research Station, 1976; 1984; Orodho, 1983). These have followed systematic research work on:

a) Forage collection and evaluation aimed at collecting in Kenya and introducing from other countries a wide range of important plant ecotypes of potentially useful pasture and fodder species and evaluating these collections and introductions with reference to their usefulness in our Kenyan Pasture Development Programme. The performance of some of these materials have been compared in similar ecological zones of Kenya and Ethiopia (Ibrahim and Orodho, 1981).
b) Forage breeding aimed at developing through selection and breeding the most suitable forage materials identified during the forage collection and evaluation for various ecological zones and livestock farming systems.
c) Forage agronomy aimed at determining the most appropriate cultural practices such as forage establishment (seed-bed preparation, time of planting, method of planting, spacing, seeding rates), forage management (weed control, fertilizer requirements and rates, time and frequency of harvesting/grazing, cutting heights) and forage conservation (silage making, hay making and standing hay).
d) Animal production aimed at measuring and assessing the forages, farm by-products, crop residues and other wastes in terms of animal production parameters and

e) Range management aimed at developing appropriate range management practices (bush control, re-seeding of denuded areas, grazing management, stocking rates) and the improvement of suitable livestock (cattle, sheep, goats, camels) through proper livestock management practices and breeding/selection.

DISSEMINATION OF RESEARCH RESULTS

One of the principal objectives of the Ministries of Agriculture and Livestock Development is to promote agricultural production through provision of extension services. In 1980 the Ministry of Agriculture alone had more than 5,000 employees distributed at National, Provincial, District and Divisional levels as well as a vast representation in the rural areas up to sub-locational and village levels (Ministry of Agriculture, 1980).

Effective dissemination of relevant forage research results depends on many factors. It is often difficult to clearly understand the causes for either success or failure in the adoption of technology. Failure in adoption of forage research results by farmers may be as a result of an inappropriate technology being imposed on the farmers before the technology has been properly tested and tailored to the need of the farmers. Poor adoption of the forage results may also result from either the farmers' own socio-economic constraints or from the fault of the extension service. The latter is defined in terms of insufficient staff, inadequate trained staff, wrong sociological approach, lack of transport facilities, inadequate use of media or the issuing of wrong advice to farmers.

Gap Between Research and Extension

In many countries there has been continuous reference to insufficient liaison and consultations between research and extension services and the inadequate communication among extension officers and their front-line workers. Researchers have always argued that their advisory reports and recommendations were ignored, often left to gather dust in piles or bookshelves in Provincial and District Offices seldom reaching the front-line staff who are in actual contact with the farmers. Researchers complain that extension staff rarely visit research stations on their own initiative to obtain any useful research results or to report any adoption problems with farmers.

On the other hand, extension officers in many countries, argue that research reports are too technical and not presented in a form that can be readily absorbed by extension officers or farmers and that researchers did not go out often enough to the field to examine farmers' problems. Some extension officers complain that research is not often tailored to solve the needs of the farmers. One fundamental problem is substantial gap in terms of professional qualification and status between researchers and extension staff. The gap considered may not only be between research and extension but also between Agricultural Officers, whether research or extension, and the technical field level staff.

Dissemination Methods

Kenya Government is aware that utilisation of research results will depend to a considerable extent on their proper dissemination to farmers. Programmes to improve extension services which include, among others, provision of additional transport facilities and training of extension staff are being implemented by both the Ministries of Agriculture and Livestock Development. There are a number of ways that are being used to make the flow of information to the field staff more effective.

Orodho (1983) discussed various methods currently being used in disseminating pasture research findings to farmers in addition to the normal extension methods. These methods include tours, field-days, demonstrations, pre-extension trials, fodder bulking sites, visits to Research Centres, correspondences with farmers, public media, lectures, seminars, scientific papers, farmers' publications, agricultural shows and Provincial Research Advisory Committees. Most of these methods involve research, extension, farmers and other complementary services working together. Some of these methods of research results dissemination have weaknesses for they are dependent on the initiative of individuals but are not built up into works programme as regular procedure.

Linkages

Effective agricultural research can only be measured in terms of its contribution to solutions of the farmer and to the National Development problems. It is not enough to do research, obtain results and develop technology, the research results and technology developed must rapidly be transferred to farmers' fields and be adopted. There is therefore, need not only for effective Research-Extension-Farmer linkages, but also linkages with all those complementary services which play a role in the farmers' adoption of the developed technology as illustrated in Figure 1. For technology development there is need for strong linkages between Research, Extension and Farmer as illustrated by the bold lines on the diagram. However, for technology adoption, linkages should have been made with all the other important complementary services as illustrated by the dotted lines. Important complementary services that Research - Extension - Farmers should have linkages with during livestock technology development are:

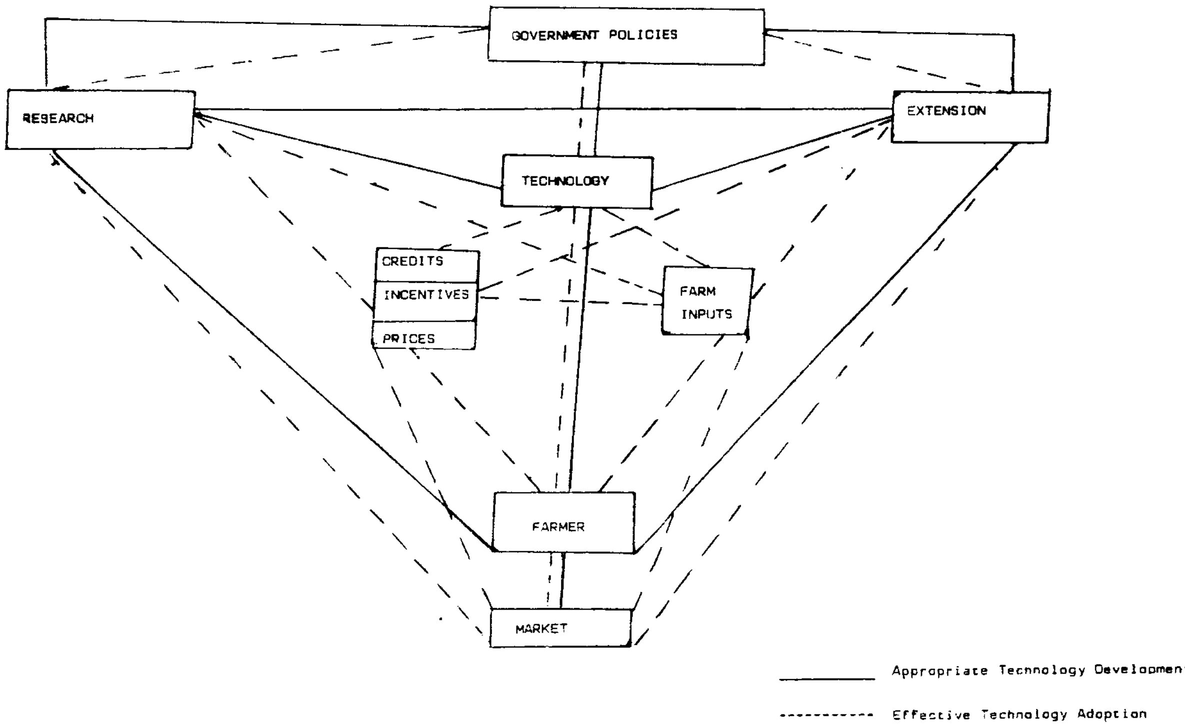
a) The input supplies such as Kenya Seed Company, Kenya Grain Growers' Co-operative Union (KGGCU).

b) The commodity Boards and Marketing agencies such as the National Cereals and Produce Board (NCPB), the Kenya Co-operative Creameries (KCC) and the Kenya Meat Commission (KMC).

c) Financial and credit organisation such as the Agricultural Finance Corporation, Commercial Banks, and

d) Price control services such as the committees that determine appropriate prices and/or give incentives to farmers and the bodies such as the Kenya Bureau of Standards that regulate quality of chemicals and livestock feeds.

Figure 1. Necessary linkage for effective technology development and adoption



Effective linkages between research, extension, farmer and other complementary services such as input supplies, credit organisations will ensure that the inputs recommended for increased livestock production will be available and will be supplied in areas where farmers can obtain them on time and that the financial organisations will be aware of the farmers' financial requirements ahead of time. Such effective linkages will enhance proper planning and facilitate research results and technology adoption.

The need for liaison is less clearly established for marketing agencies concerned with animal products. The Review Committee on Pasture, Seed and Fodder Development (Ministry of Agriculture, 1983) recommended that agencies like KCC, KMC, Kenya Seed Company should take an active role in supporting, morally and financially, pasture and fodder crop research activities and extension services since these agencies benefit directly from products of those crops.

UTILISATION OF FORAGES AND FARM BY-PRODUCTS BY SMALL-SCALE FARMERS

Due to the declining farm sizes in Kenya, there has been a rapid move towards zero-grazing system of livestock management and thus high-yielding fodder crops such as Napier grass and farm by-products have inevitably become more popular with farmers. Stotz (1983) noted that crop residues consisting mainly of maize and bean stover provided an average of 35 - 45% of the total livestock feed requirements. The contribution of farm by-products to feeding cattle depends on farm size: the smaller the farm the larger the proportion of feed drawn from the crop residues compared to forages (Sands et al, 1982). These farm by-products are generally used throughout the year although their use tends to increase during dry periods. Following a survey of 18 districts in Kenya, Goldson (1977) gave a list of 21 different farm by-products that are commonly used by small-scale farmers (Appendix 1).

Napier grass (Pennisetum purpureum) is a tall productive perennial fodder grass that occurs naturally from sea level to over 2,000 metre altitude. It has high production /ha in both dry-matter and total digestible nutrients and is relatively drought tolerant. A number of high-yielding cultivars have been developed. With recommended management practices, Napier grass can provide continued supply of green herbage throughout the year and can act as a supplement feed during the dry months of the year. It fits well in intensive small-scale farming systems.

Apart from Napier grass, many other forages (Table 1) have been evaluated and found promising for various livestock production systems. From research results, recommendations have been made for these forages to be grown in the various ecological zones of Kenya. Williams (1970) pointed out that "if we are producing a great deal of unusable research, it means that we are choosing the wrong problems. If we are producing a great deal of usable but unused research, this means that we are researching beyond the absorptive capacity of the industry."

ADOPTION OF RESEARCH RESULTS ON NAPIER GRASS

Because of the importance of Napier grass in the small-scale livestock farming enterprise, the Pasture Research Specialist Committee Meeting held at the National Agricultural Research Centre, Kitale in 1980, set up a Napier grass Review Committee comprising of the author and five other research officers. The Review Committee was to tour various parts of the country to determine whether research results and technology related to Napier grass establishment, management and utilisation are being followed by the small-scale farmers.

The committee developed two sets of questionnaires - one for the farmer and the other for the extension officers and undertook an extensive tour of 14 districts in 6 provinces of Kenya (Appendix 2). During the tour which took 18 days, over 50 farms were visited and detailed discussions held with each farmer or farm manager. Discussions were also held with about 60 Government Extension Officers at the provincial, district and sub-divisional levels. The discussions held and questionnaires filled were mainly centred on:

a) Whether farmers knew and followed research recommendations and if not, what were the main reasons for not doing so.
b) What further research was felt necessary on Napier grass establishment, management and utilisation.
c) What constraints prevented Napier grass development in the area.

Although this was a Napier grass review mission, some very useful information was gathered on the use of other forage and farm by-products (Kusewa et al, 1983). The Napier Grass Review Committee confirmed that Napier grass was one of the most important fodder crops used by small-scale farmers in the country. It was noted that although many farmers are following some of the research recommendations on Napier grass establishment, management and utilisation, there were some farmers who reported lack of awareness of research results and technology on this important grass. A number of constraints were reported as hindering Napier grass development and adoption of research results as shown in Figure 2. Some of the most important constraints given were:

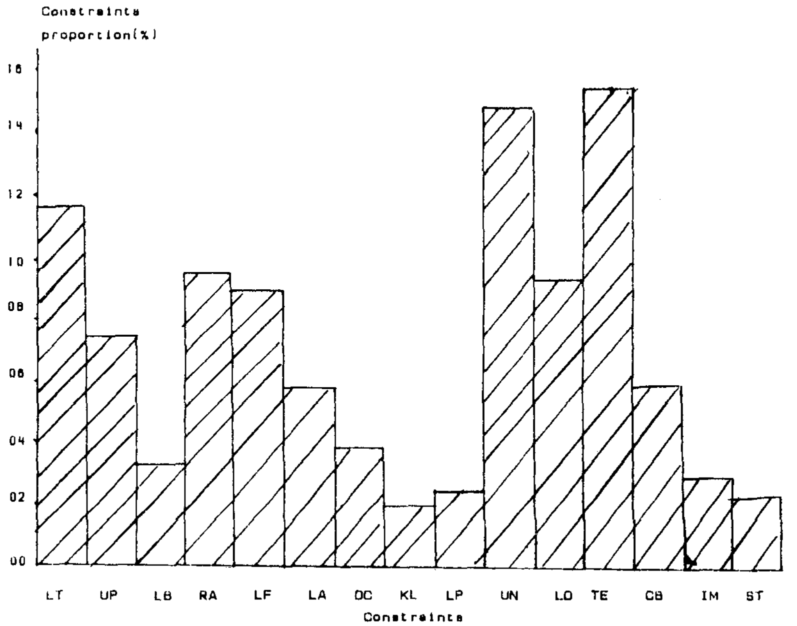
a) Lack of adequate extension staff to reach more farmers
b) Lack of farmer's awareness of the importance of Napier grass use
c) Lack of adequate transport for extension staff
d) Reluctance on the part of farmers to accept and adopt research recommendations.
e) Lack of finance by farmers
d) Unavailability of planting materials

It was also noted that a few extension officers were not aware of the availability of research results and recommendations on Napier grass to be extended to farmers. This indicated some break-down in communication or inadequate linkage either between research and extension service or between the agricultural officers and the field level extension staff.

Table 1: Some of the promising grasses and legumes collected for various ecological zones of Kenya.

GRASSES	LEGUMES	FODDER GRASSES	FODDER GRASSES
Brachiaria brizantha	Clitoria ternatea	Avena sativa	Atriplex spp.
Cenchrus ciliaris	Centrosema pubescence	(Oats Cv. Suregrain & Lampton)	Dolichos Lablab
Chloris gayana	Desmodium uncinatum	Pennisetum purpureum	
(cv Boma, Elmba, Masaba,	(Silver leaf desmodium)	(cv Bana, Clone 13, French	
Mbarara & Pokot Rhodes)		Cameroon, Uganda hairless	Leucaena leucocephala
Chloris roxburghiana		P. purpureum x P. typhoides	Lupinus spp
Cynodon plestostachyus	Desmodium intortum	Panicum maximum	Prosopis spp.
	(Green leaf Desmodium)	(Giant panicum)	
Cynodon dactylon	Lotononis bainesii	Setaria splendida	Acacia spp.
		(Giant Setaria)	
Dactylis glomerata	Macroptilium atropureum	Sorghum sudanense	
	(Stylo)	(Sudan grass)	
Eragrostis superba	Medicago sativa	Ipomea batata	
	(Lucern Hunter river)	(Sweet Potatoes)	
Enteropogon macrostachyus	Neonotonia wightii		
	(Glycine)		
Festuca arundinacea	Phaseolus atropurpureus	Tripsacum laxum	
	(Siratro)	(Guatamala grass)	
Lolium perenne	Stylosanthes guyanensis		
Panicum coloratum	Stylosanthes gracilis	Gana edulis	
		(Edible cana)	
Panicum maximum	Stylosanthes scabra	Symphytum paregrium	
		(Russiana Confrey)	
Pennisetum clandestinum	Trifolium semipilosum		
	(Kenya millet clover)	Zea mays (all types of maize)	
Phalaris tuberosa			
Setaria ancepts			
(cv Nandi & Nasiwa setaria)			

Figure 2. Constraints to Napier grass adoption and development efforts as reported by extension staff and farmers.



Key:

LT - Lack of transport for Ext. staff
UP - Unavailability of planting material
LB - Lack of improved breeds of livestock
RA - Reluctance to accept new ideas by farmers
LF - Lack of Finance by farmers
LA - Lack of land adjudication/communial grazing system
DC - Dry condition for the Napier variety
KL - Keeping local Zebus discourage Napier growing
LP - Lack of proper co-ordinated programmes on fodder development
UN - Unawareness on Napier use
LD - Long distance travelled to get Napier inhibit spread
TE - Thin extension staff on ground
IM - Insufficient milk marketing channels
ST - Stocking rate low

Farmers also indicated that long distance travelled to get the vegetatively propagated Napier grass planting material inhibited spread of this fodder crop. Most farmers had obtained their planting materials from either Government Farmer's Training Centres, their neighbours or from Government Research Stations as shown in Figure 3.

From the time this Napier grass review mission was carried out to-date, the Ministry of Livestock Development has made numerous efforts to develop and extend fodder crops to small-scale livestock farmers in the country. A fodder bulking project was started which multiplied a lot of fodder crops in the country at sites within easy reach of farmers. Many farmers have benefited from the planting materials bulked at those sites. A United Nations Development Programme (UNDP/FAO project) was started in 1980 to develop promising forage materials and extend these to farmers through pre-extension trials (FAO, 1985). This project was extended in 1984 with an objective of promoting the use of improved fodder and pasture crops to small-scale farmers (Ibrahim, 1988). A National Dairy Development Project which started in 1980 is now covering 14 districts in Kenya, extending the zero-grazing package to the small-scale farmers.

Inadequate extension services is one of the many obstacles to increase livestock production that the Ministry of Livestock Development is aware of and is planning to overcome (Ministry of Livestock Development, 1985). The Ministry is steadily improving and expanding its livestock extension activities and staff especially those related to demonstrations that improve farmer's management practices and awareness of livestock production technologies.

The Napier grass review mission observed that some farmers were reluctant to adopt research results and recommendations. Other farmers tended to modify these recommendations to suit their farming situations and circumstances. This indicated that there is need to evaluate research recommendations under those farmers conditions and ultimately come up with appropriate domains tailored to the farmers' conditions. An on-farm research as an effective means of dissemination, utilisation and adoption of research technology is discussed below.

TECHNOLOGY DEVELOPMENT AND ADOPTION THROUGH ON-FARM TRIALS

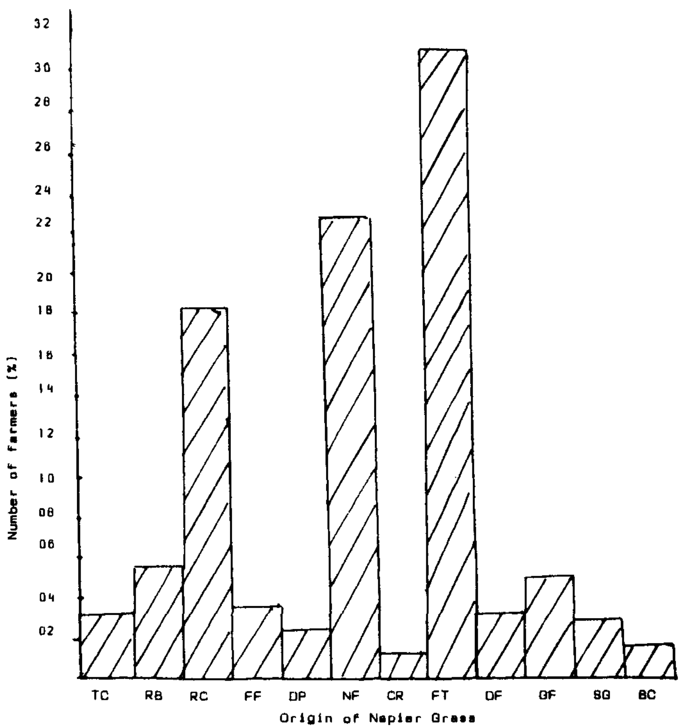
On-farm biological research is one of the main tools in the farming systems approach to develop appropriate technology for the small-scale limited resource farms. An on-farm team basically composed of a socio-economist, forage agronomist, animal production specialist and extension officer identifies farmer's problems through diagonistic surveys, priorities these problems and then brings them back to the research centres for experimentation and technology development.

In order for the researcher to properly evaluate the technology he is developing, it is necessary for the trials to be conducted under the real condition of the small-scale livestock farmer for whom the technology is being developed. This provides opportunity for the researcher to fully understand the conditions under which the farmer is operating and the extension officers and farmer to actively participate in the forage evaluation process.

Technology frequently responds differently to environment. Most small-scale limited resource farmers, however, are not able to apply inputs required to achieve maximum forage production similar to those in Research Centres.

Because response to livestock technology can be different in those less optimal conditions of poor environment found in farms, it is essential to evaluate technology under these conditions. By evaluating the technology both in the station and under various farmers' environments, the technology is subjected to all the good and bad that the farmers are going to give it if they adopted it.

Figure 3. Origin of Napiergrass planting materials as reported by farmers in various parts of the country.



Key:

TC	-	Teachers' training colleges	CR	-	Cooperative ranches
RB	-	River banks	FT	-	Farmers' training centres
RC	-	Research centres	DF	-	Distant farmers
FF	-	Farmers' own farms	GF	-	Govt. farms
DP	-	Demonstration plots	SG	-	Show grounds
NF	-	Neighbours' farms	BC	-	Bulking centres

The environment in which farmers produce forage crops is the result of all factors that affect livestock production so that livestock farmers are usually associated with each environment. Other factors such as capital and labour also influence the kind of environment under which forage crops are being produced. Management which is responsible for allocating all the resources to different enterprises in the farm is ultimately the most important determinant of the crop environment.

In order to begin evaluating the influence of farmer management on technology, farmers must be given an opportunity to participate actively even in research managed trials. In order to evaluate the economic factors on the technology, large plots must be used. This means only a few treatments are included in the trials and usually there are no replications.

CONCLUSION

For many years, the Kenya Government has had sound livestock development policies which have encouraged the development and utilisation of forages and agricultural by-products. A lot of forage research work has been done in various research centres and recommendations formulated for farmers. Most of the research results on forage have been utilised by farmers to increase livestock production in the country. There have been cases, however, where not all research results and recommendations on forages have been adopted.

Generation and adoption of appropriate technology depends on an interdisciplinary team and approach organised into an interacting and cohesive group involving researchers, extension staff, farmers and other complementary services that affect the technology adoption. An on-farm research approach is an effective method that will enhance testing and adoption of forage research results and technology because it incorporates both the farmer and the extension staff actively in the research evaluation processes and the researcher can participate actively in extension activities. Because on-farm testing utilises a wide range of farm environment, the feedback from the farmer is immediate and the proper understanding of the technology aids in the participating of clientele into most appropriate recommendation domains for the benefit of the technology adoption by farmers.

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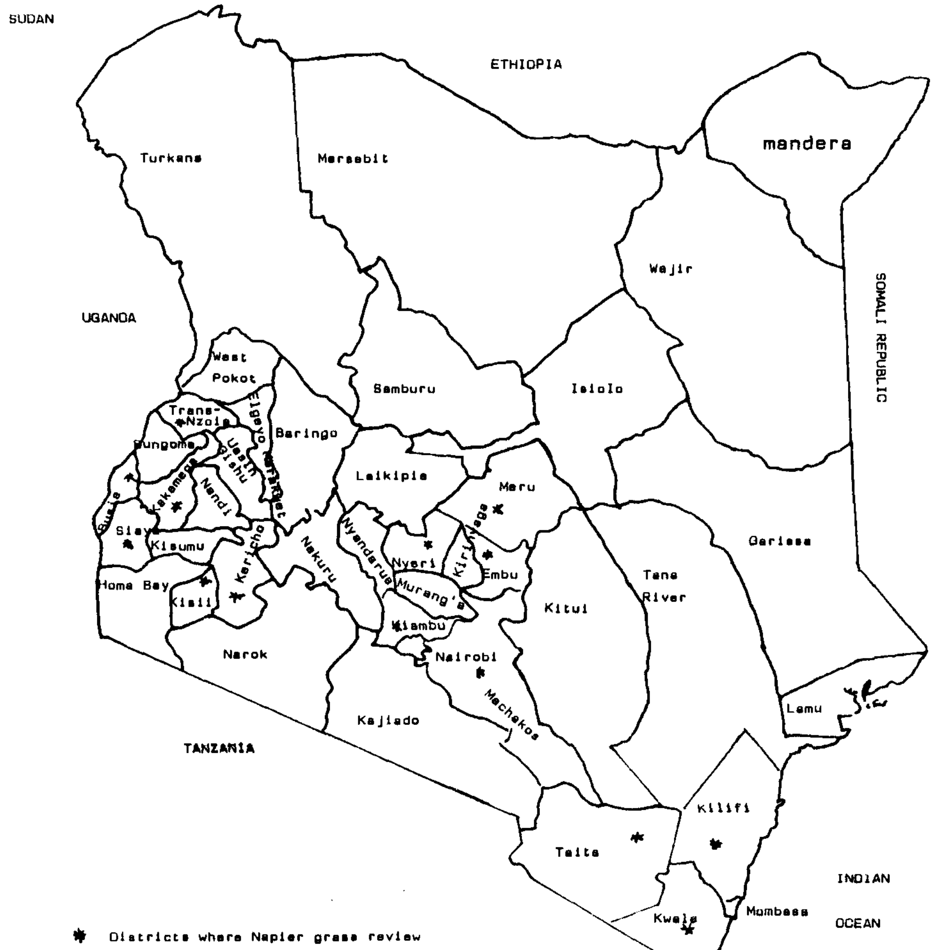
Appendix 1. Farm by-products used by small-scale farmers.

By-products used	% of districts in which by-products were used
Crushed maize grain (rejects)	88.8
Green maize stalk	83.3
Potato vines	77.8
Maize stover	72.2
Brewers waste _(Machicha)_	66.7
Banana stems and leaves	61.1
Vegetable waste	55.6
Bean and soyabean hulls	50.0
Sunflower heads and seeds	50.0
Sugarcane tops	22.2
Pineapple waste	16.7
Sisal-leaf waste	11.1
Cowpea waste	11.1
Pigeon pea waste	11.1
Coconut cake	5.6
Coffee husks	5.5
Cotton-seed cake	5.5
Simsim cake	5.5
Cassava peels	5.6
Millet stover	5.5
Chick pea	5.5

Source: Goldson (1977)

Appendix 2: Administrative district boundaries of Kenya.



* Districts where Napier grass review mission toured farms and held discussions with farmers and extension staff

EXPERIENCE IN THE UTILISATION OF FORAGES AND AGRO BY-PRODUCTS AS INTERVENTIONS IN SMALLHOLDER LIVESTOCK PRODUCTION SYSTEMS

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ABSTRACT

Means were calculated on the weight gains of Malawi zebu steers stall-fed for beef. These steers were fattened using groundnut haulms, maize stover and maize bran. The mean stall-feeding period in Lilongwe Agricultural Development Division was 135 days and the average total weight gain was 62.1 kg. Steers in the Kasungu Agricultural Development Division were fed for 150 days and gained 92.6 kg. In each case gain was seen to be influenced by period of feeding and quality of feed though there was no statistical analysis of the data.

The means for lactation length and lactation yields were determined by simple division for the dairy cows in the Blantyre and Mzuzu Milk Shed Areas. The average lactation length was 313 days and 2288.6 kg. as the average lactation yield. Lactation length was seen to increase with breed. Milk yields were substantially increasing with breed and decreased with the 7/8 crossbreed.

It was found that besides this level of performance adoption of technology by farmers was affected by unqualified extension services, high cost of inputs and low product prices which were not reviewed at frequent intervals. Increased economic security, high social status within the farmers and increased employment opportunities were singled as obvious impacts of dairy farming which are managed based on research recommendations.

INTRODUCTION

The Republic of Malawi is a landlocked country. It lies south of the Equator between latitudes 9° 30'S and 17°S and longitudes

$33^{o}E$ and $36^{o}E$. The climate is subtropical. Rainfall is unimodal occurring between November and April. The rainy season is followed by a long dry season from May to October. The average annual rainfall ranges from 750 mm in the drier parts of the country to 1000 mm in the wetter parts.

The total land area is 119,140 sq. km, 20 percent of which is under water in the form of lakes. The total population is 7.5 million (1987 population census).

The country has a basically agricultural economy. The largest proportion of foreign exchange is earned from the agricultural industry. It is estimated that over 85 percent of the population live in the rural areas and depend on small-scale agricultural production. Average size of holdings varies from region to region and is 1.72, 1.81 and 1.96 ha in the South, central and North regions respectively. The cattle population is estimated at 838,471 (Dep. of Animal Health and Industry, unpublished).

The following economic key indicators confirm the important role of the agricultural industry to the economy of the country (Econ. and Planning Dir., 1987).

1. Agricultural contribution to GDP - 38%

2. Labour force in Agriculture - 85%

3. Agriculture contribution to foreign exchange - 30%

4. Livestock contribution to the overall agricultural GDP - 8%

The Agricultural sector in Malawi is divided into two divisions. The smallholder (subsistence) sector grows crops maize, rice, beans, groundnuts, cassava, sweet potatoes, and pulses and keeps over 95 percent of the livestock. The estate or commercial sector grows tea, tobacco, tung, coffee and sugar. In both sectors there is adequate production of crop residues and other agricultural by-products.

THE LIVESTOCK INDUSTRY

This paper outlines the practical experiences in the utilisation of forages and by-products in the two popular livestock production systems of dairy and beef stall-fattening. It also discusses the potentials of forages and crop by-products as alternative forms of profitable land use through animal production.

Stall feeding

The beef cattle fattening programme started in 1957. It has since met with considerable success and has gained acceptance by smallholder farmers in most parts of the country. The purpose of the scheme is to produce top grade beef for the domestic market with consequent sparing of foreign exchange. Additionally the financial benefits that accrue to the farmer enables him to purchase inputs to intensify crop production. An additional benefit is in the production of manure which plays an important role in the maintenance of soil fertility and hence increases crop yields. The management system is based on resource available to the farmer and fattening is mostly done soon after crop harvest.

Dairying

Rural dairying as a sideline of traditional and extensive cattle keeping has been practiced in Malawi for a long time. Real dairying originated with estate crop farmers before independence in 1964. These farmers kept mainly Jersey, Ayrshire and Friesian Cattle. Milk produced was used at the estates and in nearby communities. Smallholder dairying is now a little over 1.5 decades old from the time it was initiated by the Food and Agricultural Organisation (FAO/UNDP) in 1971. At the moment there are 1156 smallholder farms established. The management system is based on the cultivated forage crops of Napier grass (Pennisetum purpureum) and in some cases complemented with Rhodes grass (Chloris gayana) while for concentrate feeds these are procured from commercial feed companies that use ingredients of agro-industrial by-products, and to some extent, locally mixed rations from maize bran, cottonseed cake or dried Leucaena-leaf meal.

This paper focusses the discussions on stall-feeding in the Central Region where maximum use is made of crop residues of groundnut haulms, maize stover and maize bran and the smallholder dairy farming in the Blantyre and Mzuzu Milk shed Areas where Napier grass is a cultivated fodder crop and very localised use is made of crop residues due to the limited crop production activities in the areas.

METHODS AND MATERIALS

The programme of beef cattle fattening commonly known as stall-feeding and small-holder dairy farming exist in the four and five of the 8 national Agricultural Development Divisions respectively. For the purpose of this paper the following criteria were used in choosing the source of data:

i) Information available on the feed resources utilised
ii) The feeding system which should exclusively be based on any one of the two feed resources; forages with no crop residues and the latter without the former
iii) Cows that completed one year lactation under the small-holder milk recording scheme

The data set used in this paper though small could be taken to represent a complete set of all data that were recorded from both the smallholder dairy and stall-feeding programmes.

Stall-feeding

Records for individual steers fattened were built up for 1985, 1986 and 1987 from the Central Region of Malawi.

The data used are from a total of 3056 steers. Basic information for each steer included issue weight and cold dressed weight and total output weight was found by dividing the cold dressed weight with a dressing percentage of 52 (Nkhonjera et al, 1984). The difference between this weight and the issue weight was divided by the number of steers to arrive at the average weight gain. The average gross income was the difference between total output value and total issue value divided by the number of steers.

Dairying

In the data set for dairy farming, average lactation length and average milk yields were derived by simple division of the totals of lactation days and milk yields by the number of animals in each breed group. All the data was extracted from the records kept under the milk recording scheme.

RESEARCH RECOMMENDATIONS

An extract from "small-holder dairy farming handbook in Malawi" on feeding a heifer in her first lactation is used to illustrate feeding standards in both the wet and dry seasons. These standards are:

1. Wet Season

   a) Young leafy grass from either Napier or Rhodes grass
   b) Maize bran with some leucaena or groundnut cake or cotton-seed cake.

2. Dry Season

   a) Grass hay and/or silage
   b) Groundnut haulms or sweet potato vines
   c) maize bran with some leucaena or groundnut cake or cotton-seed cake

In each case levels of combination were to be decided upon based on the weight of the heifer cow, animal production record and nutritive value (in terms of dry matter, digestible crude protein and total digestible nutrients) of the ingredients.

The stall-feeding programme had the following as minimum recommended package,

i) 1200 of maize bran (Madeya) for two steers
ii) A heap of groundnut haulms with volumetric dimensions of 5 x 4 x 2 metres
iii) Initial liveweight of 227 kg and two permanent teeth and 250 kg liveweight for Malawi Zebu and Crossbred, steers (Mz x Fr or Mz x Br) respectively.

MANAGEMENT

Stall-feeding

Two steers issued to a farmer in a group of 5 farmers were dosed against internal parasites before putting them in stall. Whilst in stalls steers were given crop residues of groundnut haulms, maize stover and maize bran on ad lib basis. Water was available at all times.

Dairy farming

A minimum area of 0.8 ha per a two-cow unit was required. Each farmer established a pure stand of Napier and in a few cases a pure stand of leucaena.

Very occasionally, mixed stands of Napier grass and silver leaf (*Desmodium uncinatum*) could be seen. In the drier areas, Rhodes grass (*Chloris gayana*) was cultivated. Using the "cut and carry" system, cattle were stall-fed on ad lib basis. During the dry season liberal amounts of hay and silage were fed in the drier and wetter areas respectively. An alternate system of feeding concentrates with maize bran as a production ration was common as dictated by the supply of the concentrate feeds. All cows were kept in stalls as a means of conserving energy, for easy detection of heat and to avoid contact with local Malawi zebu bulls. Cows within easy reach of dip tanks were dipped while spraying was common in areas without dip tanks. Deworming was done twice a year before and after the rains.

After parturition calves stayed with their dams for 5 days after which they were separated. Hand milking started on the fifth day. The calf is from this time on allowed to suckle for 30 minutes twice a day after each milking. These calves were weaned at 12 to 15 weeks old. Each cow as she calved down was immediately entered in the recording scheme. The farmer kept records on; daily production, date served, veterinary treatment received and remark column in which he was expected to report amount of concentrate feed given, mortality and calvings.

RESULTS

Stall-feeding

Means of weight and days in stall are given in Table 1. Since no statistical analysis was done it was not possible to qualify the differences in the weight gains by years and Agricultural Development Division statistically. However in the Lilongwe Agricultural Development Division (LADD) average weight gains were lower than those in Kasungu Agricultural Development Division (KADD).

Average gross income was higher in Lilongwe ADD and lower in Kasungu ADD as shown in Table 2.

Dairy farming

Milk production parameters considered in this paper were lactation length and total milk yields. Averages of total lactation length and lactation yields are shown in Table 3. Average financial returns are also shown in Table 3.

The average lactation yields were 2053, 2511 and 2302 kg. For 1/2, 3/4 and 7/8th Friesian Crossbred cows. The trend was that the higher the Friesian blood level the higher the milk yields. When corrected to 305 lactation days yields were 2159, 2479 and 2059 kg for 1/2, 3/4 and 7/8 Friesians respectively.

Lactation length was longer with the 7/8 Friesian and shortest for the 1/2 Friesian cows. However yields were the lowest in case of the former.

Table 1. Performance of cattle fattened on crop residue and maize bran in the Central Region.

ADD	N	Year	Issue wt.(kg)	Total Output wt.(kg)	Total calculated Av. wt.gain	Days in stall
LADD	1069	1985	123258	194132.7	66.3	135
	767	1986	200954	239327	50.03	135
	780	1987	101123	155567	69.9	135
KADD	227	1986	62768.8	86097.3	102.7	156
	213	1987	55930.0	73505.46	82.5	150

Table 2. Gross farm income from fattening steers in the central region.

ADD	N	Year	Total issue Value (MK)[1]	Total output Value (MK)	Average Gross Income (MK)
LADD	1069	1985	66516.77	145975.54	74.33
	767	1986	113973.83	162325.51	63.04
	780	1987	47988.77	142483.97	118.84
KADD	277	1986	42020.68	56410.96	63.39
	213	1987	52022.32	64978.85	60.82

[1]MK = malawi Kwacha (1 US$ = 2.38 MK, average 1985, 1986)
Average prices of cold dressed carcasses were:

1985 : MK1.12 (US $0.50)
1986 : MK1.26 (US $0.50
1987 : MK1.70 (US $0.68)

Table 3. Average lactation length milk yields and gross income for dairy cows in the Blantyre and Mzuzu milk shed areas.

Breed	No.	At lactation length	Milk yields litres	Gross income per cow (K)
1/2 fresian	18	290	2052.95	821.18
3/4 fresian	24	309	2511.07	1004.43
7/8 fresian	11	341	2301.9	920.76

Table 4. Total land size under Napier rhodes grass and leucaena and herd size in the Blantyre and Mzuzu shed areas.

No. of cows	Napier	Land size (ha) Rhodes	Leucaena
2013	499.9	80.57	47.05

Average pasture land per cow: 0.31 ha

DISCUSSION

Steers in Kasungu Agricultural Development Division stayed in stalls longer than the ones in Lilongwe Agricultural Development Division. The recommendation is that steers have to stay in stall for a minimum period of 150 days. By this time they will have gained an average of 90 kg. However, Addy and Thomas (1975) indicated that steers finished on fertilized Rhodes grass and supplemented with 5 kg of maize bran stayed in stalls 130 days and gained an average of 115.7 kg. In the results above the low weight gains were attributed to two main reasons. In Lilongwe ADDs farmers quite often ran short of feed and therefore steers were removed before completing the recommended period. The second reason is that due to inadequate feed supply which very likely led to low feed intake the steers showed low weight changes even if they stayed in stalls for 150 days.

It is recommended that two steers would require 1200 kg of maize bran throughout the fattening period. Using the factor of 15 percent as maize bran from pounded maize grain, ideally there should be about 88, 90 kg bags of maize within the locality. Nowadays maize production levels are so dubious that it is very unlikely to get more maize bran. Worse still, maize bran has many alternative uses these days.

The price of cold dressed carcases depended on grade and weight. Regardless of higher weight gains in Kasungu ADD it is likely that the majority of the steers fetched the lower grade of standard. In addition Lilongwe ADD farmers stayed longer in the stall-feeding programme. They had therefore long experience to be able to judiciously assess a finished steer.

The dairy data used are from areas with rainfall above 750 mm per annum. This is favourable for intensive cultivation of pasture. Consequently due to the rapid growth potential, pastures are in plentiful supply although there is limited land under pasture. Although the sample is too small, the average milk yields of 2289 kg is 4% higher than 2188 kg which was reported by Agyemang and Nkhonjera (1986). Research recommended that as Friesian blood level increases in a continuous upgrading programme the resultant cows should be fed balanced rations. Most of these farmers were feeding either concentrates from commercial companies or these were diluted with maize bran. Feeding was according to the production record of 1 kg of feed for every 2 kg of milk. However, the 7/8 Friesian cows could have not adequately been fed and probably that is why their milk yields were low.

Besides the research recommendations on Napier fodders and pasture grasses to be established, farmers established both species regardless of the ecology of the area. The result was that where these grasses were grown alongside each other, Rhodes grass could not be conserved as hay in wet areas. Farmers therefore opted to graze the grass, a management system requiring heavy fertilizer application to the pasture. Most farmers could not manage this. The grass therefore, became unacceptable to the majority of farmers. Seed multiplication plots were also not set up to enable expansion of pasture plots. An additional factor is the cost of legume seeds which is prohibitively high.

DISSEMINATION OF RESEARCH RESULTS TO USERS BY EXTENSION AGENTS

Quality of extension service was affected by: the lack of effective leadership which is due to background training and lack of motivation. A further limitation to adoption of technologies such as silage making is the labour requirement in the absence of mechanical facilities like choppers and compacting materials.

An integrated approach in planning crop and livestock production does not exist. The consequence has been inadequate feeds for livestock.

In the past, areas of research have been decided upon by ministerial policy making body. This body has also reviewed research findings to examine their relevance to the programmes being promoted. However, the services of this body disappeared and the result has been that a lot of research results have not been passed onto users. Nevertheless field days have been organised by both research and extension. In the former feedback had been expected from extension agents the majority of whom had poor background training. While the latter has used it as a means to transfer technology to the producers. All farmers training centres have established relevant demonstration units to be used when conducting demonstrations classes on specific animal production disciplines. In addition to meeting certain standards, farmers who have intended to establish dairy farms have undergone a two-week training course in dairy husbandry including feed conservation. Stronger farmer group organisations have been involved in order to participate in the development of the dairy industry. Their functions are three fold; as a medium for supply of inputs, to provide a forum for extension services and to initiate self help programmes necessary for the development of the industry.

Publications, handouts, other leaflets and the mass media have been used to disseminate information.

INPUTS SUPPLY

Land holding sizes are becoming smaller and as population increases farmers are finding it difficult to spare adequate land for the number of cows. An alternative solution could be to adopt a mixed pasture establishment under intensive management. This again is restricted to areas of at least 1000 mm of rainfall. Cost of legume seeds is also seen as an inhibiting element.

PRICES

Farmers in both programmes have been sensitive to any lag in price reviews. There has often been a decrease in participation in stall-feeding. It is clear that (Table 2) besides other factors the prices directly affected farm income. In dairy, milk had found alternative markets which was a demonstration against the low prices. Management of pastures and feed conservation has been lagging behind. Farmers could not afford high prices of fertilizers and some equipments.

Impact of utilisation of research results

Besides the shortfalls highlighted and with the recently instituted price liberalisation scheme economic benefits are being realised by the majority of farmers (Tables 2 and 3). Dairy farming has become one of the most prominent source of rural income. The economic advantages range from monthly flow of income which offers economic security to the cutting down of the dependency on inorganic fertilizers. Social status is above average in most of the dairy areas. Nutrition has improved in most families due to household consumption of milk. The farmers organisations offer employment opportunities and provide social services to the public. In general, there is a better economic atmosphere.

CONCLUSION

The increase in livestock productivity is inhibited by a number of factors; inadequate land, unqualified extension services and high costs of some inputs. It is necessary that feed resources research work should pay attention to some work in trying to come up with low cost inputs. This will enable adoption of technologies that could be most acceptable in the existing economic climate. Interaction between extension and research is of poor quality because the farmer is manned by personnel with inadequate background training. Above all, frequent price reviews are necessary if the farmers are not to lag in their management systems.

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FORAGE AND CROP BY-PRODUCT UTILISATION: PRELIMINARY RESULTS ON FARMERS' ADOPTION WITH LACTATING DAIRY COWS

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ABSTRACT

Forage and crop by-products were utilised to feed lactacting dairy cows in a crop-livestock integration package. Fourteen smallholder farmers owning 3 - 5 hectares of land and practising crop livestock integration with dairy cattle were monitored in Unguja and Pemba to see how well the technological package was adopted.

A forage mixture of elephant grass (Pennisetum purpureum) Guatemala grass (Tripsicum laxum), gliricidia (Gliricidia maculata) or leucaena, (Leucaena leucocephala) and banana pseudo-stems and leaves fed to lactating cows influenced milk yield to indicate a reasonable good adoption of the feeding practice by smallholders.

Number of insemination per conception were 2 and 3.4 and calving intervals were 13.1 months and 14.3 months for Unguja and Pemba respectively. Adoption in Pemba was slower compared to Unguja inspite of breed differences of the cattle used.

Occurrence of East Coast Fever was more frequent in Pemba and this indicated low adoption rate in the use of acaricides for spraying.

It is expected that intensifying extension and credit facilities will increase rate of adoption as these appear to be the main constraints.

INTRODUCTION

Landmass area of Zanzibar is only 2332 km^2 with a human population of nearly 0.5 million people and growing at a rate of

2.7% per year (Dept. of statistics, 1984). Crop-livestock integration has been advocated as a means of efficiently utilising land in the cropping areas. On station research carried out by FAO in Zanzibar between 1980 - 1985 indicated that a farm family could thrive on 3 - 5 hectares of land if crop-livestock integration is fully practised where dairy cattle and few poultry birds are kept and crops and forages such as bananas, sweet potatoes, cassava, elephant grass, guatemala grass, gliricidia, leucaena and kudzu (Pureraria phaseoloides) are grown. Forages and crop by-products fed to dairy cattle tremendously increased revenues (Pedersen et al., 1984). Since early 1987, a crop-livestock integrated technological package is being disseminated to livestock keepers in the country.

This paper discusses preliminary results of production parameters as adopted by farmers and the constraints encountered during the process of adoption of the technological package.

MATERIALS AND METHODS

Selected Farmers

Fourteen farmers were selected within the two islands of Unguja and Pemba. These farmers were given alphabetical identification letters from A to N. Together they had a total of 21 milking cows most of which were in their first lactation. The choice of the farmers was limited by the rate at which monitoring could be conducted on their farms, and also by the fact that during the time of selection in early 1987, there was not as yet wide participation by farmers. Selection was also based on the willingness of the farmers to be monitored constantly and those who agreed to grow forages and food crops, and to provide zero - grazing management.

Cattle Used

In Unguja Island the type of breed used by the farmers was mainly Jersey. In Pemba island a composite breed made up of Sahiwal, Ayrshire and Brown Swiss originating from Wilson's farm at Kilifi, Mombasa, Kenya was used. In Unguja the emphasis is on milk production, while in Pemba the emphasis is on a dual purpose animal for milk and meat.

Roughage Used

Forages grown were elephant grass, Pennisetum purpureum var Gold Coast and guatemala grass, Tripscum laxum. Legumes included Leucaena Leucocephala, Gliricidia maculata and Tropical Kudzu, Pueraria phaseoloiders. Banana stems and leaves were the crop by-products mostly used. These were all cut and fed to the animals individually in their stalls. Nutritional values of some of these forages is still being assessed.

Concentrate

A home made concentrate consisting of one part coconut cake to three parts rice bran with some molasses and maclik supper, a Wellcome Kenya Ltd mineral mixture, was provided to milking cows. Supplementation was based on milk yield, one kilogram concentrate for each 2 kg of milk after the first 4 kg. This mixture was preferred because it was cheaper at TShs.125/- per 50 kg compared to TShs.500/= per kg for cattle feed manufactúred by state owned feed mill.

Technological Package

During the monitoring the technological package emphasized to the farmers consisted of:

i) Record keeping
ii) Feeding practices
iii) Forage and food crop maintenance
iv) Regular spraying (Disease survillance)

Parameters observed as a measure of adoption of technological package included the following:

i) Actual milk yield and fat-corrected milk
ii) Number of inseminations per conception

iii) Calving intervals
iv) occurrence (No. of times).

Adoption rate of technological package was considered low, medium and high as follows:-

i) For milk yields
- Mean yield below 1500 kg /Cow/lactation - low
- Mean yield between 1500-2500 kg /Cow/lactation - medium
- Mean yield above 2500 kg /Cow/lactation - high

ii) For number of inseminations per conception:-
- 3.5 - 4 and above inseminations - low
- 2 - 3.5 insemination - medium
- 1 insemination - high

iii) Calving intervals
- above 15 months - low
- 13 - 15 months - medium
- 12 - months - high

iv) Disease occurrence
- above 50% - low
- 25% - 50% - medium
- below 25% - high

RESULTS AND DISCUSSION

Milk yield

Table 1 shows actual milk yield and fat-corrected milk yield attained by farmers in Unguja island, while Table 3 shows actual milk yield attained by farmers in Pemba island.

Arithmetic means for actual milk yield and yield of fat-corrected milk for Unguja were 1940 kg /Cow/lactation and 2165 kg /Cow/lactation respectively. The mean fat-corrected milk yield found was similar to that reported by Hamad (1986). Hamad (1986) found that milk yield in the first lactation in a large Jersey dairy farm in Unguja was 2035.7 kg. Yield attained by the smallholders monitored in this study compares favourably with this finding.

The rate of adopting practices pertaining to milk production was found to be in the medium range with 1940 kg /Cow/lactation and 2165 kg /Cow/lactation for actual and fat-corrected milk respectively. Mean actual milk yield for Pemba 1612 kg /Cow/lactation was slightly lower compared to Unguja yield. The adoption rate was found to be in the medium range.

Table 1: Actual and fat corrected milk yields per lactation (Unguja).

Owner	Cow No/Name	Breed	Actual milk yield (kg)	Fat content (g/100 g)	Fat-corrected (kg)
A	1964	F[1]	1847	3.40	1681
	Mabaka	J[2]	1690	5.50	2070
B	Bimkubwa	J	2456	4.26	2552
C	932	J	1325	4.51	1426
D	10	F	2527	3.40	2291
	9	F	2407	3.30	2154
	Mweusi	FX[3]	1670	3.50	1545
E	933	J	2067	6.50	2842
	12	J	2240	5.96	2899
F	975	J	2210	6.20	2939
G	919	J	1737	5.89	2229
	979	J	1103	5.53	1356
Mean (X)			1940		2165

1. F = Friesian
2. J = Jersey
3. FX = Friesian Cross

Number of Inseminations per conception

Tables 2 and 3 show the number of inseminations per conception for Unguja and Pemba respectively. The mean insemination per conception in Unguja was 2 and 3.4 for Pemba. In both situations, adoption was in the medium range. In Pemba there was some difficulties experienced by the owners to detect heat. Probably this explains the higher number of inseminations compared to Unguja.

Calving Interval

Tables 2 and 3 also show calving intervals for Unguja and Pemba respectively. The calving intervals found were 13.1 months and 14.3 months for Unguja and Pemba respectively. These findings were in the medium range of adoption. At Kilifi, Trail and Gregory (1981) reported calving interval of 13.1 months (394 days) within the Sahiwal crosses. The calving interval found within the small holdings in Pemba is higher compared to that reported at Kilifi. This again probably reflects the difficulty experienced in heat detection in Pemba and also how effective the adoption rate in observing heat symptoms was embraced by the smallholder.

Occurrence

East Coast Fever (E.C.F.) is one of the major cattle diseases in Zanzibar. Tables 2 and 3 show the number of times ECF and Mastitis occurred in Unguja and Pemba. Pemba showed a very high occurrence of ECF at 70 per cent compared to Unguja 25 percent. This means that there was a low rate of adoption as regards to ECF surveillance practices in Pemba, whereas in Unguja adoption was within the medium range. In both islands smallholders were required to hand spray their animals twice a week, but it was found that most of the farmers in Pemba did so irregularly.

Survellance of mastitis was equally adopted in Pemba and Unguja reported more cases. This was attributed to poor milking hygiene specifically exibited by one smallholder in Unguja.

Constraints observed

Crop-livestock integration is a new technology to smallholders in Zanzibar. Farmers are used to having separate areas for crops; and cattle are tethered on open land or fallow land. Zero grazing coupled with pastures and forage growing and utilisation of crop residues are all new innovations. Constraints during adoption were therefore observed and these included:

i) Financial constraints

ii) Socio-economic constraints

iii) Low perception

The major constraints observed was financial. The crop-livestock integration package entails high investment. Cattle shed, animals and drugs are all expensive and beyond the reach of smallholders. To overcome this constraint, a credit scheme has now been initiated. This entails low interest 2.5 - 3% and a grace period of twelve months before loan repayment commences.

During monitoring it was difficult to find some of the farmers particularly in the morning. Some smallholders were found to have other jobs to maintain their families especially during the early stages of adoption when no income was being generated.

Most of the smallholders monitored had low standard of education. They are simply peasant farmers. Their perception was found to be low and took time. This indicated that more frequent visits by extension staff were required, but adequate transport and sometimes motor fuel shortage problems hampered the exercise.

Table 2: Number of inseminations/conception, calving intervals and disease occurrences (Unguja).

Owner Treated	Cow No/Name	Breed	No. of Inse-mimation/ Concet. Nos.	Calving Intervals (Months)	Times ECF	Times Mastitis
A	1964	F	3 (O)	-	-	-
	Mabaka	J	1 (P)	12	-	1
B	Bimkubwa	J	1 (P)	12	-	-
C	932	J	3 (O)	-	-	-
D	10	F	3 (P)	15	-	-
	9	F	3 (P)	15	-	1
E	Mweusi	FX	1 (P)	12	-	-
E	933	J	1 (P)	12	-	-
	12	J	3 (O)	-	1	1
F	975	J	1 (P)	12	1	-
G	919	J	1 (A)	-	-	-
	979	J	3 (P)	15	1	3
Mean (X)			2	13.1	0.25	0.5

F = Friesian

FX = Friesian cross

(O) = Open

(P) = Pregnant

Table 3. Actual milk yield, No. of insemination/conception, calving interval and disease occurrence (Pemba).

Owner	Name/cow No.	Breed	Actual milk Yield (kg)	No. of insemination/ Conception (Nos)	Calving Interval (Months)	Times ECF	Treated Mastitis
H	Mbololo	S^C	2016	2 (P)	12.0	1	-
I	Nyota	"	1741	3 (P)	16.5	-	-
	Voi	"	1444	2 (P)	14.0	1	1
J	Suris	"	2252	4 (P)	16.5	1	1
	Harambi	"	1607	5 (P)	16.0	1	1
K	Naviosa	"	1246	3 (P)	13.0	-	-
L	Kazuauzala	"	1455	1 (P)	12.0	-	-
M	Zimamoto	"	1708	2 (O)	-	1	-
N	Bungoma	"	1047	7 (O)	-	1	-
	Mean -X		1612	3.4	14.3	0.7	0.3

S^C = Sahiwal composits

CONCLUSION

Crop livestock integration appears to be a viable enterprise in Zanzibar. Reasonable milk yield have been obtained using forage and crop residues by smallholders in both Unguja and Pemba. Efforts to improve extension and facilitate a credit scheme will most likely improve adoption and income of the farmers.

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A REVIEW OF FORAGE PRODUCTION AND UTILISATION IN NIGERIAN SAVANNA

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ABSTRACT

The low level of animal production from the savanna zones of Nigeria is generally associated with the inability of the stock especially in the dry season. Various forage species have been evaluated and recommended for inclusion in these zones to increase animal output. This paper examines the productivity of these legumes and grasses with respect to establishment and management under different production systems.

The extension of this research information to farmers is discussed. The role of the government is assessed and suggestions offered to improve the utilisation of these research results by farmers.

INTRODUCTION

Nigeria lies approximately between latitudes 4^{o} and 13^{o} and longitudes 3^{o} and 14^{o}E. It has an area of about 94 million hectares 75% of which is savanna. The savanna extends from latitudes 6^{o} to 13^{o}N. The savanna can be divided into Sahel/Sudan Savanna and Guinea Savanna zones, corresponding to annual rainfall of ,<300 - 800 and 800 - 1500 mm respectively. Most of the estimated 12.5 m cattle, 12.8 m sheep and 26 m goats in Nigeria are principally under extensive system. Forage availability is an important nutritional factor. During the wet season which lasts between 3 to 8 months, there is adequate forage of good quality for ruminants; but during the dry season, the range does not meet the feed requirements of these ruminants both in terms of quantity and quality. During this period, the range grazing has to be supplemented by the utilisation of legume pastures, browse plants, conserved fodder, crop residues and food processing by-products.

The use of highly productive good quality pasture grasses and legumes has given increased productivity in these animals in Nigeria (Agishi, 1971; de Leeuw and Agishi, 1978). Research into both indigenous and exotic forage species has been going on in Nigeria, particularly in the savanna zones, since 1950s. The productivity, utilisation by livestock and extension of these forage species to farmers is the subject of this paper.

FORAGE SPECIES EVALUATION

Introduction of pasture species into Nigeria started in the 1950s. Table 1 is the summary of the species found to be adapted, and recommended for production on large scale in the Nigerian Savanna (Agishi, 1979). The criteria used for their evaluation were based on ease of establishment, high dry matter yield, nutritive value, persistence, good seed yield and their suitability for conservation as hay or silage. (Foster and Mundy, 1961; Miller and Blair-Rains, 1963; Miller et al, 1964; Haggar et al, 1971 and de Leeuw, 1974). Presently, the most frequently cultivated forage species are gamba, Rhodes grass, Digitaria, Signal grass, giant star grass, stylo, verano, centrosema, lablab and Leucaena.

Table 1. Recommended forage species for the different vegetation zones in Nigeria.

		Vegetable Zones				
Species	Common Names	SDS	DS/SGS	NGS	SS	M
A. Grasses						
Andropogon gayanus	Northern gamba	X	X	X	X	
Andropogon tectorum	Southern gamba	X	X			
Brachiaria decumbens	Signal grass	X	X	X		
Cenchrus ciliaris	Buffel grass	X	X	X	X	
Chloris gayanus	Rhodes grass		X	X		
Cynodon dactylon	Bermuda grass	X	X	X		

Cynodon plectostachyus	Giant star grass	X	X	X		
Digitaria decumbens	Pangola grass					
Digitaria smutsii	Wooly finger grass		X	X		
Hyparrhenia rufa	Jaragwa grass	X	X	X		
Milinis minutiflora	Molasses grass	X	X	X		
Panicum maximum	Guinea grass	X	X	X		
P. maximum cv. gatton	Gatton panic		X	X	X	
P. maximum var. trichoglume	Green panic		X	X	X	
Pennisetum clandestinum	Kikuyu grass					X
P. pedicellatum	Kyasuwa				X	
P. purpureum	Elephant grass	X	X	X		
P. typhoides cv. Maiwa	Maiwa millet			X	X	
Setaria anceps	Setaria		X	X		
Sorghum almum	Columbus grass			X	X	
Tripsacum laxum	Guatemala grass	X	X	X		X
B. Legumes						
Cajanus cajan	Pigeon pea	X	X	X	X	X
Centrosema pubescens	Common centro	X	X	X		
Desmodium intortum	Greenleaf desmodium		X	X		X
D. scorpiurus	Samoan clover		X	X		
Gliricidia sepium	Almond blossom	X	X	X		
Lablab purpureus	Lablab, Hyacinth bean	X	X	X	X	
Leucaena leucocephala	Leucaena	X	X	X		
Macroptilium atropurpureum	Siratro		X	X	X	
Macrotyloma axillare	Axillaris			X	X	
M. uniflorum	Horsegram bean		X	X	X	
Neonotonia wightii	Glycine		X	X		X
Pueraria phaseoloides	Puero (kudzu)	X	X	X		
Stylosanthes guianensis cv. Schofield	Schofield stylo	X	X	X	X	
S. guinensis cv. Cook	Cook stylo		X	X	X	
S. hamata cv. Verano	Verano stylo		X	X	X	
S. humilis	Townsville stylo		X	X	X	

SDS = South of Derived Savanna   NGS = Northern Guinea Savanna
DS = Derived Savana   SS = Sudan Savanna
SGS = Southern Guinea Savanna   M = Montane

FORAGE PRODUCTION

Seedbed preparation for sown pastures normally requires land clearing, disc ploughing and harrowing. Forage species can also be oversown in cultivated strips in burnt rangeland (Haggar et al, 1971; Perrier, 1982) or undersown in cereal crops (Blair Rains, 1963; Saleem et al, 1986). Broadcasting method of sowing has been found to be superior to drilling for such legumes as centro, desmodium, siratro, stylo sown in mixture with signal grass (Akinola, 1981) and Rhodes grass (Onifade and Akinola 1986).

The mean dry-matter yields of grasses, legumes and their mixtures grown under rainfed conditions are summarized in Table 2. It can be seen that on average, grasses produced higher dry matter yields than legumes. Yields of grass/legumes mixtures are higher than those of legumes alone but were within the same range as sole grasses. From the various results obtained, it was quite clear that nitrogen and phosphorus were the main factors for grass and legume dry-matter yields respectively. Phosphorus tended to depress grass dry-matter yield while nitrogen had the same effect on legumes (Fayemi et al, 1970; Haggar, 1971 and Agishi, 1982).

Dry-matter yields obtained in grass pasture under rain-fed conditions were generally lower than those from both the fertilized and unfertilized irrigated grass pastures (Agishi, 1984 and Ariba, 1987). These yields were in the range 5-20 t DM/ha.

UTILISATION BY LIVESTOCK

Trials at Fashola (Adegbola and Onayinka, 1968) during the wet season showed that higher liveweight gains (LWG) (184-187 kg/ha/yr) are possible from guinea grass/Centro than sole grass pasture (82 kg/ha/yr). These and other results from (Table 4a) are used in estimating the productivity of forages available in the Nigerian Savanna. Dry season LWG are low except when animals are supplemented or grazed on pure stylo pastures

(Haggar et al, 1971) for more than 37% of their grazing time. However, Tuley (1968) observed that grazing stylo on 24 hourly basis will eliminate the legume compared with only at daytime.

Table 2: Dry matter yields of pastures in Northern Guinea Savanna of Nigeria (t/has)

Types of pasture	Species	Common Name	D.M.(t/ha)
Grass (sole)	Andropogon gayanus	Gamba	7-10
	Brachiaria decumben	Signal grass	10-16
	Cenchrus ciliaris	Buffel grass	8-15
	Chloris gayana	Rhodes grass	7-12
	Cynodon plectostachyus	Giant star grass	5-8
	Digitaria smutsii	Woolly finger grass	5-8
	Panicum maximum	Guinea grass	8-14
	P. maximum var. trichoglume	Green panic	6-11
Legumes (Sole)	Centrosema pubescens	Common centro	2-3
	Lablab purpureus	Lablab (a)	5-9
	Stylosanthes guianensis cv cook	Cook stylo	7-11
	S. guianensis cv Schofield	Schofiled stylo	7-11
	S. hamata cv Verano	Verano stylo (Caribbean stylo)	4-7
	S. humilis	Townsville stylo (a)	3-6
Grass/legume mixtures	Gamba + stylo		9
	Signal grass + Centro		10
	Signal grass + Schofield stylo		14
	Signal grass + Townsville stylo*		14
	Rhodes grass + Schofield stylo		10
	Rhodes grass + Centro		7

(a) = annual plant
* = Legume content low (10%)

Agishi (1979) reported a delay in the commencement of weight loss from Verano stylo/buffel grass pastures compared with grazing unimproved savanna. In addition, cotton-seed cake supplementation was only necessary from late February at the stocking rate of 1.1 heifers/ha. Okeagu et al (1985) reported that cattle can be stocked on signal grass for 182 days and on Digitaria smutsii for 154 days in the wet season at 2.4 Tropical Livestock Units (TLU)/ha before they start to lose weight.

Data on sheep grazing trials are lacking. In a preliminary study of N-fertilizer on Rhodes grass, Onifade et al (1986) reported a mean daily LWG of 12.6 g/ha at stocking rate of 12 sheep/ha over a period of 168 days in the dry season. Mean loss in weight (-5.9 g/ha) was recorded for sheep at the highest stocking rate (36 sheep/ha) over the same period.

A partial cost analysis showed that livestock production on sown grass/legume mixtures is profitable (Tables 3a&b). Similar findings were reported by de Leeuw and Agishi (1978) from different grazing systems in the Nigerian savanna.

UTILISATION OF RESEARCH RESULTS BY FARMERS

The National Animal Production Research Institute (NAPRI), International Livestock Centre for Africa (ILCA) and some Universities located in the savanna zones are primarily responsible for research on forages. Information available from research are made available in various forms viz. journals, newsletters, guides, bulletins and posters (Yazidu, 1985). Other channels of reaching the extension workers and farmers are through leaflets, slides, training courses, video and films, radio, television, newspaper articles, open days, conferences and seminars. All these channels are being used by the National Agricultural Extension and Research Liaison Service (NAERLS), the overall institute responsible for the linkage between research and extension in Nigeria. It also liases with farmers and researchers.

Recently, NAPRI was also mandated to aid extension activities in all aspects of livestock production. With the existence of a Livestock Systems Research Programme (LSRP) and the Livestock Research Extension Unit (LREU) at NAPRI, the linkage between livestock farmers and researchers has been further strengthened. On-farm adaptive research on forage production is carried out by LSRP in the savanna zones. This will also be expanded to other zones in the country. ILCA carries out similar activities with pastoralists in the sub-humid zone and also within the savanna area of Nigeria. LREU carries out similar functions with NAERLS but specifically for the livestock industry. On the whole, personnel for extension work are inadequate considering the huge number of farmers who keep livestock. Yazidu (1985) reported that with the existing institutions for training, the country's need for one extension worker to 500 farmers may be met by the year 1990.

Farmers are usually assisted in procurement of inputs for forage production. These inputs include, forage seed, fertilizer, fencing materials, credit facilities/loans etc.

They are either made available directly by government agencies such as the Nigerian Livestock Projects Unit or from other sources. With respect to improved seed for sown pastures, farmers are always encouraged to multiply the seed available in the first growing season so that a greater area could be sown the following season and the remaining seed can be sold to other farmers. Presently, the demand for forage seed is too high for NAPRI to cope with. This is because many of the retired civil servants and members of armed forces who have gone into livestock farming have been aware of the benefits of improved forages for livestock production.

Table 3a. Performance of cattle grazing different pastures at NAPRI, Shika, 1969-1984.

	Pasture type	S.R. (head/ha)	A.D.G. (kg/head)	Duration (days)	Gain/ha (kg)	Returns/ha (N=)
Rainy season	Rangeland	1.0	0.15	120	18	81.00
	Digitaria	4.5	0.31	106	148	666.00
	Digiraria	3.7	0.45	98	164	738.00
	Digitaria	3.3	0.76	70	176	792.00
	Brachiaria	6.8	0.33	126	283	1273.00
	Brachiaria	6.8	0.59	126	506	2277.00
	Stylo	4.1	0.44	143	251	1129.00
Rainy/dry season	Cenchrus/verano	3.33	0.40	222	296	1332.00
	Cenchrus/verano	1.67	0.41	222	152	584.00
	Rangeland	0.50	0.30	222	33	148.00
Dry season	Chloris + kg C.S. daily	3.0	0.64	72	138	621.00
	Stylo + grass	1.0	0.42	140	59	265.00
	Rangeland + C.S.[2]	1.3	0.07	112	10	45.00

[1] 1 Naira = US$ 0.20 depending upon fluctuation
[2] C.S. = Cottonseed
Assume N=4.50/kg liveweight

Sources: de Leeuw and Brickman, 1974; de Leeuw and Schillorn, 1978, Agishi, 1979, Okeagu, 1981.

Table 3b: Cost of pasture establishment

Cost items	Total costs (N/ha)	Annual costs (N/ha)	(N/ha)
Bush clearing	200.00	20.00	20.00
Seedbed tillage	150.00	30.00	30.00
Seeds	180.00	36.00	36.00
Fertilizers	170.00	170.00	-
Fertilizers	60.00	-	60.00
Fencing (25 has)	196.00	150.00	15.00
Total		271.00	131.00

<u>Note</u>: Assuming N4.50/kg liveweight is the farm-gate selling price for cattle, then a sustained production of 60.2 and 29.1 kg/ha are required to cover the annual costs of grass and legume pasture respectively.

On smallholder level, the adoption of the fodder banks technology has proved profitable to many farmers. Requests by farmers for the establishment of improved forage legumes such as lablab and forage cowpeas is on the increase.

SUGGESTIONS TO IMPROVE UTILISATION OF RESEARCH RESULTS TO FARMERS

(a) Construction of more access roads to the rural communities

(b) Allocation of more land specifically for forage production

(c) Training of more extension staff into subject matter specialists

(d) Involvement of extension staff in the provision of inputs and other forms of assistance to farmers.

(e) Provision of inputs promptly e.g. fertilizers and adequate maintenance of equipment

(f) Contact between researchers, producers and extension staff should be more regular

(g) Provision of more funds to aid in the extension of forage production.

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PRELIMINARY EVALUATION OF RESEARCH ON AGRICULTURAL BY-PRODUCTS UTILISATION BY MODERN SMALL SCALE FARMERS IN THE SUDAN

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ABSTRACT

This paper attempts to evaluate the state of research on agricultural by-products and its usefullness to modern small - scale farmers and other potential users. It highlights the quality of the research reports generated and their relevance and applicability on small-scale farms. For this purpose the authors reviewed the available research reports and conducted interviews with senior scientists and managers in the major research institutes and some agricultural production centres. Some modern small-scale farmers and feedlot operators were also interviewed.

It was observed that the modern small-scale farmer have received little, if any, benefits from the research undertaken on agricultural by-products. This observation is related to the relatively low quality research undertaken, so far.

INTRODUCTION

Approximately 258,000 of the 2,000,000 small-scale farmers of the Sudan could be described as modern small-scale farmers each cultivating an area ranging in size between 5-22 feddan[1] with cash and staple food crops. The majority of these farmers are tenants on government irrigated agricultural scheme established on the Nile and its major tributaries. Almost all farmers and farm labourers maintain small herds of cattle, sheep and goats as an alternative source of income, a way of diversifying production, to guard against risks of crop failure and/or crop price decline, as a source of food and to help with farm work.

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[1] 1 feddan = 4200 m^2

Under prevailing agricultural production system on small farms crop and livestock production are not fully integrated. The various available resources and land are directed to cash and staple food crop production. A negligible area is cultivated with forages. This has left farmers with no alternative other than maintaining their livestock herds on crop residues and to a lesser extent on fallow grazing occasionally supplemented with off-farm produced concentrate feedstuffs and forages.

Although the modern small-scale farmer employs relatively modern means of agricultural production, he uses relatively traditional means of livestock husbandry. One aspect of this traditionalism is the way crop residues are used as the main source of feed on the farm. Their use is not based on methods that maximize the benefits and reduce the waste and, consequently optimize the overall cost of production. More importantly, the research that has been undertaken, to date, is believed to be inadequate and not specifically orientated to rationalizing the use of these by-products at the farm level.

The objective of this paper is to provide a preliminary evaluation of the research generated so far on agricultural by-products and to examine its quality, relevance and applicability on modern small-scale farms in the Sudan.

Agricultural By-Products Research Undertaken

An overview of the research undertaken and reported during the period 1965-1988 is presented in Tables 1 and 2. Altogether 16 reports were generated out of 2 major research projects and a number of small-scale research activities conducted by some interested researchers and graduate students.

The two major research projects and the bulk of the research activities were performed at the Institute of Animal Production, University of Khartoum. The two major research projects (by-product-Sudan) were financed by IDRC of Canada for a total sum of about 300,000 Sudanese Pounds (Sudanese Pound = US$ 4.5) over a 3 year period for each project.

The primary objective of the research undertaken was to maximize the use of agricultural by-products in beef and sheep finishing operations. In the Sudan, meat producing animals are traditionally finished on dry feedlots using complete diets composed of costly concentrate feedstuffs (grain and cakes) with little forage and/or agricultural by-product.

The research approach adopted was the conventional on-station research methodology and only in one study (Ahmed et al. 1985) was the non-conventional on-farm research methodology employed. The technology embodied in the research undertaken involved the use of feed mills, mixers and pelleters in addition to chemicals (alkalis, acids and others) and concentrate feedstuff ingredients.

Almost all of the research results verified the technical feasibility of incorporating processed agricultural by-products at levels of 25-45% of the diets of meat producing animals. However, the economic feasibility of the majority of the results was implied and was not demonstrated following proper economic analysis. The results of the on-farm research trials undertaken indicated the potential users' interest and willingness to promote such a research approach.

Following the review of the above cited research the following observations on the quality aspects and short-comings of the research could be made.

Table 1: Inventory of agricultural by-products research undertaken in the Sudan during the period 1966 - 1988

Agricultural by-product	Number of research Reports	References
Sorghum	9	Mustafa (1988); Mohamed (1988); Mohamed Salih (1986); El Hag and George (1981); El Shafie (1976); El Hag and Kurdi (1986); Osman et al., (1987); Mohammed et al, (1987); Farah (1986).
Dura hulls	1	El Shafie and Mcleroy (1965)
Groundnut hulls	6	El Hag (1986); El Hag and George (1981); Ahmed et al (1977); El Shafie et al. (1976); El Hag and Hamad (1983); El Hag (1986).
Baggase	3	El Hag and George (1981); El Shafie et al (1976); El Hag and Kurdi (1986).
Cottonseed hulls	2	El Shafie and Osman (1965) El Shafie and Mcleroy (1965).
Cottongin trash	1	Khalafalla (1988)
Total	24	

1. The bulk of the research undertaken on agricultural by-products is an individual rather than an institutional activity as could be perceived from the weak integration of researchers and the lack of multi-disciplinary approach. Few of the activities were conducted by more than two persons.
2. It was apparent that the capacity of the Sudanese scientists and institutions to generate research on agricultural by-products is limited.
3. Almost all of the research activities were reported in the English Language (the elite Language) and very few of the reports were abstracted in Arabic which is the mother tongue of the majority of the population.
4. Almost all the research undertaken was targetted for commercial dry feedlot operators and not small-scale farmers. Some of the research was conducted for academic purposes.
5. One shortcoming of the majority of the research conducted, so far, on agricultural by-products, and as a direct consequence of the lack of coordinated research efforts, is the absence of economic analysis of the results. Thus, although almost all research results indicated the technical feasibility of agricultural by-products in animal feeding, economically this has not been verified.
6. The technology employed involved the use of capital-energy intensive machinery and relatively expensive chemicals and concentrate feedstuff ingredients.
7. The majority of the research on agricultural by-products was conducted on agro-industrial by-products, namely the oilseeds, sugar cane and cotton ginning industrial by-products. Research on crop residue was limited to sorghum stover.
8. The scientific merit of some of the research undertaken is questionable. Some of the research reports reviewed contained insufficient information, error of formulation and design and the failure to answer fundamental questions on the issues addressed by the investigator.
9. Little or no effort was made to introduce the majority of the research results obtained to the potential users, either, directly or through pilot or development experimentation.

Relevance of the Research Undertaken to Modern Small Scale Farmers.

Almost all of the research undertaken was of little or no relevance to the modern small-scale farmer in the Sudan for one or more of the following reasons:

1. The research emphasized the use of agro-industrial by-products (Table 2) which are not available on the farm or nearby local markets. They are available at industrial centres, distances away from the modern small-scale farms, at relatively low prices. Table 3 shows the crop and agricultural by-products productivity and utilisation on modern small-scale farms in the Sudan. It indicates that the agricultural by-products available on the farm are the crop residues of sorghum, cotton, groundnut (haulms) and wheat in that order of magnitude. With the exception of cotton, which is grazed in site, the bulk of the crop residues are collected and stored for later use. However, not all of the estimated amounts of the agricultural by-products produced on the farm are available for collection and storage by the farmer. This is related to the acuteness of labour shortage at harvest time and the intensity of in situ grazing by nomadic livestock trespassing to water in the nearby irrigation canals.

2. The research undertaken maybe more relevant to high producing mature meat animals (finishing cattle and sheep). The control treatments/diets were composed of high concentrate feedstuffs. This is not always the case on modern small-scale farms where the bulk of livestock are kept for milk production. Meat animals are usually disposed of at an early age at home or sold as feeders. Thus , the feeding of high levels of concentrate on modern small-scale farms is an exception rather than a rule.

Table 2. An overview of agricultural by-products research activities undertaken in the Sudan (1966-1988).

Agricultural by-product/agro-industrial by-product	Class of agricultural by-product	Materials and equipment employed	Experimental species	Research results (% of cotton)		
				DMI	ADG	FCR
Sorghum stover	Crop residue	Mills, mixers, chemicals and concentrates	Beef cattle	82-170	78-109	85-130
Dura hulls	Crop residue	Mills, mixers and concentrates	Beef cattle	83	70	
Groundnut hulls	Agro-industrial	Mills, mixers and concentrates	Beef cattle	89-103	69-103	96-140
Baggase	Agro-industrial	Mills, mixers, concentrates and pelleters	Beef cattle	102-106	66-95	104-170
Cottonseed hulls	Agro-industrial	Mills, mixers and concentrates	Beef cattle	102	105	100
Cottongin trash	Agro-industrial	Mills, mixers and concentrates	Sheep	104	100	106

Only in one study was the control an unprocessed agricultural by-product.

DMI : Dry-matter intake

ADG : Average daily weight gain

FCR : Feed conversion ration

Table 3: Crop & Agricultural by-product productivity & utilisation on modern small-scale farms in the Sudan.

Crop	Estimated grain production (kg/feddan[1])	Ratio of agricultural by-product: grain	Estimated production of agricultural product (kg/farm)	Current use in livestock production	Constraint to utilisation
Cotton	294	?	?	Grazed *in situ* within one month of harvest (March)	Collection and storage are prohibited.
Sorghum	400	3.7	1480	80% collected, stored and fed in stall. The remainder is grazed *in situ* within 2 weeks of harvest (Dec.)	Poor storage, inefficient use.
Groundnut	800	1.2	960	70% collected, stored and fed in stall. The remainder is grazed in 2 weeks of harvest (Nov.)	Poor storage.
Wheat	450	1.0	450	80% collected, stored and fed in stall. The remainder is grazed in *in situ* (March-April).	Poor storage inefficient use.

[1]feddan = 4200 m^2

Sources: (1) Current agricultural statistics (1984), Ministry of Agriculture, Sudan
(2) Better utilisation of Crop Residues and by-products in Animal feeding FAO, Animal Production and health paper.

3. The technology embodied in the research undertaken involved the processing of the agricultural by-products used. The equipment and materials employed for the processing and preparation of the diets are beyond the economic and technical capabilities of the modern small-scale farmer, and perhaps the country as a whole. The lack of electricity on the farm and the frequent shortage of Petroleum fuel to operate the processing equipment, in addition to the small amount of crop residues produced on the farm, are enough reasons to justify the inappropriateness of such a technology on the modern small -scale farms.

Applicability of the Research Results

It was found that the results of the research undertaken are inapplicable on small-scale farms and feedlots.

A number of factors have led to this inapplicability. Major among these factors are:

1. The research that has been done, so far, is on livestock finishing and more specifically on finishing in commercial dry feedlots. As such it is neither related to the local conditions of the small-scale farmer nor to the nature of their animal raising activities. Small-scale farmers in the irrigated production centres are concerned more with dairy production than with fattening animals in feedlots.

2. The materials, tools and equipment used in the research are dictated by the nature and scale of the business activities in the commercial fedlots. This obviously hinders their applicability at the small-scale level where the number of animals dealt with is rather small.

3. The research is oriented mainly towards arriving at technical feasibilities and technical optima. With the exception of one or two research projects no economic analysis has been done to translate economic optima into

monetary terms, i.e. cost savings and increased revenue that could be extended to and understood by the small-scale producers. There is need to provide adequate economic incentives to the small-scale farmers to induce them to adopt the improved production methods. This underlines the need for economic analysis of research results if the ultimate objective is to make the small-scale producers benefit from them.

CONCLUSIONS AND RECOMMENDATIONS

1 . Research on agricultural by-products undertaken in the Sudan is characterized by weakness, marginality and disarticulation. This could be due, at least in part to the inadequate human and financial resource allocated to research institutions (Appendix) and to the lack of links between them. The low pay, the lack of good support to research and the absence of a healthy working atmosphere are behind the low efficiency and dedication of the scientists to produce good quality research.

2 . Agricultural technology is known to be location specific. This makes it imperative to coordinate efforts to establish and strengthen research work to adapt new agricultural research and discoveries to local farming conditions. This is likely to yield higher socio-economic returns and better quality research.

3 . Small scale farmers are generally likely to be more ignorant than enterprisers in other sectors of the economy about the existing improved methods of production. Hence properly designed extension services that disseminate research results to farmers and bring to the researchers their problems as a feed-back are also likely to yield higher socio-economic returns and better quality research.

4 . Where possible, the tools and equipment pertinent to applying the new production techniques that are recommended, need to be designed to meet the needs of small-scale production. Simple, locally available and relatively cheap

materials, equipment and tools would encourage the adoption of the new techniques.

5 . Alternatively the new technology could be used collectively by groups of farmers in co-operative organisations or, perhaps, it could be provided as a service at cost by the administrations of the production units.

6 . Even for those to whom it is applicable i.e. commercial feedlot operators, the research results that have been arrived at, so far, have not been adopted. This is so despite the fact that the results were demonstrated on commercial dry feedlot premises. This is believed to be related to the nature of the meat animals markets. In the Sudan these markets are highly concentrated. The few commercial operators who control these markets are not very conscious of the cost effectivenes of the newly demonstrated technologies.

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Appendix: Human and financial resources of livestock research institutions in the Sudan.

	Livestock research institutions			
	ARC(NRC)	LRA	University	TOTAL
<u>Scientific and Technical</u>				
<u>Personnel</u>				
Ph.D	0	12	22	34
M.Sc.	0	23	8	31
B.Sc.	0	10	-	10
Technicians	0	36	9	45
Total	0	81	39	120
Budget 1988 (000' pounds)	280	825	50	1155

(a) Including budget for research in crop production One U.S. Dollar is officially equivalent to 4.5 Sudanese Pounds

ARC = Agricultural Research Centre

NRC = National Research Centre

LRA = Livestock Research Administration

FORAGE PRODUCTION AND UTILISATION AT THE SMALL-SCALE HOLDER LEVEL IN TANGA DISTRICT, TANZANIA

P.E.X. Kapinga[1] and E. Shayo[2] (Mrs)

ABSTRACT

The paper reviews some forage research work conducted in the coastal area of Tanga District and discusses the relevancy of such research in the context of a small-scale dairy farmer. Studies showed that the natural forages produced 5 t DM/ha and were capable of supporting 1 AU per 2 to 3 ha. Improved forages gave above 10 t DM/ha when fertilized whereas fodder grasses and browse plants produced between 15 t and 20 t DM/ha respectively. Recommended fodder species to the farmers include Napier grass (Penissetum purpureum), giant and panic (Panicum maximum) and leucaena (Leucaena leucocephala). Fodder production and quality under the small-scale dairy farming systems is more variable than that reported at the research stations. Reasons for the variations and problems of forage utilisation have been discussed. However, milk production ranged from 5 kg/day, where only forages are used, to 10 kg/day, where forages are supplemented with concentrates. Forage supply throughout the year at the farmer's level is very much limited. Thus the future research strategies are orientated towards solving the problem of feed shortages during the dry season and looking for appropriate technologies for forage conservation at the small-scale dairy level.

INTRODUCTION

The Tanga District is situated in the northern part of the coastal belt of Tanzania. The area receives between 1200 to 1400 mm of rains per annum, falling in two seasons - the long rains (March to June) and the short rains (September to November). Mean temperatures are between 26° to 33°C with relative humidity ranging from 64 to 85%.

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Three soil types are predominant in the district. The low fertile light sandy-loam soils occurring along the coast, the ıedium-fertile red loam soils of the inland and the black soils hat occur along the valleys.

The vegetation cover is commonly known as "coastal forest, ;avanna mosaic' which varies from open grassland (mainly tall lyparrhenia spp) to dense high thicket. Large areas are ›ccupied by wooded grasslands that also support vigorous growth ›f dum-lam (Hypaene tebaica) and gall acacia (Acacia :anzibarica) (Lind and Morrison, 1974).

Research on forages had been conducted at two research ;tations, Mlingano Sisal Research Station (inland) and Tanga .ivestock Research Centre (coastal area). Several forage :rials have been conducted since 1959 (Hopkinson, 1970) and :ould be grouped under such subheadings as (i) assessment of ;razing value and carrying capacity of natural flora (ii) improvement of the natural pastures through fertilizer ıpplication (iii) bush and weed control and the incorporation ɔf improved legumes in the natural sward (iv) grazing nanagement and animal performance studies on natural pastures ınd (iv) adaptability and compatability of improved grasses and legumes.

Assessment of the grazing value and carrying capacity of the natural flora.

Ground surveys, supported by aerial photographs and aerial reconnaissance, were used to map grass-legume associations and assess their importance to livestock production (van Voorthuizen, 1970). The sandy-loam soils along the coastal plain supported important grasses such as Hyparrhenia rufa, H. dissoluta, Setaria sphacelata and Andropogon schirensis. Associated grasses included Cynodon dactylon, Panicum infestum, Digitaria mombasana and Bothriochloa glabra. Several unpalatable legumes were noted to occur but their contribution to the livestock industry were questionable. Such an association was capable of supporting 1 AU per 3.2 ha and produced between 3.9 to 4.5 t DM/ha. The red loam soils were dominated by *Panicum maximum* with few grasses such as *Cynodon*, *Digitaria milanjiana* and *Hyparrhenia rufa*. Van Voorthuizen (1970) noted that the latter grass cover were capable of supporting 1 AU per 2.4 ha and produced 11.8 t DM/ ha when the grass-wooded areas was cleared. Generally, forage production fluctuated under grazing management and were lower than seldomly grazed areas but crude protein levels were reasonable almost throughout the year for both the grazed and ungrazed areas (Watkins, 1969) (Table 1).

Improvement of the natural pastures

Trials aimed at improving the natural pasture through fertilizer application, bush and weed control and the incorporation of improved legumes in the natural pastures had been attempted.

Application of deficient nutrients to the natural sward had produced variable results but generally the response was very low. The light sandy soils are deficient in many important nutrients. The application of N, P, K, Mg, Cu and Co had produced only 4.23 t DM/ha which was a 100% increase over the unfertilized sward (Schmidt and Watkins, 1968). Noticeable changes in the botanical composition of the pasture were the increased legume component wherever P and K were applied (Anderson, 1969; Hendy, 1975).

Table 1. Dry matter (DM) yields and chemical composition of herbage cut from seldomly grazed and heavily grazed areas.

Treatment	Seldon grazed						Heavily grazed					
	DM	DM	CP	CF	Ca	P	DM	DM	CP	CF	Ca	P
	Kg /ha	%					Kg /ha	%				
2 week cuts	1.5	28.6	9.9	34.4	0.27	0.085	0.7	28.0	8.8	31.6	0.25	0.056
1 month	2.1	30.7	8.6	35.3	0.28	0.083	0.9	29.5	8.7	33.8	0.22	0.074
2 months	3.1	39.8	7.0	36.5	0.38	0.083	0.9	42.8	6.3	35.6	0.25	0.064
3 months	3.9	40.5	7.0	35.7	0.38	0.059	1.0	32.4	7.8	36.5	0.35	0.089
6 months	-	-	-	-	-	--	2.0	36.0	7.3	36.4	0.32	0.089

Source: Watkins (1969).

Table 2. Stocking rates and weight gains (kg) by Sahiwal cross bulls grazing natural pastures

Stocking rate Ha/bull	1969 Gain/bull	1969 Gain/ha	1970 Gain/bull	1970 Gain/ha
1.8	170.4^{b}	94.7^{c}	210.7^{c}	67.1^{c}
1.2	188.6^{a}	157.2^{b}	128.4^{a}	107.0^{b}
0.6	172.7^{b}	287.7^{a}	92.7^{b}	154.5^{a}

Figures bearing different superscripts on the same column are different ($P<0.05$).

Source: Broatch (1970).

The problem of bush and weed encroachment in the grazing lands had received the greatest attention as most of the cleared or grazing lands tend to revert into bushland. So far most of the technologies tested have not produced tangible results (Hendy, 1975). It was noted that slashing alone was ineffective in bush and weed control but where slashing was combined with herbicide application (Tordon 101) to the regenerated bushes a 90% kill was achieved (Hendy, 1973a). Burning at the end of the dry season produced partial control of trees and shrubs (Hendy, 1975).

Oversowing improved legumes into the natural sward had to some extent been tried. Hendy (1973b) oversowed several legumes onto the natural pastures after slashing the native vegetation down to 10 cm. The only legume established was siratro (Macroptilium atropurpureum) but gradually disappeared from the sward. The cheapest method of introducing legumes into the natural pastures was the strip ploughing of land and sowing the legumes in the ploughed strips (Carrodus, 1975). Legumes failed to establish when sowed into furrows and ash seed-bed which received triple superphosphate fertilizers.

Grazing management and animal performance studies on natural pastures

The major problem encountered in the use of the natural pastures is that most of the valuable grass species disappear under grazing and are replaced by low producing, less palatable grasses, weeds and bushes (Broatch, 1970; Hendy, 1973c). This occurred even when grazing was practiced at low grazing pressures (Hendy, 1975). Broatch (1970) noted disappearance of Brachiaria spp. at all the stocking rates tried whereas Hyparrhenia sp. disappeared only under heavy grazing (1.2 and 0.6 ha/beast). Animal performance tended to vary with stocking rates (Table 2) and the season of the year. During the rainy period, 1.2 ha/beast gave the highest gain per beast, but all stocking rates suffered similar weight losses in the dry season. In investigating the effects of rotational grazing, slashing and fertilizer application on the growth and botanical composition of the natural pastures and animal performance, Hendy (1973c) noted that the natural pastures were insensitive to the changes in the grazing management imposed over a short period i.e. the botanical composition appeared fairly stable over the entire experiments so far carried out along the coastal area of Tanga Hendy (1975) concluded that the desirable stocking rate and management techniques that can maintain the natural pastures at a reasonable level of production are not yet known.

Adaptability and compatibility of improved grasses and legumes

Forage plant introductions particularly legumes, started in the early 1960s with the objective of smothering weeds and improving soil status in the sisal estates (Hopkinson, 1970). But with falling prices of sisal in the world markets, the sisal company integrated sisal production with other crops and livestock production. Grasses were added to the legume collections and plant evaluation was directed towards getting adaptive and productive forage plants. Forage species proved promising under the light sandy-loam soils. These included

Panicum maximum (local ecotype), *Andropogon gayanus*, *Chloris gayana*, *Macroptilium atropurpureum* cv. Siratro, *Stylosanthes guianensis* and *Pueraria phaseoloides* (Hendy and Carrodus, 1974). Adaptive forages on red loam soils were *Brachiaria ruziziensis*, *Cenchrus ciliaris*, *Chloris gayana*, *Cynodon dactylon*, *Melinis minutiflora*, *Panicum coloratum*, *P. duestum*, *P. maximum*, *Pennisetum purpureum*, *Setaria anceps* and *S. splendida*. Legumes included *Centrosema pubescens*, *Neonotonia wightii*, *Macroptilium atropurpureum* cv. Siratro and *Calopogonium mucunoides* (Hopkinson, 1970).

Responses to fertilizer application varied with species, but generally all responded to the fertilizer application (Table 3). *P. purpureum* gave the highest yields under both fertility levels but the lowest response to the applied fertilizers came from *P. maximum*.

Yields of *C. gayana* went up to 19 t DM/ha when nitrogen fertilizers were applied together with P and K fertilizers at the rates of 90, 90 and 120 kg N_1, $P_2 O_5$ and K_2O/ha, respectively (Hendy and Carrodus, 1974). Compatibility of grasses with legumes had been difficult to achieve along the sandy coastal soils (Hendy and Carrodus, 1974) but several grasses had shown to associate well with legumes on the red loam soils (Hopkinson, 1970). *P. coloratum* and *M. minutiflora* were the most compatible grasses with all the legumes tried but the legume suffered severely under *B. ruziziensis*, *C. dactylon* and *P. maximum* competition. It was also noted that where grass competition was more severe, *S. guianensis* survived the best whereas where the competition was less severe, *P. phaseoloides* thrived the best.

Table 3. Dry matter (DM) yield, crude protein (CP) and phosphorus (P) levels of some grasses at two levels of fertility.

Grass	No. of cuts	No fertilizers DM	CP	P	P+K fertilizers* DM	CP	P
Panicum coloratum	7	6.55	11.2	0.155	13.9	10.2	0.178
Setaria anceps	6	9.35	10.1	0.104	14.3	9.3	0.158
Panicum maximum	9	13.21	9.8	0.13	15.9	11.2	0.173
Brachiaria ruziziensis	7	9.22	9.8	0.093	15.5	7.8	0.161
Cenchrus ciliaris (Coastal)	7	9.54	8.9	0.108	16.9	9.5	0.184
Chloris gayana (Mbarara)	5	9.14	9.8	0.089	15.9	9.0	0.125
Pennisetum purpureum	6	14.35	11.1	0.117	27.0	8.6	0.121
Cynodon dactylon	5	9.23	9.0	0.163	15.8	10.4	0.221
Melinis minutiflora	4	5.09	9.5	0.109	11.7	9.0	0.148
Chloris gayana (Mpwapwa)	7	10.98	9.3	0.090	14.2	8.3	0.157

Source: Hopkinson (1970)

*Rate: P as 200 kg/ha double superphosphate
K as 250 kg/ha muriate of potash.

Table 4. Land use under three smallholder systems.

Land use		1	2	4
		----------ha----------		
Cropping:	Natural pastures	2.12	-	-
	Napier	-	0.58	0.58
	Luecaena	0.27	0.28	0.37
	Cassava	0.56	-	0.44
	Banana	0.32	0.86	0.54
	Sorghum	-	-	0.63
Total crop area		3.85	1.82	0.58
Homestead + animal shed		0.18	0.26	0.12
Total farm area		4.03	2.08	2.68

Limitations on the use of research results

Two main features can be noted from the reviewed work:

1. Duration of the research: Most of the research work reviewed could not last more than two years. Such a short period could not provide enough information on the trend of the results. For example, the experience gained with cultivated forages shows that the plants could hardly persist more than a year under grazing management along the coastal belt of Tanga Region and that legumes had failed to persist more than one growing season in mixed swards.
2. Inconclusive information: In reviewing research work on grazing management, Hendy (1975) pinpointed that most of the stocking rates tried and the grazing management imposed could not provide sufficient information on the management of the forages at reasonable productive levels. This shows that some of the research results do not provide a ready-to-use technology that can be transferred to the farmers or extension personnels.

Considering these two general features it is unrealistic to blame for a weak research - extension/trainer-farmer linkage. Nevertheless, many research findings from outside the district and from other countries with similar ecological conditions have penetrated to some farmers through the extension personnels and farmers' training institutions. This has been the case for the smallholder dairy farmers in Tanga District.

SMALLHOLDER DAIRY FARMING

The smallholder dairy farming is jointly coordinated between the Regional Extension Office and the Farmers' Training Sector in the Ministry of Agriculture and Livestock Development and supported by the Dutch Government through the Smallholder's Dairy Extension Programme (SDEP). The programme is responsible for training farmers in all aspects of dairy husbandry, distribution of heifers to eligible farmers and the monitoring of farmers' activities. The major objective is to improve dairy enterprises on smallholder farms.

The programme started with the identification of the smallholder farming systems and the training of the farmers. Upon completion of the training, the farmers were eligible to the acquisition of one heifer per hectare of planted fodder crops.

This paper will only discuss the efforts taken by Buhuri Livestock Training Institute in transferring some of the forage production and utilisation technologies to the smallholder dairy farmers in Tanga District.

In performing such a task, the institute in collaboration with the district extension office have identified three major types of smallholder dairy farming systems which in turn have led to the construction of three representative smallholder dairy models. The modes are used to demonstrate the keeping of dairy cows at small-scale levels under the village conditions; to monitor any improved technology before introducing to the farmers themselves and to collect useful information and data for teaching and advisory purposes.

During training, the farmers spent most of the time in models (known as units) in order to acquaint themselves with the techniques of establishing and managing small-scale dairy farms.

Types of the smallholder systems

Each system or unit is maintained by a single family and keeps two lactating cows and two followers (mainly calves).

System 1: The animals are tethered on natural pastures which are dominated by locally growing Guinea grass (P. maximum). The system has constructed a multipurpose structure which aids during milking, spraying acaricide against ticks and other managerial practices. The farmer grows leucaena (L. leucocephala), cassava (Manihot esculenta) and bananas (Musa sapiens) for supplementing the natural pastures. The farmer aims at meeting all animal feed requirements from his farm.

System 2: Practices zero-grazing (stall-feeding). Grows Napier grass (P. purpureum), leucaena and bananas. The farmer purchases some feed stuffs especially energy and protein concentrates. The farmer has constructed a good animal shed capable of housing the milking cows and the followers plus a feed store.

System 3: Practice zero grazing.
Grows Napier grass, bananas, cassava, leucaena and sorghum. The farmer has to meet feed requirements from his farm and practices silage making. Animal shed is made from locally available building materials (thatched shed).

Feed supply and utilisation in the three smallholder systems

Many recommended forage species were screened for yield and persistence before their introduction to the farmers. The hairless Napier grass and leucaena were the most productive fodder crops and were highly recommended for use by the smallholder dairy farmers. A dwarf variety of bananas (locally known as Malindi) was also recommended as a fodder crop because it was popularly grown by the farmers along the coastal area and does not dry up in the dry season. Likewise cassava was recommended as an energy supplementary feed for the animals. The average production of each crop is shown in Table 5.

Production figures for the natural pastures, Napier grass and sorghum are within the reported averages but leucaena and cassava produced lower yields (van Voorthuzein, 1970; Hopkinson, 1970; Skerman, 1977; Acland, 1973). Considering that each farm has to maintain 2.9 LUs, the total feed supply from the farms seemed to be above the estimated animal requirement (2.9 LU x 8.75 kgDM/LU/d x 365d = 9262 kg DM/yr). But the actual feed consumption recorded, when hay was used instead of banana pseudostems/leaves and sorghum silage, were 10530, 10815 and 9773 kg DM/yr for the farms 1, 2 and 3, respectively (Table 6).

Table 5. Average feed production in the three smallholder farms.

Crop	Fresh	wt	DM	Farms 1	2	3
	kg/ha	%	kg/ha	------kg/ha------		
Natural pastures	18000	25.0	4500	9540	-	-
Napier	73329	22.5	16500	-	9570	9570
Leucaena	22100	30.0	6630	1790	1856	2453
Cassava	3603	28.0	1009	565	-	444
Bananas	53794	19.0	10221	3271	8790	5520
Sorghum	16917	26.6	4500	-	-	2835
Total				15166	20216	20822

Table 6. Seasonal feed supply and utilization in three smallholder farms.

Farm	Crop	Mid Apr-Mid Jly (90d)		Mid Jly-Sept (75d)		Oct-Nov (60d)		Dec-Jan (60d)		Feb-Mid Apr (75d)		Total Consumption
		Avail.	USed	Avail.	Used	Avail.	Used	Avail.	Used	Avail.	Used	kg DM/yr
1	Natural	58	20	26	20	26	20	29	30	-	-	
	Cassava	5	3	5	3	5	3	5	3	8	8	
	Leucaena	8	5	8	5	8	5	8	5	8	6	
	Hay	-	-	-	-	-	-	-		20	20	
	Total	71	28	39	28	39	28	42	28	36	34	10530
2	Napier	55	20	17	15	-	-	27	20	-	-	
	Leucaena	12	3	12	6	12	4	12	3	12	4	
	Cassava	-	-	-	-	5	2	-	-	5	2	
	Maize bran	5	5	6	6	8	8	5	5	8	8	
	Hay	-	-	-	-	20	20	-	-	20	20	
	Total	72	28	35	27	45	34	44	28	45	34	10815
3	Napier	46	20	14	14	-	-	22	20	-	-	
	Leucaena	16	4	16	6	16	10	16	4	16	10	
	Cassava	6.5	3	6.5	5	6.5	6.5	6.5	3	6.5	6.5	
	Hay	-	-	-	-	12	12	-	-	12	12	
	Total	58.5	27	36.5	25	34.5	28.5	44.5	27	34.5	28.5	9773

Table 7. Daily feed intake by animals in farms 2 and 3

	Maize bran	Leucaena	Banana stem/leaf	Napier	Total
	----------------		kg	----------------	
Fresh weight	4	10	50	140	208
Dry matter	3.5	3.0	6.0	17.5	30.0

Feeding the animals depended upon feed availability. It was noted that when feed supply was abundant, the animals in farms 2 and 3 were fed on the ration shown in Table 7.

Although the dry matter requirements by the animals were met at certain periods of the year, the overall quality of the feedstuffs remained much to be desired.

PROBLEMS IN THE USE OF SOME TECHNOLOGIES

Forage utilisation

Efficient use of the forages produced has been one of the problems noted with the smallholder dairy farmers. The farmers follow recommended spacing in growing the fodder crops but it has been difficult to follow recommended cutting regimes. The farmers are advised to cut the Napier grass within 0.75 -1.00 m height but often they are forced to cut below those heights when feed supply is limited. Likewise, when forage production is at peak the farmers cannot harvest the herbage within the specified height because consumption is below production. It is during this period that fodder conservation could take place (see Table 6 for April - July period).

Some reports show that fodder production from leucaena harvested at one metre height is greater than harvested at the ground level (Pound and Cairo, n.d). Simple trials at Buhuri Training Institute indicated no difference in production between the two cutting heights and the farmers have adopted cutting the fodder at the ground level due to lower harvesting losses and this method is more convenient.

Availability of inputs

The farmers are encouraged to apply farm yard manure in the fields after each harvest in order to boost forage production. The use of chemical fertilizers is very limited due to the high cost. Lack of machinery for cultivation, harvesting and chopping makes the job more cumbersome.

Lack of specialisation

Although the farmers are identified as smallholder dairy farmers, actually they produce a variety of crops for home use and sale. They grow maize, cassava, groundnuts and coconuts. All these other crops have to use the same family labour, land and time. This diversification has led to low forage and milk production. Milk production under the smallholder dairy farming in the rural areas get between 3 to 6 litres per cow per day. Dairy farmers near towns get between 10 and 15 litres per cow per day due to the use of high proportions of concentrate feedstuffs.

FUTURE RESEARCH STRATEGIES

It has been realised that the major problem faced by the smallholder farmers is the inadequacy of feed supply throughout the year. With this in mind, the future research strategies have:-

1. Continued to look for adaptive forage plants that are drought tolerant and can maintain growth in the dry season.

2. Continued to develop cropping systems (crops + forage) for the optimum food/feed production and land use.

3. Been developing proper technology of fodder conservation (hay, silage, etc.) appropriate to the smallholder dairy farmer.

4. Been designing simple tools or machinery which can improve the efficiency of forage production, management and utilisation.

5. Continued to improve feed supply in order to meet the nutrient requirements of the improved dairy animals.

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UTILISATION OF RESEARCH RESULTS IN RANGE PRODUCTION AND MANAGEMENT SYSTEMS IN KENYA[1]

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ABSTRACT

An overview of the development of range production and management research on Kenya is presented. The status of utilisation of research results in range production and management systems is discussed with special reference to their nature, record of utilisation and constraints in their utilisation. On the basis of the nature of available research results and the factors influencing their utilisation, the paper presents a dossier of future agricultural research needs for the small-scale farmers in the semi-arid and arid areas of Kenya.

INTRODUCTION

Actual coordinated range research work in Kenya did not start until in the late 1960's. Much of the early range research work was exploratory and rudimentary in nature, focusing on land use surveys, ecological monitoring and applied research on specific problems of range development and productivity. (FAO), 1967 - 1973; Gwynne and Croze, 1975). However, in the course of the period spanning the mid 1970's and early 1980's, emphasis in range research shifted dramatically away from autecological research investigations to embrace synecological dimensions in response to the utilisation needs of game departments, national parks, irrigation schemes, tourist

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[1] Views expressed in this paper do not represent the official policy of Egerton University or the Government of Kenya.

development organisations and the Range Management Division. In the last half decade we have witnessed a coupling of autecological and synecological research approaches in the investigation of range - livestock - wildlife feed resources. The need and rationale for integrated approaches to the study of range - livestock - wildlife feed resources has been facilitated by the establishment of range research institutions in Kenya with the mandate of prioritising and executing range research programmes with a view to generating innovations for range utilisation and management on a sustained yield basis.

Research institutions with responsibilities in range research and training in Kenya include: Kenya Agricultural Research Institute (KARI), Moi University, University of Nairobi (College of Agriculture), Egerton University (Faculty of Agriculture), Kenya Rangeland Ecological Monitoring Unit (KREMU) and the International Livestock Centre for Africa (ILCA-Kenya) all of which undertake inventory and analysis of range resource base and land-use planning in the rangelands.

In an attempt to provide a broad-based scenario of the status of utilisation of research results in Range Production and Management Systems in Kenya this paper will address aspects relative to;

a) The nature of results available
b) Record of utilisation of available results
c) Limitations in the utilisation of available results
d) Future directions for agricultural research - What needs to be done.

NATURE OF AVAILABLE RESULTS

The available results in Range Production and Management Systems in Kenya comprise technical innovations that have occurred mainly from the National Range Research Centre - Kiboko, its regional substations and other public range research and teaching institutions. These results could be categorised as follows:

Range Improvement

- Bush management
- Reseeding and overseeding

Range Watershed Management

- Mechanical or physical work on soil or vegetation e.g. contour furrowing and range pitting, water spreading, revegetation etc.

Range Plant Ecology and Management

- primary productivity: quality and quantity of forage
- Forage development: evaluation and testing
- Feed preservation and conservation on small-scale farms in semi-arid regions
- Basic autecological and synecological work: habitat variation, ecological status, phenology, physiological and morphological adaptation to drought, soil - plant - water relations, Defoliation stress in relation to water stress and nutrient relations.
- Ecological monitoring: Development of methodologies related to evaluation of range resources; range inventory and analysis of range resource ecosystem components.
- Grazing management: Plant responses to grazing treatments, season of use, mixed species utilisation, stocking rates and grazing systems.

RECORD OF UTILISATION OF AVAILABLE RESULTS

The record of utilisation of technological innovations in the area of range production in Kenya is perhaps not as impressive as the scope of available technical information tends to suggest. The reasons behind these are many but could be conveniently categorized as being administrative, technical and socio-economic. These aspects will be further developed under constraints in adoption of new interventions. It is instructive to note that the research extension concept in range production systems in Kenya is at its infancy.

The concept is as old as the Range Management Division which was formally instituted in 1963. The Range Management Division is charged with the responsibility of research extension among other things.

CONSTRAINTS IN THE ADOPTION OF NEW INTERVENTIONS

Local Involvement

Range planning and development research in Kenya has suffered immensely from inadequate local involvement in projects. Aboud (1982) pointed out that the absence of local contribution in the design of projects meant for the benefit of country socio-technical constraints generated by the beneficiaries were responsible for the failure of the projects. Projects designed by outsiders were viewed with suspicion by local people. The recognition of the need for such projects remained nebulous in the minds of the innovators (Child et al, 1984).

Land Tenure Problems

Lack of control over land is one of the major problems limiting range livestock production systems. Production systems in Kenya include Commercial Ranching, group ranching and pastoralism. Many range improvement projects have not realised their objectives because land policies are not adequate to deal with the problems of better control of grazing land as is the case with the group ranches in Kenya (Ayuko, 1981). It has been an uphill task for the government to convince individuals to apply available technologies for pasture improvement for collectively grazed cattle or to attempt to improve existing forage base by reducing livestock numbers. Attempts made during the colonial and post-colonial era to sedentarize pastoral peoples have been disappointing because the confinement of large herds in unviable ecological land units resulted in overgrazing, soil erosion and ecological degradation. Sandford (1983) argues that the "tragedy of the commons" analysis makes several unjustified leaps if it leads to the conclusion that private ownership is the answer. He also observes that behavioural models used in the analysis may not be supported by anthropological studies. We now know that some of our pastoral tribes in Kenya have well structured regulations which when adequately enforced result in appropriate levels of control of livestock grazing. The notion that nomadic or transhumant populations must adopt sedentary lifestyles may not be tenable in all situations as our Kenyan experience demonstrates.

Appropriateness of Technology

The nature of available range research results often do not translate easily into extension messages that can readily be adopted by the clients. Sometimes, the rationale underlying the implementation of range improvement or grazing schemes remain unappreciated by a majority of the clients. For instance the requirements for the maintenance of certain grazing pressure and adherence to a grazing calendar associated with conventional grazing systems in contrast to the traditional wet-dry season grazing cycles are beyond the comprehension of pastoralists.

Cost of inputs

A considerable proportion of range research in Kenya is conventional research carried out under controlled conditions of an experimental farm.

Many technological innovations recommended by research stations are costly in terms of inputs and associated management operations which tend to run beyond the financial capability of the average pastoralist/farmer. However, the government provides subsidies relative to certain inputs (e.g. breeding stock) and extends credit facilities through the Agricultural Finance Corporation to enterprising innovators.

Research Extension Methodology

The range extension service in Kenya utilises "baraza" (group meetings) as the recipient group of range production innovations rather than a select group of clients actually involved in range-livestock production. It is assumed that of relevant extension innovations, packages will be received and adopted by more advantaged innovators from whom the less advantaged innovators would learn (Aboud, 1982). Our experience in Kenya has shown that this may not necessarily happen. If it does happen at all, it is a very slow process indeed.

The concept of training and visits although plausible in principle has been faced with many constraints in range extension programmes in Kenya (Towett, 1986). Some of the problems have included inadequate infrastructural facilities constraining mobility, personnel resources, lack of equipment and administrative constraints (e.g. Range Management Division in Kenya falls under the Ministry of Agriculture administratively and not directly under the Ministry of Research, Science and Technology).

Social Acceptability of Interventions

Traditional range - livestock production systems in Kenya and indeed in many parts of Africa are substantially geared towards servicing subsistence needs. Other auxiliary livestock utilities include social status and prestige. These service functions have no inherent self driving inertia. Moreover, these systems are not managed as business operations of opportunities for improvement. This is particularly the case even today with our pastoral sector in Kenya mainly being managed as business operations and therefore remain unattractive and uncompetitive in terms of opportunities for improvement. This is particularly the case even today with our pastoral sector in Kenya mainly being managed by pastoral groups which include among others Maasai, Samburu, Turkana and Rendille. Complicated social and cultural organisations centred around livestock grazing and management have evolved among these pastoral groups.

Our experience with the Kenyan situation is that these traditional systems are not easily tractable to adopt interventions arising from research based on experimental research stations. This lack in the reception and adoption of new interventions calls for serious attention to multiple - use land management systems and for utilising the wealth of local knowledge, and indigenous plant and animal genetic material. Exotic species have been introduced, tested for a short time, and suggested for adoption only to have these species dramatically affected by periodic drought, parasitic infestation, adverse social acceptability or disease.

FUTURE DIRECTIONS FOR AGRICULTURAL RESEARCH - SOME THOUGHTS ON WHAT NEEDS TO BE DONE.

- It is important that research meant to address the real needs of range production clients be carried out under actual field conditions and not under idealised controlled conditions of an experimental farm.

- There is need to understand historical and co-adaptive dimensions of savanna ecosystems in order to be in a position to shed light on the functioning of these systems and help to shape their future development.

- It is apparent from a review of existing research work on Kenyan Rangelands that a fair amount of technical innovations are available. However, there is need to place these interventions within the broader social context in order to enhance their social acceptability and implementation.

- We require studies of traditional resource management and production systems as a basis for identifying constraints and prioritizing research and ensuring that new interventions are relevant to the concerns and needs of Africa's small-scale farmers.

- It is apparent from the present review that serious consideration needs to be given to our research extension linkages with a view to strengthening them. New technological innovations are of no use if they cannot be disseminated and at the same time meet the needs of the intended consumers.

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THE USE OF CROP RESIDUES FOR LIVESTOCK FEED BY SMALL FARMERS IN THE GAMBIA

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ABSTRACT

The Gambia, one of the smallest countries in Africa, was the location of The Mixed Farming and Natural Resource Management Project from 1981-86. The goals of the project were to intensify and integrate crop and livestock enterprises in existing Gambian farming systems. Cattle production was to be improved through better nutrition during the dry season, by range management techniques including deferred grazing, improvement of rangelands through re-seeding and root transplants, and the storing and feeding of crop residues. Village-level feeding trials were conducted in four villages in 1983 and had increased to 33 villages by 1986. Not all land innovations were used in each village. Socio-economic factors such as the land tenure system, social value of cattle, high labour requirements, limited market access, low land pressure and farmers' goals had a profound effect on acceptance of the innovations. Development and farmer goals must converge before acceptance and adoption will occur.

INTRODUCTION

The climate of The Gambia is characterized by a distinct, short rainy season from July-September and a long, dry season in which rain never occurs. Total annual precipitation is 600-700 mm. The sharp dichotomy between rainy and dry seasons is the dominant feature of the agricultural environment. The major cash crop and source of foreign exchange is groundnuts; the preferred crop food is rice.

Gambian farming systems are oriented around production of groundnuts, rice and other cereals. Fallow lands around the village, forests and swamps are considered to be communally owned for grazing as are cultivated lands after harvest. The farming systems are mixed agriculturally, with farmers producing crops and owning livestock. Small stock such as poultry and small ruminants are owned by many and are usually kept in the compound areas. Draft animals (horses, donkeys and oxen) are used extensively, primarily for transport. Everyone aspires to own cattle, even urban dwellers, but only one ethnic group (Fula) historically has experience in cattle management. Cattle are of the N'dama breed which is fairly trypanotolerant.

The major feature of cattle production is the way the herds are managed and their migration patterns. Animals are grouped together into one or more herds and are cared for by a hired herder who is most often Fula. The herder is responsible for keeping the animals away from the croplands during the growing season and for assuring that they have feed and water most of the year. Herders are paid on a per head basis and, when near the village, must share any milk with the owners. Water and forage availability are the most important factors when herders make migration decisions.

METHODOLOGY

The Mixed Farming and Natural Resource Management Project (MFP) was a joint project of the Gambian government and U.S.A.I.D (United States Agency for International Development) started in response to the growing pressure of both human and livestock populations on Gambia's limited land resource base. Cultivation of former grazing areas, especially swamplands, led to conflicts for food versus feed production. In 1984-85, for example, cattle population increased by 7.3% while human population increased by 3.4% (Vesseur et al., 1986). Both the Gambian government and U.S.A.I.D. felt that crop and livestock production needed to be integrated.

The project concentrated its activities on bushland and upland rainfed agriculture, working with farmers and livestock owners to determine how an adequate year-round forage supply for their livestock could be produced. The first two years of the project were involved with collecting baseline information on the farming systems, research on maize and forages, on-station livestock feeding trials, range management and seed multiplication. Although the project worked country-wide, range activities were concentrated in the two most eastern divisions, McCarthy Island Division (MID) and Upper River Division (URD). The technologies were designed to be extended easily through a combination of modest governmental support and strong farmer acceptance. Technologies were to be such that farmers could continue to use and adopt them regardless of government support.

Although there continued to be several distinct activity areas for project staff, a serious attempt was made to integrate all of these activities by 1983-84. Interdisciplinary village-level activities became the operative words for the final two years. The range management and forage production programmes operated on both the research stations and in villages. Research station work was directed toward forage introductions, seed multiplication of grass and legume species, intercropping experiments with forages and cereals, and cattle feeding trials using crop residues. Objectives of the village feeding trials were to defer an area from grazing near the village, improve it, encourage the storage of crop residues, and develop a year-round feeding strategy for cattle.

Groundwork for the village programmes was laid early in the project by meetings with Livestock Owners Associations (LOA). Villages were asked to set aside at least two hectares of land for deferred grazing and range improvement. One hectare was left unfenced, the other hectare was fenced with wire mesh and barbed wire, using creosote-treated Gmelina arborea posts and steel fence posts. No attempt was made to utilise local fencing materials. Fire lanes were made around each plot. Plots were seeded with Cenchrus ciliaris, Stylosanthes hamata, S. guianensis, S. scabra, Andropogon gayanus, and Panicum maximum. The latter two were also root transplanted. Two weedings the first year were essential for good stand establishment and grazing had to be deferred for two rainy seasons. Shrubs were controlled in some areas with herbicide injections of 2, 4-D. The project provided fencing, seeds, herbicides, and transport while the villages provided labour.

Crop residues have been an underutilised resource in The Gambia. After harvest of the various cereal crops, the residues are left lying in the fields. When the animals return to the village areas after the cropping season, they are allowed to graze on these residues but trampling spoils much of this available fodder. The project encouraged the saving and storing of these residues in a variety of ways. The only crop residue that had been used to any great extent was groundnut hay which was saved for use by draft animals and small ruminants over the dry season. Farmers were encouraged to be more efficient in gathering of the groundnut hay as it was by far the best quality feed for their animals.

Four villages were selected to participate in actual feeding trials in 1984, all of them in the eastern part of the country. These were:

Village	Significant features
Boiram	Swamplands used for grazing have been converted to irrigated rice production; most grazing sites are 1-5 km from water.
Pinai-Choya	Extensive swamplands but severe competition from other herds during dry season.
Sukuta	On river but banks are very steep; large warthog population causes serious habitat destruction.
Makama Sereh	Limited river access; one-third of grazing sites > 5 km from water; wells dry up by mid-dry season; severe soil erosion; very isolated.

Villagers were asked to contribute two animals each for the feeding trials, one of which would remain with the village herd under normal management conditions, the second of which would participate in the feeding trial. Long, protracted discussions took place concerning what class of animals should be fed. Two types were considered good candidates by the villagers - the old, sick and lame cattle or young heifers. The latter were chosen with a view toward the possibility of calving earlier than the 4-5 year norm. This decision to choose heifers was not without a great deal of project staff input. Almost all of the farmers in these villages, regardless of whether or not they owned cattle or belonged to a Livestock Owners Association, contributed some of their crop residues for the feeding trial.

The feeding trials started in January 1984. The heifers were dewormed, ear-tagged and either weighed (at Boiram) or taped for girth measurement. The "fed" group were placed in the enclosed area where the crop residues had been stored and were fed there for three months. Crop residues were maize, sorghum and millet stovers, rice straw, Andropogon and Panicum hay, and/or groundnut hay. The heifers were either taken to water once a day or water was brought to them. They then went onto the deferred range area for two months and finished the dry season back in the enclosed areas on groundnut hay. By 1986, 33 villages were participating in the feeding trials. Not all villages had every component of the package. In many villages only crop residues were stored and fed without any deferred grazing areas being developed. These latter villages were also participating in the project's maize programme so that maize stover was the primary crop residue saved in 27 of the 28 villages which had only a supplemental feeding programme. Estimates of the amount of maize stover used in 1986 were over 80 tons on a dry matter basis.

RESULTS

Boiram was the only village where we were able to place a scale so quantitative data are scarce. In 1984, heifers in the fed group lost an average of 2 kg over the six month period while the heifers that remained with the herd lost an average of 10 kg, representing 3 and 13% of their body weights. An attempt was made to record girth measurements of the heifers in the other villages. In all of the village programmes, elicited responses from villagers were that the heifers in the feeding trials looked "better" than those not in the trial but these are purely subjective data.

Watering was continually a problem during the feeding trials and methods of watering were modified on a village to village basis. Water was either brought to the enclosed area or animals were trekked to the nearest water source whether it was a well, a swamp, or the river. The watering problem caused the most discussions among the villagers and led to the abandonment, in some cases, of cooperation between villages and a strike, in another case, by village women who refused to draw well water for the heifers. Several villages hired a herder on a part-time basis to take the animals to water once a day.

In the deferred range areas there were significant improvements in the amount of biomass on offer provided that the fence had remained in place, the livestock had been kept out, that the area wasn't burned accidentally or intentionally or that the land wasn't claimed for crop production. Utilisation of biomass in the deferred grazing areas ranged from 29 - 58% with stocking rates of 6 - 12 TLU (Tropical Livestock Unit) /ha in the 1985 season. In Pinai-Choya a bush fire accidentally set by honey seekers destroyed most of the area four days after the trial started in March 1985. Fortunately, the stored crop residues were not burned.

During the first year of the feeding and deferred range programme it was observed that the weights of the control group did not start to drop until the end of March after the heifers had been in the feeding trials for three months. As a result, the following year's feeding period was changed to start in April. This was an advantage in that less labour was required to store crop residues. The actual manner of feeding the crop residues was also changed by villagers from the recommended method of separate storage and feeding areas with communal feeding of all the heifers once a day. Some villages tethered the heifers inside the enclosure with individual owners placing a quantity of crop residues before their animal once or twice a day. Other villages simply allowed all animals to enter the storage area freely, eating from stocks at will. Another adaptation of the crop residue feeding was that it changed from being a communal effort by several villages to single village efforts to, by 1986, individual efforts. In other words, owners began to save their own residues for their own animals in their own compounds. Farmers expressed surprise that their cattle would eat so much of these crop residues, in particular the maize, sorghum and millet stovers and the rice straw. Utilisation of the stovers was as high as 60% and up to 100% for groundnut hay (Deffendol, 1986).

DISCUSSION AND IMPLICATIONS OF RESULTS

The role of Animals in Gambian Farming Systems

Although livestock owners originally agreed that feeding young heifers made sense, as time went by, the older, sick and lame animals found their way into the feeding programme. This is the first example of the conflict between development and farmer goals. Development can be defined as increased total production of crops or animal products, also involving improvements in efficiency, e.g., increased output per unit of labour and increased output per unit of land. The development expert would thus see the long term goal of improved fertility of young heifers as the logical endpoint of a feeding programme. However, the Gambian livestock owner, whose goal is maximisation of total number of animals, sees the survival of all his or her animals right now as the more logical and attainable end. In the event that project staff were right about improved nutrition improving fertility, the owners placed a bull in with those heifers that were being fed additional feed in the feeding trials.

Project interviews of cattle owners at the central abbatoir indicated that owners do not sell their livestock at a seasonally opportune time. Over 3000 observations were made of slaughters in 1985 disaggregated by sex and age (Russo and Spencer, 1988). Male cattle made up 80% of the kill in February when cattle were declining in weight and body condition. In July the cattle kill of males dropped to 50% when cattle were beginning to gain weight. Yearly average kills for 1985 were 63% male and 36% female. Table 1 indicates the contribution of livestock to farmer income in The Gambia. Total income from livestock represents, however, less than 25% of the total farm income. livestock owners in The Gambia as in other West African countries look upon livestock as a form of risk reduction and security. Livestock contribute to farmers welfare in ways other than income or monetary considerations. In a livestock survey in 1985, owners indicated that even with more reliable markets they would be reluctant to sell any animals until cash needs were sufficiently demanding e.g. procurement of food for the family.

Table 1. Contribution of livestock to farmer income, The Gambia, 1985.

Item	% of Total
Sales and consumption	
Cattle	28.4
Sheep & goats	14.7
Milk	35.1
Draft	12.9
Manure	8.9

Total	100.0

Inputs into livestock management are labour, feed and capital, usually drugs (Table 2). Labour per herd is higher for cattle but lower per head. Note that cattle, sheep and goats rarely received any feed while draft animals always do. Looking at the economic efficiency measures in Table 3, cattle are indicated as having the highest net earnings per unit of labour and per head for the herds studied in these four villages. A significant reason for the high return per unit of labour is the use of contract herders. Because the herds are taken away from the crop areas during the rainy season, compounds (the farm household unit) incur no labour costs for cattle production. Sheep and goats show better earnings per TLU and 1 Dalasi cost than cattle (see Table 3), yet cattle are still preferred by most Gambians. This suggests that social considerations regarding cattle ownership are more important than monetary values to Gambian livestock owners.

Land Tenure Effects on Livestock, Crop, and Forage Production

The land tenure system in The Gambia does not function along Western (capitalistic) understanding of land ownership. Western land ownership is based on the concept of freehold while in The Gambia and much of rural Africa, the landholder has a very different set of rights. Land is to be used for specific purposes with certain restrictions, most notably, the restriction on transfer of rights. The original cultivators of the land have usufruct right that is heritable but not alienable. Moreover, lack of use means the land reverts to the village and can be reassigned by the village chief or elders. The grazing lands are open common to which every Gambian has free access. Grazing land includes almost all national territory which is not built on, cultivated or set aside as a national forest reserve (Eastman, 1986).

Table 2: Inputs utilised in livestock management in four Gambian villages by 24 farmers, 1985-86

Livestock	No. of Herds	ave. herd size	Labour per herd	ADE[a] per head	Feedstuffs (kg) per herd	Feedstuffs (kg) per head	Costs per herd[b]
Cattle	19	22.2	102.9	4.6	26[c]	1	22.63
Sheep	13	6.6	33.3	5.1	0	0	2.19
Goats	18	5.3	28.3	6.1	0	0	2.50
Oxen	11	1.9	44.1	19.4	1838	808	1.36
Horses	10	2.7	64.1	23.3	5159	1876	1.00
Donkeys	17	1.8	40.3	22.4	1482	826	0

[a]ADE = Adult Day Equivalent
Labour time from males and females 13-59 yrs is 1.0
Other ages is 0.5. Total weighted hours are divided by 8 to calculate ADE

[b]In Dalasis, 1 US = 7 D.
[c]One farmer fed groundnut hay to a single sick cow in June

Table 3: Economic efficiency measures for six livestock types of 24 farmers, 1985-6

Donkeys	ADE[a]	Head	TLU[b]	1 Dalasi Cost
Cattle	11.91	54.49	69.03	34.36
Sheep	8.45	42.78	426.17	128.43
Goats	5.93	31.84	452.24	67.11
Oxen[c]	-17.40	-337.73	-422.22	-.83
Horses[c]	-40.50	-944.53	-944.53	-1.01
Donkeys[c]	-17.87	-401.24	-177.61	-.97

[a]See Table 2 for definition
[b]TLU = Tropical Livestock Unit
1 cattle = .8 TLU 1 ox = .8 TLU
1 sheep = .1 TLU 1 horse = 1.0 TLU
1 goat = .07 TLU 1 donkey = .52 TLU
[c]Numbers for draft animals do not include value of draft services

Conflicts over intrusions into crop lands are both frequent and intense yet very few conflicts are reported over grazing lands. Gambians do not believe that the livestock belonging to other Gambians should be excluded from grazing lands. Death losses, while serious in dry years, are still not perceived as unacceptably high by livestock owners. Lack of forage in the late dry season is not seen as a serious problem. Fencing an area that is not cropland to keep cattle out of it goes against their traditional beliefs about open commons yet forage production and rangeland improvement required exclusive control over the land just as crop production does. Experience elsewhere in Africa has shown that controlled grazing is extremely difficult to achieve in democratic societies and is even difficult to achieve with coercion. The majority of farmers disapprove of fencing and controlled grazing because they do not see any benefits accruing directly to them. Livestock ownership therefore assumes the role of land ownership, i.e. the more livestock an individual owns the more the benefits of the community's land accrue to that individual (Hopcraft, 1981). Still, many Gambian villages have grazing areas where they have already established more or less exclusive customary rights through years of continuous use and would be the type of villages in which to initiate deferred grazing and fencing schemes. Makama Sereh, the very isolated village in these studies, had the most success with deferred grazing because there were no intrusions from outside livestock.

Forages in Gambian Farming Systems

The concept of a crop that is planted solely for use by animals is totally outside Gambian experiences. Livestock owners were always impressed by the numerous types of forages they saw at field days on the research stations but except for less than half dozen owners, most did not care to try forage production for their herds. Every attempt at forage production in the villages, especially in the case of fodder banks, met with misunderstandings and conflicts. Land presumably given for several years to the project for legume fodder banks would get reassigned by the chief for crop production in the second year. Often, livestock themselves would unfasten the gates of the fodder bank and totally defoliate it. The production of forage crops conflicts with food crop production for both land and labour. Improvements of the deferred grazing areas, for example, took place at the same time that farmers were busy with their food crops.

Two conflicting forces operate against including forages in either small pastoral/semi-pastoral productions systems (McIntire and Debra, 1986). One is land abundance in rural areas where herds are highly mobile, such as in The Gambia. Forages compete with rangeland and crop residues which can be grazed with very little labour input. The second force operating against the inclusion of forages into the system is land scarcity near urban areas, such as Dakar, Senegal, or in rural areas where land is scarce due to high population pressures, such as Western Kenya. There, forages compete with food crops for land while more crop residues are available. Table 4 indicates these conflicts and interactions and includes the use of crop residues. One interaction is that crop residues can be transported to urban areas and sold; another interaction is that the herds can move to the rural areas. In The Gambia, the advantages of livestock production as practiced currently in terms of labour saving alone make it difficult to convince farmers of the value of forage production *per se*.

Finally, many villagers looked at the imported fencing materials and imported seeds and saw that this technology was beyond their reach. Not only was it capital intensive in that fencing 10 hectares cost approximately US $2000 but also no attempt was made to use locally available fencing materials or local forages. Thick, strong fencing of garden plots, compounds and mosques is quite common, for example. Herdsmen were asked (Lawry, 1987) if they thought it was possible to have deferred grazing areas without fencing and they were very doubtful, citing the tradition of the open commons as the reason. As for the plant species used for renovations of the sites, Andropogon is the only locally available species, all of the other species are imported.

One of the project's goals was to develop a forage production programme in the Ministry of Agriculture, both in agronomy and range management. As discussed above, forage production in The Gambia faces a number of obstacles. It will occur if farmers see it as providing benefits to them and their livestock. That it will do so is not yet apparent to Gambian farmers. The Mixed Farming Project was mandated to begin a forage agronomy programme which the agronomists started in the usual way, e.g., plant introductions, variety testing and fertilizer trials. This has been termed the notional stage of technology evaluation and is the norm for the beginning of most projects (Menz and Knipscheer, 1981). While such research definitely needs to be done in The Gambia, it should not have been the sole focus of the forage programme because improved forages and pastures do not fit into current Gambian farming systems. Nor, as discussed earlier, will forages fit into many other African farming systems with abundant land resources.

Table 4. Food Vs. Forage Vs. Crop residues

LAND	CONSTRAINT	
ABUNDANCE	- Food and forage crop production coincide	-Forage crops are not grown
	- Crop production requires	- Crop residues use not economical more workers than herding unless it is done when there is a (i.e., grazing) labour surplus (i.e. after food crop harvest, during dry season, by children, etc) or it can be transported and sold in urban areas.
SCARCITY	- Forage crops compete for crop lands	- Forage crops are not grown
	- Management of crop residues	- Crop residues become more increases, requires more valuable animal production may workers increase, herd mobility decreases (i.e., stall feeding or animal production decreases (i.e., large ruminant production moves to rural areas).

Adapted from McIntire and Debra (1986)

The success of the Crop Residue Feeding Innovation

The only well-accepted innovation was the adoption of crop residue storage and feeding. As mentioned earlier, farmers have their groundnut hay for use by draft animals and small ruminants during the dry season. Therefore, it was not a major technological leap, complicated management decision, nor sociological blunder to ask them to save other crop residues. Four years of research station feeding trials using every type of crop residue in several combinations showed that weights of growing animals could at least be maintained, if not increased, over the dry season (Hedrick and Bojang, 1983; Russo and Ceesay, 1986). This was corroborated in the village studies by livestock owners who could see these benefits immediately. Furthermore, in 1985, the rains were late so that only those villages with stored crop residues had feed for their animals. This made a deep impression on livestock owners and probably contributed to the adoption of this innovation that year.

The major problem encountered was the amount of labour required to store the crop residues. People are busy harvesting crops but could not take the time to stack the crop residues. One solution to this problem was through community work days, a common practice in this Muslim country. A second problem was the actual manner of storage, whether on platforms, in the field, fenced, etc. Field staff were trained in storage techniques, a handbook was written for extension staff (Russo, 1985), and many discussions with farmers took place. Once it was explained that the crop residues had to be stacked so as to avoid termite and small ruminant access, villagers soon came up with their own local modifications and ways of storage. In late 1985 when technical input by both the project and the government was minimized, a survey was done of all the participating villages and surrounding villages to see what farmers were continuing to do without project input. Overwhelmingly, the crop residue storage portion of the deferred grazing scheme was the only part that was being continued and picked up by other villages which had not been in the programme (Russo and Patrick, 1986, unpublished data). These adopting villages were all Fula, the only ethnic group with experience in livestock management. This raises an interesting question as to the importance of training crop farmers in animal nutrition and management. An independent survey in 1987 of villages participating in the feeding trials (Lawry, 1987) also showed that the principles of crop residue feeding have been widely adopted in both eastern districts.

A FRAMEWORK FOR FARMER ACCEPTANCE

An early examination of Gambian farming systems which could have included socio-economic information and a more thorough investigation of secondary sources of data about similar projects would have led to a somewhat different design for this project and a much different approach to the field work. It is the current vogue to examine the "failures" of livestock development projects in Africa but concrete suggestions to prevent such failures are few. The most blatant design flaws are an oversimplification of the farming system and strong disciplinary biases. Focus on only one problem, for example, inadequate feed supplies during the dry season, by only one discipline such as range management inevitably leads to perceived failures by both the development experts and the farmers.

The project tried to introduce four innovations through these village-level feeding trials with varying degrees of success. Why did it fail dismally with some innovations and succeed with others? The answers lie not in the biological feasibility of each innovation because all were possible. The blame cannot be laid on project personnel, political reasons such as researcher vs. extension conflicts, nor weather as all impinged equally on all innovations. Rather, answers must be looked for in socio-economic areas. Borrowing heavily from social science researchers, a methodology is proposed that can be used in developing a framework for designing farmer/user level programmes. This framework focusses on the potential goals; conflicts that may arise between the so-called development experts (both national research and extension staff and expatriate staff) and farmers. Development is not simply the study of responses to an innovation by a group of local people but a study of the critical interactions between at least two groups (Galaty, 1981). Use of this framework on the four innovations is described by Table 5. It can be seen that while development goals and farmer goals are similar, i.e., production of more feed, farmers concerns in 3 out of 4 areas prevent them from adopting the innovation. These concerns are all socio and/or economic. Some of the farmer concerns are beyond their control, such as the land tenure system; while some could be alleviated by cash alone. The framework simply asks what logical conclusion can be reached concerning farmer acceptance based on the constraints he or she faces. There may be possible conflicts between government planners and donors who have specific concepts and goals, local staff with their own agendas, and the farmers who have a socio-economic system which is perceived as being flawed by the former two groups.

This framework is used in Table 6 to explore other possible innovations associated with livestock production in a mixed agricultural system like The Gambia. The innovations are rotational grazing, imposition of a grazing fee or setting livestock quotas, practising selective feeding of certain classes of livestock, and increasing offtake. With rotational grazing, goals are similar in that more feed is a desired product but farmers cannot or do not want to devote labour to increased herd management. A grazing fee goes against farmer goals to maximize herd size and against an almost universal goal to avoid taxation of any kind. Farmer acceptance of the first two innovations could be modified by a government and about which farmers can do nothing. In the case of selective feeding, again, a change in government policy, in this case, the price structure, allowing more to be paid for better quality meat might encourage more sales. Selective feeding is a system requiring much labour and contact hours per animal. In the Gambia, livestock owners are rarely the managers; over 90% of the input cost in livestock production is for contract labour. The last innovation, increased offtake, could only occur if nutrition were improved, leading to improved calving and calf and adult survival. Data show that there are very few surplus males, that the calving interval is 1.5 years, and that calf mortality is 16% (Vesseur et al, 1986). For the latter two innovations, farmer acceptance is questionable but not necessarily negative.

The major problem with this framework, or with any other, is getting people to use it. Using the framework may seem unwiedly or too "soft" an approach for a biological scientist but it is a rapid way to test which innovations might be more acceptable to farmers and therefore, more likely to succeed. Researchers who are willing to try a new fertilizer or vaccine should be equally as willing to use the tool of another discipline such as social science, to improve their programmes.

Table 5: Innovations introduced by the Mixed Farming Project, 1981-86

Innovation	Development goal	Farmer goal	Farmer concerns	Farmer acceptance
Range renovation	more feed	more feed low inputs to LS	land tenure system, low land pressure, labour, no seeds	no
Deferred grazing	more feed < overgrazing	more feed low inputs to LS	land tenure system, social cost economic cost	no
Fodder banks	more feed > production	more feed low inputs to LS	land tenure system, compete with CS, no seeds, 'free' range vegetation	no
Crop residue feeding	more feed > livestock production	more feed low inputs to LS	tradition low conflict with CS	yes

LS = Livestock systems
CS = Cropping systems

Table 6: Possible innovations in rangeland management for The Gambia

Innovation	Development goal	Farmer goal	Farmer concerns	Farmer acceptance
Rotational grazing	more feed < overgrazing	more feed low inputs in LS	land tenure system high level costs	no
Grazing feed or livestock quota	< overgrazing	> herd size	land tenure system inequitable seen as tax	no
Selective feeding	> production	> herd size	save all animals, no market incentive	?
Increased offtake	> production	> herd size keep all females	management incentive to market prices most males already sold	?

LS = Livestock systems

CONCLUSIONS

The struggle to design meaningful, useful and appropriate research is not new and, in fact, has been the subject of many meetings, conferences and panels. Concerned individuals and institutions continue to believe that there must be a better way and that it must be found soon in the light of the very real problems faced by Africa. Recently, several researchers have been developing frame workers and models to link technological innovations and the agricultural system that is both under study and the target for development. These frameworks vary in their methodological approach, some using local research and extension staff, secondary sources of data and farmers as key components in design (Patrick and Russo, 1988) while others rely heavily on research staff, experimental data and computers (Hart, 1987; ILCA; 1987). The former, into which this particular framework can be fitted, is useful in farming systems where little quantitative data is available yet much is known about constraints in the system. It could, indeed, be seen as the first step for the more quantitative frameworks and models. The more analytical frameworks and models are useful in agricultural systems which have had the benefit of physical and biological experimentation and where a decision needs to be made concerning which of many alternatives to choose.

In many projects, potential development impact is not quantitatively considered in the design and evaluation of the technology selected (Hart, 1987). There are too often serious gaps in knowledge and time lags between the notional stage of technology evaluation which is the start of a project and actual field implementation by farmers which could be ten years down the road. Use of any of these frameworks to facilitate an integrated development process is not only indicated, but essential. Most planners seem to remain unaware and insulated from the findings of experienced field workers that the most important aspect of development is involving local populations in the planning, design, implementation, and evaluation of development activities intended for their benefit in light of both farmer and development goals that the likelihood of success increases.

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FORAGE RESEARCH AND DEVELOPMENT FOR LIVESTOCK PRODUCTION IN UGANDA

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INTRODUCTION

The high potential for pasture productivity and subsequent animal production in Uganda has not been fully exploited mainly because the existing research data is not easily applicable to the livestock farmers. For example, virtually all the available data since the 1950's has come from research done on research stations with little relevance to farmers problems related to pasture management and utilisation. Even that portion of the data that could be utilised by the farmers is still locked-up on these stations, in libraries or with the individual scientists. But most important is that the overwhelming data is either descriptive or basic in nature probably because of the developmental stage in forage research in the country.

There are also several factors that have limited utilisation of some of the research data that has relevance to the farmers' problems. These include lack of emphasis by the Government to support the application of such research data, limited manpower to develop co-ordinated research and to conduct on-farm research and to extend the results to farmers, lack of the necessary inputs, type of data available and lack of continuity in the research programmes.

The objectives of this paper are to review critically the research data on forages with the view of identifying the major constraints that have limited their utilisation and to suggest appropriate approach for generating utilisable forage research data by the farmers.

Review of forage research programme since 1900

Until up to 1947, grass in Uganda was typically used for resting land in the crop rotation system or shifting cultivation. Emphasis was laid on soil conservation rather than grazing as this was considered detrimental to the soil fertility and subsequent crop production. Fortunately, Kerkham (1947) found that the grazing of the "resting" land was beneficial. Later on Stobbs (1969) and Stephens (1967) confirmed Kerkham's findings. Their data created a new awareness about pasture research that could be considered as a "true crop" (Henderlong, 1973).

Type of research

Considerable review of research work done in Uganda since 1900's has been given by Henderlong (1973), Ogwang (1974), Ochodomuge (1978), Sabiiti (1980) and more recently by Byenkya (1989). Most of these reviews did not bring out vividly the limitations or which research data was not easily applicable.

The following types of research were highlighted namely, descriptive or exploratory, basic research (quantities) and applied.

Descriptive research

This was necessary because information was needed before forages could be introduced and this work began in 1906 up to 1954. During this period several grasses and legumes were identified and by 1958 about 8 grass and 9 legume species were recommended for further research Horrell (1958) and by 1970 a generalised recommendation of forages for different agro-ecological zones was produced (Table 1).

Quantitative research

The work which followed descriptive research emphasized quantitative data on establishment, seeding rates, fertilizer requirements, grass/legume mixtures, inoculation, intensity of grazing/defoliation, chemical composition and digestibility and grazing trials to determine acceptability and animal production.

In all, over 25 research projects of this type have been reported (see references). Since most of this data was basic, little of it could be utilised by the livestock farmers. For example, knowledge about chemical composition and digestibility which is abundant (Bredon and Horell, 1963; Bredon et al., 1963 (ab, Ogwang, 1974; Reid et al, 1973; Soneji et al., 1980; Mugerwa and Bwabye, 1974; Odwongo and Mugerwa, 1980) although very useful in forage evaluation, has no direct meaning to a local farmer and as such a lot of these data are purely academic and could not be utilised. A few examples of basic data are given in Tables 2-4 and that have no relevance to solving our farmers problems.

However, to an educated farmer, some of these data may be useful since one could see easily the trend in crude protein and digestibility with age.

The most useful quantitative research data available have, unfortunately, been provided by a few research workers in Uganda between 1965 and 1978 (Stobbs, 1965; 1966; 1969; Bareeba, 1977; Odwongo 1976; Mugerwa et al, 1973; 1974; Musangi, 1965; 1969; Soneji, 1970; 1971; Tiharuhondi, 1970; Olsen, 1971; 1972; Olsen and Tiharuhondi, 1972; Mugerwa, (unpublished data). These researchers related forage production and animal responses. A few examples are shown in Tables 5-6. Such data have a real practical meaning to the farmer because the farmer is able to see the final product in terms of milk, beef or crop yields and the costs when he utilises the results on his/her farm.

Table 1: Species recommended for planted grasslands in the different ecological zones of Uganda

Species	Pennisetum purpureum zone		Hyparrhenia spp. zone		Themeda triandra zone		Pennisetum clandestinum zone
	Good soils	Poor soils	Good soils	Poor soils	Ankole	Karamoja	
Grasses							
(a) Pasture							
Brachiaria brizantha	x		x		x		
B. ruziziensis	x	x	x				x
Cenchrus ciliaris				x		x	
Chloris gayana	x	x	x	x	x	x	x
Cynodon dactylon					x	x	
C. plectostachyus						x	
Hyparrhenia rufa		x	x	x		x	
Melinis minutiflora					x		x
Panicum maximum	x		x				
Pennisetum clandestinum							x
Setaria anceps	x	x			x		x
Pennisetum purpureum	x						
(b) Fodder							
Pennisetum purpureum	x		x		x		x
Tripscum laxum	x		x				x

Pennisetum typhoides			x	x	x		
Sorghum bicolor (wild sorghum)			x		x		x
Zea mays	x				x		x
Legumes							
Centrosema pubescens	x		x				
Desmodium intortum	x		x				
D. uncinatum	x		x				
Glycine wightii	x		x				
Macroptilium atropurpureum	x	x	x	x	x	x	
Medicago sativa	x						x
Stylosanthes guianensis	x	x	x	x	x		
Trifolium repens							x

x where the species are adapted

Table 2: Percentage crude protein in the major grasses in Uganda.

Species	Ankole	Buganda-Busoga Lake shore areas	Eastern region	Acholi lango area	Mean
Brachiaria spp	7.01	14.07	-	12.77	11.28
Chloris gayana	5.96	12.52	12.65	12.65	10.95
Cynodon dactylon	8.27	23.56	-	-	15.92
Digitaria scalarum	-	19.96	-	-	19.96
Hyparrhenia spp	4.41	11.78	11.36	10.60	9.54
Panicum maximum	6.61	15.00	14.07	13.49	12.54
Setaria spacelata	5.82	14.45	-	12.28	10.85
Sporobolus pyramidalis	5.15	-	-	10.91	8.04
Themeda triandra	4.14	-	-	-	4.14
Pennisetum purpureum	6.28	13.02	12.52	12.52	11.08
Zonal Mean	5.97	15.68	12.65	12.17	11.08

Source: Bredon and Horell (1961).

Table 3. Effect of age on protein, fibre content and digestibility of Hairy Indigo.

	Leaves			Stems			Whole plant (leaf + stem)		
Age	% CP	% NDF	% IVDMD	% CP	% NDF	% IVDMD	% CP	% NDF	% IVDMD (wks)
4	29.1	32.1	64.4	17.2	42.7	56.8	26.6	35.0	61.0
5	29.8	34.2	62.3	17.2	41.7	55.1	26.4	37.5	60.0
6	29.1	36.9	62.0	17.1	42.2	54.5	25.6	40.9	61.1
7	27.2	37.3	61.2	16.3	45.4	53.3	26.1	46.9	59.6
8	27.6	36.2	60.4	16.3	48.1	54.5	25.6	40.9	61.1
9	27.1	37.8	59.9	15.7	50.1	55.0	25.5	48.4	57.8
10	26.8	38.0	54.7	15.3	49.4	51.0	24.6	48.2	52.1
11	26.3	39.7	56.6	14.3	48.8	50.8	20.4	47.6	53.1
12	26.4	39.8	52.6	13.3	53.9	48.9	22.4	46.9	50.2
13	26.2	40.0	54.1	11.0	58.8	46.3	16.7	50.1	51.8
14	26.0	40.1	52.1	11.0	55.3	47.5	17.3	52.1	49.8
15	25.1	42.5	56.6	11.4	58.1	45.1	16.7	49.2	52.1
16	25.7	41.4	52.1	11.0	58.6	43.4	16.0	50.2	48.3
17	26.5	43.1	51.6	10.9	57.5	41.0	15.9	54.4	41.5
18	25.1	44.6	51.2	10.7	59.9	41.3	16.5	56.4	43.4
19	23.1	44.8	54.6	9.1	64.3	42.6	16.2	59.5	45.2
20	21.4	43.6	55.3	11.4	66.5	40.2	14.3	66.8	45.1
21	21.7	40.7	50.4	10.4	68.2	41.3	15.3	67.5	44.8
Mean	26.1	39.6	56.2	13.3	53.9	48.3	20.5	50.1	52.0

Source: Sabiiti (1979).

Table 4. The *in vitro* digestibility of *Panicum maximum* in pure stand and in legume associaton

Season	*Panicum maximum*	Panicum in Stylo	Panicum in Siratro	Panicum in Centro*	Panicum in Desmodium
1st rain	59.1 ± 1.05	59.9 ± 1.24	59.2 ± 1.51	53.9 ± 1.51	57.2 ± 1.30
2nd rain	61.2 ± 2.30	57.5 ± 0.96	59.0 ± 1.20	59.0 ± 1.73	56.1 ± 1.1
Dry season	49.8 ± 1.18	56.6 ± 1.01	55.9 ± 1.07	49.0 ± 1.84	42.5 ± 1.43
Mean	56.7a	58.0b	57.7b	54.1c	51.9d

Means with the same superscript was non-significant at the 5% level.

* Centro was slow to establish so over 80% of the pasture was made up of *Panicum maximum*.

+ *Desmodium intortum* was equally sensitive to drought like *Panicum maximum*

Source: Otim (1973).

Unfortunately, for the Uganda case, this type of research came to a halt in mid 1970's with the onset of political instability. Much of the research was done on the research stations under high technology so there is no indication of how such technology would produce under farmers' conditions of poor management. We are not aware of any published work done at farm level. Furthermore, most of the research was of short duration and the conclusions always recommended further research to generate more knowledge about the forage responses to various management practices. Such data would be considered as preliminary and this would limit their utilisation.

However, one big advantage we have achieved from some of the research findings was to produce a handbook on pastures for farmers (Wendt et al., 1970) although it is written in English and as such has limited audience. Also there is hardly any copy now available for the farmers and scientists.

Forage Development Phases

We are convinced that the research results to-date are extremely important because of the developmental phases that have to be followed in forage evaluation programmes. There is generalised data on most of forage species under different agro-ecological conditions in the country so it was and will be necessary to continue with basic data generation on research stations and then move to the farm-level studies. There is also a need to develop or introduce new forage species to replace the less productive ones with changing farming practices.

Current Research Programmes

Reactivation of forage research began in 1986 with aid from USAID following 15 years of no effective research. There is a need to continue forage evaluation (Sabiiti et al. 1989). Since the previous research programmes were terminated prematurely and there is still too general or no information on the potential of these forage species (both native and exotic) in terms of animal productivity. The studies are based at Makerere University Farm, Kabanyolo and Agricultural research stations in the country. The new approach is collaboration at both national and regional levels, e.g. with the Pastures Network for Eastern and Southern Africa (PANESA) as this generates quicker and more useful data.

We intend to extend our research programmes to the farm level after generating adequate data and when funds do permit.

Table 5. Estimated milk producing potential of some Uganda forages, based on results from indoor digestion trials with sheep and assuming an average cow weighing 450 kg and consuming the forages at the same rates as the sheep.

Forage	Stage of Stage of growth (weeks)	Range of DMI (% BWT)	Range TDN Intake Maintenance (kg)	Range 4% FCM (kg/day)
Pennisetum purpureum	4 - 7	2.4 - 2.6	3.30 - 4.20	10.0 - 12.70
Panicum maximum	4 - 7	2.7 - 3.0	2.52 - 3.14	7.6 - 9.50
Sorghum Sudanese	4 - 8	1.2 - 2.1	-0.73 - 1.70	-2.20 - 5.20
Tripsum laxum	4 - 15	1.8 - 2.6	1.57 - 4.62	4.80 - 13.90
Hyparrhenia rufa	5 - 13	0.8 - 1.6	-1.41 - 1.0	-4.3 - 3.0
Desmodium intortum	6 - 9	2.7 - 2.9	3.21 - 3.89	9.7 - 11.8
Stylosanthes gracilis	6 - 15	2.2 - 2.6	0.90 - 2.64	2.8 - 8.0

Source: Mugerwa (unpublsihed data)

Table 6. Estimates of pasture TDN and milk production in Uganda based on US-NRC nutrient requirements

Location	Breed	Duration of Experiment	TDN from pasture (kg/day)	FCM from pasture (kg/day)	Investigator
Makerere University Farm	Friesian (12)*	Full lactation	3.94	2.56	Christensen et al 1973
Makerere Univ. Farm	Friesian (12)**	Full lactation	3.77	2.56	Christensen et al 1973
Makerer Univ. Farm	Friesian (23)	Full lactation	3.98	2.01	Mugerwa unpublished data
Makerere Univ. Farm	Jersey (16)	Full lactation	4.05	3.79	Mugerwa (unpublished)
Nakyesasa Expt. station	Friesian (24)	Rainy season	4.93	6.00	Mugerwa _et al_ 1974
Nakyesasa ECpt.	Friesian (24)	Dry season	3.12	0.52	Mugerwa _et al_ 1974
Nakyesasa Expt.	Friesian (24)	24 weeks	4.10	2.9	Mugerwa _et al_ 1974
M.U.K. Farm	Friesian ( )		5.10	6.4	Musangi 1967
Nakyesasa Expt. St.	Jersey ( )***	8 weeks	4.50	5.15	Phipps 1970
Nakyesasa Expt. St.	jersey ( )****	8 weeks	2.79	Nil	Phipps 1970

* Supplemented with a low protein concentrate (17.7%).

** Supplemented with a high protein concentrate (21.6%).

*** Low dairy meal supplementation.

**** High dairy meal supplementation.

Major constraints in Uganda and possible remedies

(i) Manpower

Forage research and development for animal production was predominantly in the hands of expertriates; about 20 of them up to 1973. Firstly, they were located on research stations where there were the necessary facilities so there was hardly any involvement with the farmers. Secondly, following the 1971 military government, all of these researchers left the country and this marked the deterioration of forage research programmes. From the literature, considerable publications were done between 1965 and 1973 and thereafter publications more or less ceased. This led to discontinuity in research and eventual collapse. The few Ugandan scientists who remained lacked facilities to continue with research either on research stations or at farm level. In short, there is limited forage and animal scientific personnel in Uganda to be effective in forage research. For example, there is one qualified pasture agronomist working in collaboration with three animal nutritionists at Makerere University. There is a poor linkage between researchers and extensionists and this is partly due to limited qualified forage/animal extension personnel. People in the extension tend to shy away from researchers and this has tended to limit dissemination of research data to the farmers.

There is a need to train several forage, animal and extension personnel so as to create confidence between the researcher and the extension staff and increase interaction.

Furthermore, there has been lack of co-ordination in our research programme for several years. Some research scientists have quietly taken all their data leaving no publication behind and have changed jobs since research does not pay well here. The Government should create good conditions for researchers to remain dedicated in their jobs by providing research funds, promotion prospects and other incentives.

(ii) Government Policy

There is no clear-cut Government policy on how to implement research data generated by the scientists. There is no full-fledged department of Animal and Pasture production headed by qualified personnel in the Ministry of Animal Industry and Fisheries. Forage scientists who work with this Ministry are generally ignored by the Veterinarians. A situation of this kind is not productive for any researcher.

(iii) Lack of inputs

This is a very crucial factor both from the researchers and the farmers point of view. Researchers lack the necessary inputs such as funds, transport, equipment to conduct applied research or even to reach the farmers; there is a poor extension system with poor or no facilities to disseminate results; and the farmer does not have the recommended inputs. For example, elephant grass hybrids and forage legumes which have been recommended by researchers have remained at the research stations because of lack of planting materials. Pasture seed is not available and if available it is too expensive. A kilo of legume seed costs about Ug. Sh.1700/= (US$ 12) and this is prohibitive to the farmers. The use of nitrogen fertilisers to increase grass pasture under irrigation is too expensive because of the high cost of nitrogenous fertilizers.

(iv) Type of technology

Most of the existing results were generated by using complicated experimental designs and this would limit their utilisation. Also a very important aspect is to try and indicate the economics of such technology because a few of the studies have incorporated this (Stobbs, 1967; Tiharuhondi et al., 1973) in Tables 7 and 8 respectively.

(v) Socio-economic constraints

The majority of our livestock farmers are rural (over 90%) and have produced cattle in their traditional systems and seem to be contented with that system because the new technology involves high expenses to utilise. One farmer in 1976 found me (senior author) studying forages at the University Farm and commented that "I was wasting Government's money". Many farmers take pastures for granted and this hinders adoption of research findings. However, the progressive dairy farmers seem to understand the importance of research.

Strategies to generate utilisable research data

We have indicated some of these strategies in our discussion above and here we are emphasizing them once again.

i. Research must be geared toward solving farmers problems if it has to be utilised. To overcome this constraint, there should be collaborative research so that several problems are solved at once and a full technological package developed. Farmers should be involved; i.e. scientists should visit farmers when planning their research in order to see or be told those problems at the farm level.

ii. Training of personnel (research and extension) cannot be overemphasized. This is lacking here and in other African countries. Also farmers should be educated through mass media, holding of field days or during workshops.

iii. There should be a clear-cut policy by the Government on application of research data; otherwise the information will remain where it was developed.

Table 7: Animal production under different grazing management systems.

	Continuous grazing	Three paddocks	Six paddocks	Mean
Liveweight gain per acre (lb) 336 days	334	335	300	323
Mean liveweight gain per beast per day (lb)	0.50	0.50	0.45	0.48
Estimated gross return (Shs.) at-50 per lb	167	167.50	150.00	161.50

Source: Stobbs (1967)

Table 8: Treatment cost and grain in beef production

KgN/ha	Costs (Sh./ha)			Returns/Ha		
	N	Irrigation	Total	Beef (kg)	Value (Sh)	Net gain (Sh)
Non-irrigated						
0	-	-	0	187	939	939
224	509	-	509	307	1534	1025
448	1018	-	1018	464	2323	1305
672	1527	-	1527	544	2728	1201
Irrigated						
0	-	395	395	153	768	373
224	509	395	904	489	2449	1545
448	1018	395	1413	654	3772	1859
672	1527	395	1922	748	3744	1822

Source: Tiharuhondi et al (1973).

iv. Publication of research information should be done in a language which farmers understand. We are suggesting farming bulletins or use of local newspapers.

v. The Government should create incentives for researchers to stay in their jobs so as to keep continuity and this of course, includes provision of research inputs. The inputs should be available for the farmer.

CONCLUSION

Almost all the available data in Uganda has come from research stations with better technology compared to the local small-scale farmers. Secondly, most of the findings are descriptive or basic in nature. This coupled with the above reason tends to limit their utilisation.

Several constraints which have tended to limit their utilisation have been discussed and strategies suggested. When there limited data on forages, basic data is essential and in order to generate a complete research package, collaborative research is the best approach.

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SESSION II

ON-FARM FEEDING SYSTEMS

THE KILIMANJARO DAIRY FEEDING SYSTEMS: AN ATTEMPT AT EVALUATING THE IMPACT OF ON-FARM LIVESTOCK RESEARCH

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ABSTRACT

The paper presents results of an evaluation survey conducted in the Kilimanjaro highlands to determine the impact of phase I of the Dairy Feeding Systems (DFS) project. Deviations from the conventional experimental design is advanced as the major reason for employing expost evaluation instead of quantitative analysis based on statistical method in assessing the impact of on-farm trials conducted in phase I of the DFS project.

The results of the evaluation survey reveal that the project has had a positive impact on the performance of dairy cattle. Farmers felt that the DFS project has been instrumental for the current closer link between farmers and extension staff. However, extension staff would have wanted to be more involved in future project activities. Farmers considered shortage of veterinary drugs, improved dairy heifers and scarcity of feeds as the main factors constraining dairy development.

Introduction

Traditional approach to on-farm livestock research include steps such as farm surveys, research at experimental station(s), implementation, extension and interpretation of results (Davendra, 1987). These steps have more or less been followed in on-farm livestock research conducted in the highlands of Kilimanjaro by an inter-disciplinary research team of the Dairy Feeding Systems (DFS) project. Preliminary farm surveys were conducted in 1984 (Urio and Mlay, 1984, Mdoe, 1985). Experimentation on use of crop residues, molasses-urea mixture and pasture agronomy have been going on at the Sokoine University of Agriculture. The implementation stage involved the selection of project participating farmers among the farmers who were willing to participate. On-farm trials conducted during phase I of the project included the incorporation of bean haulms, maize stover and molasses-urea mixture in livestock basal rations. Preliminary work on the incorporation of legumes on farmer plots as a means to improve nutritive value of home grown pastures was also carried out.

Except for the pasture agronomical studies started towards the end of phase I of the project, the design of most of the on-farm trials deviated from the conventional experimental design. It was decided to ignore blocking for non-experimental variations within and across households. Sampling was to be purposive

rather than random and the trials were to be farmer managed. This decision was necessary after considering the following factors:

i. The herd size per household was small, averaging 4 cows. This factor restricts the number of treatments possible within a single household.
ii. Large variation within and between households exists in terms of breeds kept, age of animals, number and stage of lactation of individual cows and feed management including composition and feeding levels. Thus, under conventional methods of experimentation, a design used need to separate out these sources of variation from the treatment effects.
iii. Farmers attach high value to their animals and short of providing them with animals for the trials, an experimental design that requires differential treatment of the animals or transfer of daily management to "outsiders" is bound to fail.

The deviations from the conventional experimental design imply that quantitative analysis based on statistical methods cannot be employed in assessing the impact of the series of on-farm trials conducted in phase I of the Dairy Feeding Systems project. This paper employs expost evaluation in assessing the impact of the on-farm trials on dairy production in Kilimanjaro highlands. Expost evaluation is the analysis after the completion of a project or of a distinct phase of it. According to FAO (1981), the primary purpose of expost evaluation is to review the overall relevance, efficiency, and effectiveness of a project with a view to generating empirical lessons for planning, designing and implementation of similar future activities. An expost evaluation of projects requires considerable data and information entailing measurement and assessment of effects and impact. This calls for a systematic collection and compilation of information on the selected key indicators (e.g. increased production, benefit-cost ratio etc.) through project monitoring and well designed periodic surveys. It should be emphasized that the evaluation of the phase I of DFS project is just an attempt to assess the impact of the farmer managed on-farm trials. The evaluation is based on a single visit survey and its scope and vigour fall short of a complete expost evaluation.

The objectives of the evaluation were to determine:

- the impact of the DFS project on dairy cattle management
- the impact of the series of on-farm innovations on milk production
- the impact of the project on research-extension-farmers linkage
- ways and means of improving future project activities

2. Methodology

The evaluation was based on three target groups: project participating farmers, non-project participating farmers and extension staff at village, division and district levels. Data for the evaluation were obtained by administering structured questionnaires to the three target groups. It was planned to interview all twenty project participating farmers but at the time of the survey only 9, 4 and 5 farmers were available from Ng'uni, Wandri and Mowo Njamu villages respectively. In case of extension staff, the intention was to interview all of them. However, at the time the survey was conducted only 9 extension staff were available.

3. Survey Findings

3.1 Project participating farmers

3.1.1. Contribution of the Dairy Feeding Systems Project to Dairy Production

All the interviewed project participating farmers in the three villages indicated that they were not incorporating legumes in fodder production before the project. 55% of the farmers interviewed in Ng'uni village reported to have been incorporating molasses in the basal ration of dairy cattle before the project. All farmers in Mowo Njamu village indicated to have not been incorporating molasses in the basal ration while only 50% of the farmers interviewed in Wandri village reported to have been using molasses even before the project. The information given during the survey clearly indicates that all the project participating farmers in the three villages were feeding dairy cows with bean straw and maize stover.

With regard to the impact of the project, most of the participating farmers interviewed in the three villages indicated that the project has had an impact on dairy management in terms of keeping records, use of molasses, better utilisation of maize stover by chopping, increased use of crop residues and improved pasture management practices (Table 1).

Table 1 shows that the greatest impact of the project on dairy management has been on increased use of molasses and keeping milk production records. The least impact has been on increased use of crop residues and pasture management.

Table 1: Impact of project on Dairy Management.

Management practice changed	Number of Farmers			
	Ng'uni	Wandri	Mowo Njamu	Total
No change in management	1	0	0	1
Record keeping	8	2	3	13
Extensive use of molasses	7	4	5	16
Milk measurement	3	2	2	7
Chopping maize stover	1	1	0	2
Increased use of crop residues	1	0	0	1
Pasture management	0	0	1	1

Source: Mlay and Mdoe (1987).

The resultant effect of changes in various management aspects presented in Table 1 was the improvement in performance of dairy cows in the research site. All project participating farmers interviewed in Ng'uni and Wandri villages reported performance of dairy cows to have improved as a result of the project. In Mowo Njamu, 80% of the participating farmers reported improvement in performance of dairy cows while 20% of the farmers indicated that the performance of dairy cows remained the same.

There has been an overall increase in milk yield per cow as reported by project participating farmers (Tables 2.1, 2.2 and 2.3). On the average, milk yield increased from 4.5 litres/cow/day to 5.5 litres/cow/day in Ng'uni village. This was a rise of 22% over the project period. In Wandri village, milk yield increased by 21% from 5.25 litres/cow/day to 6.4 litres/cow/day. Average milk yield in Mowo Njamu increased by 23% from an average of 4.8 litres/cow/day to 5.9 litres/cow/day during the project period.

3. Survey Findings

3.1 Project participating farmers

3.1.1. Contribution of the Dairy Feeding Systems Project to Dairy Production

All the interviewed project participating farmers in the three villages indicated that they were not incorporating legumes in fodder production before the project. 55% of the farmers interviewed in Ng'uni village reported to have been incorporating molasses in the basal ration of dairy cattle before the project. All farmers in Mowo Njamu village indicated to have not been incorporating molasses in the basal ration while only 50% of the farmers interviewed in Wandri village reported to have been using molasses even before the project. The information given during the survey clearly indicates that all the project participating farmers in the three villages were feeding dairy cows with bean straw and maize stover.

With regard to the impact of the project, most of the participating farmers interviewed in the three villages indicated that the project has had an impact on dairy management in terms of keeping records, use of molasses, better utilisation of maize stover by chopping, increased use of crop residues and improved pasture management practices (Table 1).

Table 1 shows that the greatest impact of the project on dairy management has been on increased use of molasses and keeping milk production records. The least impact has been on increased use of crop residues and pasture management.

Table 1: Impact of project on Dairy Management.

Management practice changed	Number of Farmers			
	Ng'uni	Wandri	Mowo Njamu	Total
No change in management	1	0	0	1
Record keeping	8	2	3	13
Extensive use of molasses	7	4	5	16
Milk measurement	3	2	2	7
Chopping maize stover	1	1	0	2
Increased use of crop residues	1	0	0	1
Pasture management	0	0	1	1

Source: Mlay and Mdoe (1987).

The resultant effect of changes in various management aspects presented in Table 1 was the improvement in performance of dairy cows in the research site. All project participating farmers interviewed in Ng'uni and Wandri villages reported performance of dairy cows to have improved as a result of the project. In Mowo Njamu, 80% of the participating farmers reported improvement in performance of dairy cows while 20% of the farmers indicated that the performance of dairy cows remained the same.

There has been an overall increase in milk yield per cow as reported by project participating farmers (Tables 2.1, 2.2 and 2.3). On the average, milk yield increased from 4.5 litres/cow/day to 5.5 litres/cow/day in Ng'uni village. This was a rise of 22% over the project period. In Wandri village, milk yield increased by 21% from 5.25 litres/cow/day to 6.4 litres/cow/day. Average milk yield in Mowo Njamu increased by 23% from an average of 4.8 litres/cow/day to 5.9 litres/cow/day during the project period.

3.1.2. Contact with extension staff

It was revealed during the survey that the Dairy Feeding Systems project has had a very big impact on farmers contact with extension agents. All the projects participating farmers interviewed in the three villages reported that their contact with extension agents had improved since the commencement of the project. They strongly indicated that the project really opened way not only to frequent visits by extension staff but also to frequent visits by other government officials from district and regional levels.

3.1.3. Farmers' views on future project implementation

Most of the project participating farmers interviewed during the survey, had the view that the project should be implemented as it was being implemented in the first phase. This view was given by 44%, 50% and 80% of the farmers interviewed in Ng'uni, Wandri and Mowo Njamu villages respectively. Project participating farmers from Ng'uni village felt that the sample size should be increased while those from Wandri and Mowo Njamu villages felt that the frequency of visits by researchers should be increased while those from Wandri and Mowo Njamu villages felt that the frequency of visits by researchers should be increased. The project participating farmers interviewed reported a number of issues they would like to be addressed in future. The issue reported by majority of the farmers as one of the issues to be addressed in future was that of availability of veterinary drugs which are currently in short supply. Availability of minerals as one of the issues to be addressed was reported by 67% and 40% of the interviewed farmers in Ng'uni and Mowo Njamu villages respectively. The issue of incorporating legumes in pastures was reported by 60%, 22% and 25% of the project participating farmers interviewed in Mowo Njamu, Ng'uni and Wandri villages respectively. Other issues in the order of being reported by a large proportion of the farmers as issues to be addressed in future include research on improved pastures, availability of concentrates, selection of high yielding cows, availability of heifers and co-operative marketing of milk.

Table 2.1: Ng'uni village: milk yield before and during project period.

Farmer No.	Yield before project	Yield during project	Change in yield
	Litres		
1	6.5	8.0	1.5
2	4.0	5.0	1.0
3	4.5	5.0	0.5
4	4.0	5.5	1.5
5	6.0	7.0	1.0
6	4.0	4.5	0.5
7	3.0	4.0	1.0
8	5.0	6.0	1.0
9	4.0	5.0	1.0
Total	41.0	50.0	9.0
Mean	4.5	5.5	1.0
Standard Error	1.10	1.26	0.35

Source: Mlay and Mdoe (1987).

Table 2.2: Mowo Njamu village: milk yield before and during project period.

Farmer No.	Yield before project	Yield during project	Change in yield
	Litres		
1	6.0	7.0	1.0
2	7.0	8.0	1.0
3	5.0	6.5	1.5
4	3.0	4.0	1.0
5	3.0	4.0	1.0
Total	24	29.5	5.5
Mean	4.8	5.9	1.1
Standard error	1.79	1.82	0.22

Source: Mlay and Mdoe (1987).

Table 2.3: Wandri village: milk yield before and during project period.

Farmer No.	Yield before project	Yield during project	Change in yield
	--------------------Litres--------------------		
1	7.0	8.5	1.5
2	5.0	6.0	1.0
3	5.5	6.5	1.0
4	3.5	4.5	1.0
Total	21.0	25.5	4.5
Mean	5.25	6.4	1.125
Standard error	1.44	1.65	0.25

Source: Mlay and Mdoe (1987).

3.2. Non-project participating farmers

Majority of the non-project participating farmers interviewed in Ng'uni, Wandri and Mowo Njamu villages indicated that they were aware of the existence of the Diary Feeding Systems project in the area. The number of farmers who were aware of the project was relatively small in Ng'uni village whereas only 45% of the interviewed farmers in each of the remaining two villages indicated that they were aware of the existence of the project in their villages. The farmers indicated to have first learned about the project from other farmers, village leaders and extension staff.

3.2.1. Impact of the project on dairy production

The non-project participating farmers who reported to be aware of the Dairy Feeding Systems project were further asked to indicate if the project has made them change dairy management practices. In Ng'uni and Wandri villages, all these farmers reported that the project has had an impact on how they managed their dairy herd. However, only 71% of the farmers who reported to be aware of the existence of the project indicated to have changed dairy management practices as a result of the project.

Dairy management practices which have changed include feeding, pasture management, and record keeping. The non-project participating farmers were also of the opinion that the changes in dairy management have had an impact in the performance of their dairy herd and improved as a result of management changes. In Mowo Njamu village, only 86% of the farmers indicated improvement in performance of dairy herd due to changes in management practices.

There had also been an overall increase in milk yield as a result of changes in management as reported by the non-project participating farmers. Tables 3.1 to 3.3 show the impact of changes in dairy management on milk production per cow per day. In Ng'uni village, average milk yield increased from 3.7 litres/cow/day to 4.3 litres/cow/day during the project period. Average milk yield in Mowo Njamu increased by 22% from 3.7 litres/cow/day to 4.5 litres/cow/day. In Wandri village average milk yield increased by 25% from 3.6 litres/cow/day to 4.5 litres/cow/day during the project period. This shows that impact was greatest for non-project participating farmers in Wandri village where milk yield increased by 25% as compared to 22% and 19% for Mowo Njamu and Ng'uni respectively.

Table 3.1: Ng'uni village: daily milk yield before and during project.

Farmer No.	Yield before project	Yield during project	Change in yield
	--------------------Litres	--------------------	--------------------
1	5.0	6.0	1.0
2	3.0	3.5	0.5
3	4.0	5.0	1.0
4	3.5	4.0	0.5
5	3.0	3.5	0.5
6	3.0	3.5	0.5
7	4.0	5.0	1.0
8	3.5	4.0	0.5
9	4.0	4.5	0.5
Total	33.0	39.0	0.6
Mean	3.7	4.3	0.7
Standard error	0.66	0.87	0.25

Source: Mlay and Mdoe (1987).

Table 3.2: Mowo Njamu village: daily milk yield before and during project

Farmer No.	Yield before project	Yield during project	Change in yield
	Litres		
1	4.0	5.0	1.0
2	5.0	6.0	1.0
3	3.0	4.0	1.0
4	4.0	5.0	1.0
5	3.5	4.5	1.0
6	3.0	3.5	0.5
7	3.5	3.5	0.0
Total	26.0	31.5	5.5
Mean	3.7	4.5	0.8
Standard error	0.70	0.91	0.39

Source: Mlay and Mdoe (1987).

Table 3.3: Wandri village: Daily milk yield before and during project.

Farmer No.	Yield before project	Yield during project	Change in yield
	Litres		
1	2.5	4.0	1.5
2	4.0	4.5	0.5
3	3.0	3.5	0.5
4	5.0	6.0	1.0
Total	14.5	18.0	3.5
Mean	3.6	4.5	0.9
Standard error	1.10	1.08	0.48

Source: Mlay and Mdoe (1987).

3.2.2. Views on future project implementation

The non-project participating farmers reported a number of issues that they would have liked to be addressed in future if the project was to be extended. These issues reported in their order of being reported by a large number of farmers include easy access to veterinary drugs, pasture establishment and improvement, easy access to concentrates and minerals, use of molasses, general dairy husbandry, upgrading of animals through artificial insemination and access to improved dairy heifers.

3.3. Extension staff

3.3.1. Contribution of the project

The main contributions of the Dairy Feeding Systems project in the research site as indicated by the extension staff interviewed during the survey include better use of crop residues through implementation, use of alternative feeds and improved pasture management. 56% of the extension staff indicated better use of crop residues through supplementation as the main contribution of the project in the research site. Improved pasture management practices was reported by 22% of the interviewed staff as the main contribution of the project. 11% of the extension staff reported that the main contribution was that farmers learned how to use alternative feeds for dairy cows. The remaining 11% had the opinion that the project had not had any significant contribution in the research site.

3.3.2. Views in future project implementation

About 44% of the extension staff interviewed gave the view that the project should have several focal points in Hai district. The views that researchers should frequently visit the project site, local extension staff should be fully involved in the project, and that the project should involve both poor and rich farmers were suggested by 33% of the extension staff. Other views given in the order of importance include intensification of follow up, more research on fodder production, use of visual aids to educate farmers on dairy husbandry, improving baling and transportation of crop residues and emphasizing feed supplementation.

4. Implementations of the evaluation results

The results of the survey indicate that the project has had a positive effect on the performance of dairy cattle mainly attributed to better utilisation of crop residues by choosing and supplementating with urea-molasses mixture. Work on pastures was just at its preliminary stage when phase I of the project ended and therefore it is not surprising that farmers' have not substantially changed their pasture management practices. Both farmers and extension staff were of the opinion that research on pastures should be given priority in future studies.

Farmers felt that the project has been instrumental for the current closer link between farmers and extension staff. However, extension staff felt that they would have wanted to be more involved in the project than it was made possible under the arrangement that prevailed in phase I of the project.

The main weaknesses related to the project include poor follow up as a result of remoteness of researchers from the project site, coverage (in terms of number of farmers and area) was considered too small and limited involvement of local extension staff at village level.

When proposals from farmers on problems to be addressed in future were examined, it was clear that they considered shortage of veterinary drugs and improved/exotic dairy cows as most important factors constraining dairy development in the study area. However, given that these can be available, feeds (particularly roughages) will continue to be a problem. This is supported by the fact that all the target groups gave emphasis to pasture research among proposed future activities.

On the basis of continuous monitoring of the on-farm experiments and the expost evaluation surveys, corrective measures have been undertaken to improve performance in phase II of the project. These measures include:

i. Location of a permanent technician at the project area to ensure a close follow-up on on-going project activities.
ii. Significant part of phase II project activities to concentrate on on-farm forage research with both researcher and farmer managed trials.
iii. Incorporation of farmers field days in the programme of project activities.
iv. Making some project facilities available to extension staff as a deliberate effort to facilitate increased participation of extension staff in project work.

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BUDGETING AND ALLOCATION OF FEED RESOURCES

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INTRODUCTION

In most of the semi-arid Eastern Kenya, small-scale farmers cultivate maize, beans, cowpeas and pigeonpea as well as keeping cattle, goats and sheep. The majority of farms are between 2 and 15 ha in size and most land is privately owned. Cropped land increases with farm size from 1.5 ha to 5 ha, the remainder of the land being left for grazing (Rukandema, 1984; Tessema et al, 1985). Annual rainfall is between 600 and 900 mm per year falling in two seasons with a growing period of 50-80 days each (Jaetzold and Schmidt, 1983; Stewart and Kashasha, 1984). Cattle are kept for milk, traction and cash sales while small stock are sold for cash. Cattle are the most important, comprising 75-85% of the total livestock mass. Stocking rates are high and decrease from 1.5 TLU /ha (Tropical Livestock Units of 250 kg) for a 5/ha farm to 1.0 TLU/ha for a 10 ha farm. Forage from rangeland and crop residues are the principal feed resources. Except in good rainfall seasons demand for livestock feed are likely to exceed supplies resulting in overstocking, land degradation and low productivity (de Leeuw, 1988).

On-farm research has shown that the fodder supply in smallholder farms can be increased by 1) establishment of grass-legume leys, 2) planting of grass and legume forages and 3) better utilisation of crop residues. Household welfare and cash income was improved by channeling most of the planted forage and high quality fodder to one or two crossbred cows for milk production (Tessema et al, 1988). Livestock productivity can be further enhanced by more efficient utilisation of feed resources through proper budgeting and allocation of feed resources to the various livestock enterprises maintained on farms.

There is, therefore, a need to develop efficient feed budgeting and allocative procedures that can assist in manipulating feed resources to the best advantage of the farmer and in line with his priorities for his various livestock enterprises. The objectives of such procedures are 1) to access the quantity and quality of all feed components, and 2) to determine the production goals of each enterprise and allocate feed in relation to their requirements within the framework of overall feed supplies.

MATERIALS AND SUPPLIES

To develop procedures for feed budgeting and allocation, the following assumptions were made:

1. The existence of an average 'model' farm with a fixed land area and a stable land-use pattern resulting in known areas under crops and rangeland.
2. A fixed monthly growth rate for pastures and planted forages and a fixed yield of crop residues at harvest together with quality parameters for each component.

These assumptions are based on actual data and the conditions under which smallholder farmers operate (de Leeuw, in press). The projected 'model' farm has 9 ha of land, of which 3 ha was cropped, one ha was allocated to planted forages and legumes, and 5 ha was used as rangeland (Table 1). All farmed land had maize and one third was sole-cropped and the remainder was intercropped with beans, cowpeas and pigeonpea. Estimated seasonal yields are derived from regular surveys data measured during the 1987/8 period in a number of sample farms. In total the 9 ha farm produced 32 t DM of feed or 3.7 t DM/ha/annum over two growing seasons (Table 1).

Table 1: Land, Crops and Feed Resources of the 'model'

Type	ha	Yield t DM/ha 1st Season	Yield t DM/ha 2nd Season	Total yield (t DM/ha)	
Rangeland	5.0	1.7	1.5	16.0	(49%)
Maize Residues	3.0	1.7	1.7	10.2	(31%)
Beans and Cowpea	1.0	0.6	0.5	1.1	(3%)
Pigeonpea	1.0	-	0.6	0.6	(2%)
Planted grass	0.5	3.0	2.6	2.8	(9%)
Planted legume	0.5	1.9	1.7	1.8	(6%)
Total for farm	11.0	16.6	15.9	32.5	(100%)

Source: de Leeuw (in press).

Quality parameters were restricted to crude protein content and digestibility; these were estimated monthly for rangeland and planted forages. Since crop residues were produced at fixed times after harvest, only two quality classes were relevant: either when fed or grazed immediately after harvest or when fed later leading to a small reduction in quality (Tables 2 and 3).

Table 2: Crude protein (CP) content and digestibility (DIG) of rangeland, planted grass and legume forage (in % DM[a])

Period	Rangeland CP	Rangeland DIG	Grass CP	Grass DIG	Legume CP	Legume DIG
Early season	12	65	12	65	20	65
Mid season	8	55	10	60	17	60
Late Season	6	50	8	55	15	55
Dry season	5	45	6	50	15	50

[a]/ means calculated from estimated monthly values (de Leeuw, unpublished)

Table 3: Crude protein (CP) content and digestibility (DIG) of crop residues (in % DM).

Harvest time	Early		Late	
Crops	CP	DIG	CP	DIG
Maize	6	50	4	45
Cowpea/beans	12	60	10	55
Pigeonpea	12	60	10	55

Source: de Leeuw (in press)

Four main livestock enterprises were kept on the'model' farm. Crossbred cattle for milk production, oxen for traction, a few zebu cattle and 15 small-stock (goats and sheep). The total livestock mass was 2440 kg or 9.8 TLU, which converts to a stocking rate of 1.1 TLU/ha (Table 4). Their daily feed intake has been taken as uniform across enterprises at about 3% of their liveweight and was kept constant during the year. Based on the total stock weight of all enterprises, daily and annual feed requirements were estimated at 73 kg and 26.3 t DM respectively (Table 5). Thus, the 'model' farm produced sufficient feed for its stock. Given the distribution of body mass across the livestock groups, the crossbreeds required 40%, the oxen 29% and the remaining 31% was needed for the zebu and small-stock (Table 5).

Table 4: Livestock holdings and daily feed requirements.

Class/type	Number	Weight (kg) Unit	Weight (kg) Total	Daily Intake Kg DM
CB Cows	2	350	700	21
CB heifer	1	200	200	6
CB calf	1	70	70	2
	---	---	---	---
All crossbreds	4		970	29
Work oxen	2	350	700	21
Zebu cow	1	250	250	8
Zebu heifer	1	150	150	4
Zebu calf	1	70	70	2
	---	---	---	---
All zebus	3		470	14
Goats	10	20	200	6
Sheep	5	20	100	3
	---	---	---	---
All smallstock	15		300	9
All stock	24		2440	73

Source: de Leeuw (in press)

Table 5: Monthly and annual feed requirements of different stock classes.

Class/type	Requirements, t DM Month	Year	% of total
Crossbreds	0.87	10.5	40
Work oxen	0.63	7.6	29
Zebus	0.42	5.0	19
Smallstock	0.27	3.2	12
	----	----	----
Total	2.19	26.3	100

Source: Calculated from Table 4.

The budget started on 1 October in one year and ended on 30 September in the following year. For each feed component, monthly changes (in t DM/ha) were determined and cumulative totals were entered on the spread sheet. For instance, DM yield of rangeland on 1st October was 1 t DM/ha as a left-over of the previous year, which increased in monthly steps to a maximum of 2.7 t (i.e. a 1.7 t increment in line with data in Table 1) at the end of the growing season in February, declined by 15% during the short dry season due to seed and leaf fall as well as termite attack and insect damage. During the second season, yield increased by 1.5 t/ha falling progressively by 5% per dry month up to the end of the 'model' war. Cumulative yields for forage grasses and legumes were assessed in a similar manner.

Crop residues are easier to assess due to their fixed harvest times and outputs. They are harvested twice during January-February and May-June; as farmers did not harvest all crops at once, availability was spread over several months. For each monthly entry, protein content and digestibility coefficients were added (Table 3).

The allocation of feed sources to each livestock enterprise was expressed as a percentage of their total monthly feed consumption (Table 6). The four groups were reduced to three by combining small-stock with the zebu cattle herd. As there was no shortage of total feed, the allocation was based on quality with a priority ranking from crossbred, through work-oxen to the zebu/small-stock group.

Table 6: Diet composition (%) of three livestock enterprises over three-monthly periods.

Period	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Annual Mean
Feed Source			Crossbreds		
Rangeland	54	30	43	10	34
Maize	13	29	30	43	29
Grain legumes	7	7	3	10	7
Forage grass	23	17	17	20	19
Forage legumes	3	17	7	17	11
	---	---	---	---	---
	100	100	100	100	100
			Work oxen		
Rangeland	83	50	56	27	54
Maize	10	37	34	53	33
Grain legumes	-	7	4	7	5
Forage grass	4	3	3	7	4
Forage Legume	3	3	3	6	4
	---	---	---	---	---
	100	100	100	100	100
			Zebus and smallstock		
Rangeland	89	50	53	30	55
Maize	11	43	40	53	37
Grain legumes	-	7	7	17	8
Forage grass	-	-	-	-	-
Forage legumes	-	-	-	-	-
	---	---	---	---	---
	100	100	100	100	100

Source: Calculated from assumed monthly diet composition.

The monthly consumption of each feed component was calculated and subtracted from the cumulative total. It was assumed that harvesting did not affect subsequent growth; hence for each month the balance consisted of the quantity of feed at the end of the previous month and growth minus consumption and losses during the current month. A number of test runs were done to adjust diet composition to available feed components to avoid negative values. Thus, this part of the procedures was done manually and no computer programme has as yet been developed. For the final run, the crude protein and digestibility contents of each of the three diets were determined on a monthly basis.

RESULTS

In principle, the monthly feed allocation was based on the availability and the quality of each feed source with adaptation to priority rating for each livestock group. However, since forage from rangeland and maize stover constituted 80% of the total feed, all groups had to rely on these two sources as the main components of their diet. Maize residues were available only during two distinct periods and as large-scale storage was thought unfeasible, most was allocated soon after harvest.

Diet composition for the three livestock enterprises are summarized over four 3-monthly periods (Table 6). Crossbred cattle relied more on rangeland in the wet than in the dry seasons and they, together with the oxen, were the main beneficiaries of planted forages, which constituted 30% and 8% of their respective annual diet. When the quality was high, these forages were cut and carried and fed after grazing to promote greater daily intake, whereas during the dry season they also assisted to improve diet quality. The residues fed during the first three months were stored feeds from the previous year (Table 9).

Work oxen were given access to some planted forage and legume residues in July-August to improve their body condition for ploughing in the dry season and again in October-November when tillage was required after the first rains. No planted feed was supplied to the zebus and small-stock and they relied entirely on natural pastures and crop residues (Table 7).

Table 7: Annual allocation of feed resources for crossbreds, work oxens and other stock.

Source	Crossbred	Oxen	Others	Total use
	% of total available			
Rangelands	22	26	28	76
Maize residues	30	24	30	84
Legume residues	41	21	38	100
Forage grass	71	11	-	82
Forage legume	64	17	-	81

Source: derived from Tables 4 and 6.

Table 8: Average crude protein content (CP%) and digestibility coefficient (D%) in diets of three livestock enterprises over 3-monthly periods.

Enterprises		Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Annual Mean
Crossbreds	(CP%)	9.6	7.3	8.2	8.0	8.3
	(D%)	58	50	54	51	53
Work oxen	(CP%)	9.2	6.0	7.3	6.0	7.1
	(D%)	58	48	53	48	52
Zebus and	(CP%)	9.2	5.3	7.0	6.0	6.9
smallstock	(D%)	58	47	52	48	51

Source: Derived from Table 2, 3, 4 and 6.

Table 9: Annual feed utilisation and balance (t DM).

	Start 1/10	Livestock use	lost	end 30/9
Rangelands	5.0	12.3	4.1	4.6
Maize residues	0.9	8.6	2.4	0.1
Legume residues	0.2	1.7	-	-
Forage grass	0.5	2.3	0.5	0.5
Forage legume	0.2	1.4	0.4	0.2
Total	6.8	26.3	7.4	5.4

Source: Derived from Table 1, 5 and 6.

In terms of protein content, the crossbreds received the best diet, followed by the work oxen. Differences in diet protein between groups were pronounced, because protein content is easy to manipulate as several sources of high-protein feed were available, be it in limited quantity (Table 7). Differences in digestibility were much less pronounced and therefore providing crossbreds with a higher digestible diet was difficult to accomplish. The overall value in feeds given to crossbreds was only 2% higher than that in the diets of zebu cattle and small-stock.

On an annual basis about 26 t of feed was used by the three livestock groups or about 80% of the total annual production of 32 t (Table 1); another 23% was assumed 'lost' to other consumers (termites, wildlife, etc.) and decomposition (Table 9). Overall, utilisation was slightly higher than production with the result that less feed was carried over at the end of the 'model' year than at its start. However, for rangeland and planted forages sufficient herbage was left standing to insure continued growth in the following year.

DISCUSSION

The feed supply of the model farm demonstrated that intensive livestock production was possible in normal years provided one hectare was set aside for planted forages and crop residues were fully utilised. The timing of the allocation was crucial and geared to specific animal requirements. In addition, sufficient herbage was left for the next year to avoid overgrazing and to secure sustained feed output. The assumed stocking rate was realistic and 1.1 TLU/ha corresponded to the actual rates recorded in the sample farms and in other parts of the semi-arid zone (de Leeuw, 1988; Jaetzold and Schmidt, 1983; Tessema et al, 1985).

Further fine-tuning of the 'model' is required particularly with respect to the quality parameters of the different feed resources. Since monthly inputs were used, it is possible to adjust feed allocation more closely to the animal requirements by taking into account calving dates, stage of lactation of crossbred, zebu and small-stock, or if required, including feed for fattening stock for sale. Iterative procedures can be included in the programme so that feed resources are allocated automatically according to set priority ratings of quantity and quality as was done for feed allocation in smallholder farms in Bangladesh (Hermans, 1986).

The feed allocation programme is flexible and can be adjusted for farm size, cropping pattern, herd size and composition and production goal of farmers as well as changes in yields and quality of each feed components. It can also become a tool to test the effects of feed resources utilisation on farm output when it is linked with holistic economic farm models.

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TOWARDS AN INTEGRATED CEREAL CROP-FORAGE PRODUCTION FOR IMPROVED CATTLE PRODUCTIVITY: THE MALAWI EXPERIENCE

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INTRODUCTION

Intercropping is traditionally a widely accepted practice in Malawi and it represents approximately 94% of the country's total cultivated area (NSO, 1970; 1981). Intercropping, as practiced by the smallholder farmers, is deliberately planned to provide the farmer with a variety of returns to land, labour and other inputs, minimize the risk of dependence upon one crop that could easily succumb to environmental damage, and the farmer also takes advantage of the differences among crops in time to maturity. The overall benefit to the smallholder farmer is increased food security and efficiency with which scarce resources are used to produce food.

The concept and advantages to the following cereal crop of including legumes such as groundnuts in a rotation, is widely acknowledged by farmers, particularly those in Lilongwe and Kasungu Agricultural Development Divisions. For cattle owners, it has been demonstrated by trials at Chitedze Agricultural Research Station that the inclusion of groundnut tops to basal diets of maize stover doubles the liveweight gains of fattening steers (Addy and Thomas, 1976; Mtukuso et al., 1984; Munthali, 1987). The prices of major inorganic fertilizers such as ammonium sulphate (21% N), calcium ammonium nitrate (26% N) and 20:20:0 have risen by an average of nearly nine from 1969/70 to 1986/87 whereas the price of the major cereal grain, maize, increased only sixfold during the same period (ARMP, Ministry of Agriculture, Malawi, unpublished). Inorganic fertilizers are therefore well above the reach of most smallholder farmers.

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Since the integration of cereals with food legumes is already widely practised by the smallholder farmers, who also keep more than 90% of the cattle in Malawi, a well planned integration of cereals forage legumes through N-fixation should improve soil fertility status for the subsequent or associated food crop, whilst producing adequate quantities and added quality of the residue dry matter which would benefit both a crop and a cattle farmer.

This paper will review available information in the field of integrating cereal crop-forage production, the degree of acceptance of success, reasons for success or failure and suggestions for improving the system in Malawi.

AVAILABLE TECHNOLOGY

Research on integrating cereal crops (maize) with forage (Rhodes grass and legumes) started at Chitedze Agricultural Research Station in 1971/72 wet season.

The objective was to find a simple method and time of undersowing forages with maize without reducing maize grain yield whilst increasing total herbage dry matter to support the smallholder cattle stallfeeding schemes. The studies showed no reduction in maize grain yield although total herbage was increased by undersowing maize with forages (Thomas and Bennett, 1975a, b). Recent studies conducted by Dzowela (1987a) and the Pastures Research Commodity Team, Chitedze (unpublished) confirmed the reports made by Thomas and Bennett, 1975a, b). In one trial at Chitedze Agricultural Research Station, maize was grown on the same ridges with forage legume undersown on the same ridges only once at the beginning of the experiment. Results persistently showed no appreciable reduction in maize grain yields (Table 1) and maize grain yields compared favourably with those obtained when maize was either a sole crop or intercropped with food legumes (Table 2).

Maize stover yields dropped after the establishment year but stayed the same during the subsequent years (Table 1) whereas legume dry matter yields increased from the establishment year onwards (Table 1). Total dry matter yield did not show any pattern but yields during the following years never exceeded those obtained during the establishment year of the trial (Table 3).

Although the total dry matter yield declined after the establishment year, total herbage crude protein yield (Table 3) increased substantially by 1988 over that of 1986, except in the maize - C. pascuorum combination. In 1988, the maize - herbage crude protein yield came from the forage legume except again for the maize - C pascuorum combination. Therefore the overall quality of the herbage improved with time as a result of legume inclusion in maize crop.

In all the undersowing trials conducted at Chitedze Agricultural Research Station, little emphasis was placed on the possible contribution of nutrients by the undersown legumes to the soil. Soil samples were collected from one maize-legume intercropping trial, three years after establishing the experiment. Soil analysis results (Table 4) did not show any difference in the parameters analyzed between plots intercropped with or without legumes. There were also no differences among the maize-legume intercrops even though large differences among legumes regarding their ability to fix nitrogen have been reported (MOA, 1983). The application of recommended rates of fertilizer to the maize crop in the maize-legume intercropping trials might have reduced the ability of the legume to fix nitrogen.

Table 1. Grain; maize stover and legume forage dry matter yields (kg/ha) in maize-forage legume mixed cropping.

Maize-Forage Combination	Grain			Stover			Forage Legume		
	1986[a]	1987	1988	1986[a]	1987	1988	1986[a]	1987	1988
Maize-*N. wightii*	6149	5531	7420	8240	4074	3862	68	1225	2622
Maize-*C. pubescens*	6222	7427	6945	8445	5493	4105	269	1409	2311
Maize-*C. pascuorum*	5939	9230	8558	8017	6651	4207	571	456	1237
Maize-*D. uncinatum*	6816	5793	7725	8002	4286	5460	457	2360	2889

[a] From 1986 to 1988, maize was grown on the same ridges with legumes sown only in 1986.

Source: Adapted from Dzowela (1987b)

In an attempt to quantify animal production from maize-forage legume residues, a feeding trial was conducted on-station using the 1988 maize-forage combination residues. There were five treatments and three steers per treatment. Unfortunately the quantity of the residues was poorly assessed in the field so that all the maize stover-forage residues were used up by the end of the month. The trial was, however, continued using groundnut tops to finish the steers. All steers received 5kg of maize bran to which 25g of salt had been added, but the residues were fed ad libitum. Steers were dewormed at the beginning of the trial. All steers lost weight during the first month during which the maize-stover legumes were fed (Table 5), but started gaining weight during the second and third months when groundnut tops substituted for the forage legumes. Roughage dry matter intake was also very low during the first month (Table 5) but improved dramatically during the following months for all treatments.

Table 2: Grain yield (kg/ha) of maize grown as an intercrop with selected food legumes

		Intercrop				
Year	Sole maize	Groundnuts	Soybeans	Cowpeas	P. beans	G. beans
1987	6182	5807	6129	6319	6473	5795
1988	6653	6383	6055	6338	6323	6609

Source: Kabambe et al. (1987, unpublished and Munthali (1988, unpublished)

Table 3: Total dry matter yield (kg/ha) and crude protein yield (kg/ha) in maize-forage legume-mixed cropping.

Maize-Forage combination	Total DM yield			Total CP[1]		
	1986	1987	1988	1986	1987	1988
Maize - *N. wightii*	8308	5927	6484	505	436	644
Maize - *C. pubescens*	8704	6902	6416	545	531	577
Maize - *C.* pascuorum	8588	7113	5444	564	465	431
Maize - *D. uncinatum*	8459	6646	8349	543	584	727

[1] Crude protein of maize, *N. wightii*, *C. pubescens*, *C. pascuorum* and *D. uncinatum* was 6.0%, 15.7, 14.3%, 14.5 and 13.9% respectively

Table 4. Soil analysis results (maize) legume undersowing trial

Maize-Forage combination	H H_2O		C%		OM%		N%		C/N		P (PPM)		EXCH Cations Me K	
	TOP	SUB	TOP	SUB	TOP	SUB	TOP	SUB	TOP	SUB	TOP	SUB	TOP	SUB
Maize	5.7	5.8	2.87	2.81	4.95	4.84	.25	.24	12	11.7	3.3	4	.66	.47
Centrosema pubescens	5.7	5.8	2.80	2.68	4.79	4.65	.23	.23	12	11.8	2.5	2.2	.43	.45
Centrosema pascuorum	5.7	5.9	2.56	2.64	4.41	4.56	.23	.23	11.5	11.7	3.2	3.1	.57	.53
Neonotonia wightii	5.7	5.8	2.86	2.85	4.92	4.91	.25	.25	11.8	11.7	4.8	2.5	.50	.44
Silverleaf desmodium	5.7	5.8	2.93	3.02	5.05	5.20	.25	.25	12	12	3.2	2.7	.52	.44

Table 5. Liveweight changes (kg/day) dand daily intake of roughage dry matter (kg/steer/day) of steers fed maize-forage legume combinations.

Maize-forage combinations	Liveweight changes in months				Intake in months			
	1	2	3	Overall change	1	2	3	Overall
Maize stover only	-0.97	1.0	0.64	0.22	1.97	5.33	7.06	4.79
Maize stover - N. wightii	-0.18	1.21	0.68	0.57	2.81	5.58	6.65	5.01
Maize stover - C. pubescens	-0.02	1.43	0.73	0.71	2.38	5.68	6.95	5.01
Maize stover - C. pascuorum	-0.02	0.96	0.84	0.59	2.66	5.28	6.86	4.93
Maize stover - D. uncinatum	-0.77	1.38	0.79	0.47	2.45	5.26	7.00	4.90

Although it is premature to discuss one month's data of any feeding trial, it is important to note here the changes in the proportion of forage legumes in the field, harvested and ready to feed residues and orts. This factor might influence the performance of animals fed harvested residues as is the case with most stallfeeding operations in Malawi. In all cases except in the *C. pubescens* combination, there was a big loss in the proportion of forage legumes between field samples and those sampled at the time of feeding (Table 6.) The difference in the proportion of legumes between the field and harvested residues was mainly due to legume leaves falling to the ground before and during harvesting as maize was stocked whilst some legumes such as *Centrosema pubescens* and *Neonotonia wightii* were still relatively green. *Centrosema pascuorum* is a creeping legume whereas *Desmodium uncinatum* falls to the ground after growing to a given height. Therefore very little of these legumes were harvested together with the crop residues.

Table 6: Proportion of legume dry matter in total dry matter in 1988

Maize-Forage combination	Field Residues	Harvested Residues	Orts
		%	
Maize stover - *N. wightii*	40.4	33.0	9.0
Maize stover - *C. pubescens*	36.0	36.0	23.0
Maize stover - *C. pascuorum*	22.7	4.6	3.0
Maize stover - *D. uncinatum*	34.6	1.7	1.0

For stallfeeding purposes, the method and stage of harvesting the legume hay needs to be carefully monitored, as fallen leaves and dry prostrate legumes if left in the field would be subject to termite damage.

Lessons Learnt

Apart from showing that intercropping maize with forages does not reduce maize grain yields, the studies gave a number of important observations on-station and even on-farm (Dzowela, 1987b; Chitedze Pastures Research Commodity, 1986 - unpublished). First, in establishing grass-legume swards, the maize can be used to suppress the growth of vigorous sown grasses, allowing the legume to establish satisfactorily, and resulting in mixed swards with much higher legume content than that achieved by broadcasting the seed directly. Second, the serious weed problem of <u>Eleusine indica</u> (rapoko grass) is eliminated because sowing is done after a thorough weeding of the maize. Third, on many light soils in the country, stoloniferous grasses such as Rhodes grass, established by conventional direct seeding cannot be grazed in the year of sowing because of risk of sward damage. Therefore, undersowing in the previous year permits pasture to sufficiently establish themselves to allow grazing. Fourth, the nutritional quality of the crop residues is improved by the presence of forage legumes. Fifth, to allow maize to have a vigorous start, the legumes should be cut back about three days before planting maize where maize is continuously cropped on the same ridges with legumes. Sixth, early leaf fall by some legumes such as <u>Neonotonia wightii</u> encourages termite attack of maize. Therefore, forages with late leaf fall should be sought.

UTILIZATION OF RESEARCH RESULTS

In spite of repeated demonstrations to farmers by both the extension service and researchers, the uptake of forage research results has been slow. It has been shown time and again that the smallholder dairy farmers, for whom most of the forage research work is targeted, have only been keen to adopt the research recommendation as a means of obtaining dairy cows on loan. There are a number of set requirements for smallholder dairy farmers and pasture improvement is one of them. As soon as the farmer gets the animals, his interest to manage the pastures appears to wane. Pastures are usually good during the first two to three years after which one hardly sees planted pastures on some farms.

There are, however, some exceptional smallholder farmers, particularly in Blantyre Milkshed Area, who have been able to adopt forage technology. On a national basis the problem of pasture development and management is socio-economical, and it is strongly linked with the customary land tenure system. No farmer is committed to communal grazing land improvement.

During a simple diagnostic survey conducted by the Adaptive Research Team at Chitedze, Mwafulirwa (unpublished) made a number of observations on the utilisation of results from undersowing forage research trials.

First, undersowing forages in maize is viewed by the farmer with suspicion because the general extension message is to keep a maize crop weedfree, therefore undersowing appears to be in conflict with the accepted original message. This is a serious extension message transfer of information that is narrow minded, that looks at crop enterprises in isolation of all other activities on the farm. Such farmers need on-farm verification studies to further convince them that undersowing if done at the right time does not reduce maize grain, but that it increased the quantity and quality of animal feed resources. Second, over-dependence on inorganic fertilizers for pasture establishment could be reduced by the use of good organic manure. This was demonstrated by a farmer who had applied organic manure and inorganic fertilizer on one half of the undersown field and inorganic fertilizer on the remaining half. The field that had received organic manure was superior to the one that had received inorganic fertilizer only and the difference was persistent into the second year in which no fertilizer or manure was applied. Thirdly, the survey uncovered a farmer who had harvested and cured the pasture but left it in the field to rot in spite of having animal feed shortages. This might imply that the farmer was not advised about keeping cured grass in dry condition and this is an extension problem of not educating the farmers adequately. The fourth observation was that a farmer who had successfully undersown Rhodes grass in his maize, ploughed the grass during the following year in order to grow sweet potatoes conflicting the idea of feed resource improvement for his dairy animals. In this case the farmer might not have perceived the benefits, through increased milk production, that could have resulted from feeding improved forages to his dairy cows. In all the above examples, the message is that patience and continuous follow-up is important when introducing a new technology to smallholder farmers who may not see the immediate or future benefits of such an innovation.

In some cases in Malawi, pasture development has been slow because of lack of affordable pasture seed. Pasture seed harvesting at farm level is a very new concept that requires attention by our extension service. There is need for continued collaboration between researchers and extensionists on the one side, and the farmers on the other in order to wedge a vigorous and effective campaign for pasture production and utilisation.

SUGGESTIONS TO IMPROVE THE UTILIZATION OF FORAGE RESEARCH RESULTS

There is generally a lack of appreciation by smallholder farmers to improve forages for their animals. Furthermore, farmers appear to have accepted the low productivity of their indigenous cattle that has occurred over the past two to three decades. The decrease in cattle productivity has largely been caused by declining levels of feed intake as grazing areas have also declined over the years due to increasing land pressure for cultivation of food and cash crops. Several cattle owners, however, still recall the big productive animals they used to have in the past and this offers a good chance of improvement towards the desired type of animals through forage improvement.

In order to create awareness among farmers about the potential of feeding improved forages to their animals, there is a need to work initially with selected farmers in strategically -located places. These would be farmers willing to co-operate with both the researcher and extensionist to improve animal feed resources. The farmers would obtain seed, where the farmer cannot obtain seed easily, at a nominal fee from the government agents together with all the technical advice. Such farmers' units would act as centres of learning and dissemination of new ideas.

The second stage that would have to be conducted concurrently with the establishment of 'master farmers' would be the production of forage seed at prices that can be paid by farmers willing to invest in forages. Since no seed company would undertake pasture seed production without an assured market, the researcher or extensionist would be responsible for producing seed initially. The government would therefore, subsidize seed production until enough farmer awareness and demand for seed had been created to enable commercial seed production. Very often forage technologies never leave research stations because of lack of seed material.

Thirdly, there is a need to begin approaching forage growing from obscure angles. Research has shown that grasses such as Rhodes grass reduce the levels of nematode infestation of soils for subsequent crops and it has also been reported that soil fertility and structure are greatly improved by having grasses and forbes in fallow land (Tinsley, personal communication). It might be worthwhile to deliver a complete package of forage improvement for a number of purposes rather than livestock feeding only. Such advantages as disease control and soil fertility improvement could attract both cattle owners and non-cattle owners. The overall benefit to the country would be an increase in the hectarage under improved pastures. The same tactic could work for farmers with small land holdings. Selected annual forages (grasses or legumes) would be intercropped with food crops with the major objective of improving soil fertility and/or pest control. The residues after crop harvest would then be grazed.

There are a lot of commercial estates in Malawi that are growing grasses as part of a rotation. The scope for increasing grass production on estates is even greater if tenants would also be encouraged to grow it as part of a rotation instead of having fallow land under forbs. Very little of the planted pastures on the estates are used for feeding cattle, and yet there are a lot of hungry cattle in the country. It might be beneficial to investigate the possibility of harvesting such grass and selling it to farmers who have an animal feed shortage. This would act as an additional source of income to the farmers growing grass whilst serving those farmers who cannot grow enough pastures. The same situation applied to maize stover and other crop residues produced on estates. There is a need to find machines, preferably mobile ones, for grinding crop residues and grass at the site of production and to be sold and to enable farmers (particularly small scale farmers) to mix complete feed rations.

The above suggestions represent only a tithe of possibilities of enhancing the utilisation of forage research results . There has been enough research done and what is required now is active production of such forages to enhance cattle production. Production does not only involve the farmer but it should encompass the researcher and extensionist as agents of change. The agents of change need to be properly co-ordinated to avoid delivering what might appear as conflicting messages to the farmer as was the case with undersowing pasture in maize versus keeping maize weed-free. Finally, there is a lot of scope to improve livestock production through a co-ordinated campaign to forage production and management and this effort should be the responsibility of governments.

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USE OF RESEARCH RESULTS TO FORMULATE A FEEDING STRATEGY FOR LIVESTOCK DURING THE DRY SEASONS IN UGANDA

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ABSTRACT

Livestock production in Uganda is limited among other factors by feed availability throughout the year. Research so far done has shown the potential of crop residues, molasses/urea blocks and poultry waste as ruminant livestock feedstuffs. These results together with orage conservation in the form of silage can be used to formulate a strategy for livestock feeding during the dry season. The use of these research findings has been limited by the weakness in the extension system in the country.

INTRODUCTION

Uganda comprises of a total area of 236,000 km^2 with an estimated human population of 16 million. The cattle population which reached a peak of 5.5 million in 1978 has declined considerably (Table 1) due to the civil wars and a series of disease outbreaks. About 90% of the livestock population is made up of indigenous species and 95% of the livestock is found on small-scale crop/livestock mixed farms. Efforts are now underway to import cattle and restock the dairy farms and ranches that have in the past lost most of their livestock through civil wars.

Diseases apart, livestock feeds is one of the major factors limiting animal production in the country. An overwhelming majority of the ruminant animals depend wholly on grazing and crop residues for the quantity and quality of herbage available. The climate is characterized by two rainy seasons during which periods there is luxuriant growth of vegetation and two dry seasons when pasturage is scarce. Supplementation with compounded feeds is, therefore, necessary to maintain the animals and sustain production during the dry season.

The country is constantly faced with problems related to formulation of balanced rations for adequate feeding. Use of concentrate rations based on cereal grains such as maize, sorghum, millet or root crops as energy feeds and grain legumes such as soybean, peas and groundnuts has led to direct competition with man for the same food resources. This, coupled with the high prices of the commercial feeds necessitates feeding of more non-competitive feedstuffs.

This paper reviews research work done on utilisation of agro-industrial wastes and fodder conservation. The use of these results to formulate a strategy for feeding livestock during the dry season is discussed.

CROP RESIDUES

The major crops grown in Uganda and their potential by-products are given in Table 2. The estimated crop residue yields based on crop acreages (1986) are shown in Table 3. These residues are a potential feed resource especially during the dry season. However, most of these residues are low in digestibility because of high fibre content and are deficient in nitrogen, minerals and vitamins (Table 4). The cellwalls of low quality roughages are generally high in indigestible fractions of lignin and silica (Jayasuriya, 1986). Efforts to improve performance of animals fed on low quality roughages include physical, chemical and supplementary treatments to increase the nutritive value and digestibility of these roughages.

Senoga (1982) studied the effect of sodium hydroxide treatment on <u>in vitro</u> digestibilities of finger millet and sorghum straws (Table 5). Treatment with 1.5% NaOH for one hour maximized IVDMD for both finger millet and sorghum straw. Improvement in digestibility was higher with finger millet straw than with sorghum straw possibly because of higher initial digestibility of sorghum straw.

The use of alkali treatment was found very expensive and other alternate ways of improving straws are being investigated. Urea treatment is one of the methods being investigated as it is cheaper and easily available. Studies are also underway to assess the nutritive value of fodder legumes - Leucaena spp. and Sesbania spp. These will be used to supplement the low protein content of crop residues to improve their utilisation.

Molasses/Urea

The use of molasses/urea blocks as supplements would help to sustain production, especially during the dry season. Molasses and urea are readily available. Preliminary investigations carried out at the Makerere University Farm have shown that it is possible to use locally available binders (clay or anthill soil) instead of cement or lime (Table 6). The blocks are being tested for intake before they can be released to farmers.

Poultry Litter

The poultry industry in the country continues to be popular and has grown rapidly (Table 1) due to concerted efforts by both government and the private sector to set up more hatcheries and to import day-old chicks. Most of the commercial poultry farms use the deep litter system with either coffee husks or wood sawdust as litter material. The country produces a lot of coffee husks annually (Table 3) which is a potential feed resource. Coffee husks and wood sawdust are poor quality roughages and are poorly utilised by cattle when included up to 30% of the ration (Ledger and Tillman, 1972). These could be improved by using them as deep litter material for poultry. Poultry litter has been used successfully in feeding ruminant livestock either incorporated in dry rations or ensiled with maize (Battacharya and Taylor, 1975).

Table 1: Livestock and Poultry Statistics, 1981 - 87 ('000)

	1981	1982	1983	1984	1985	1986	1987
Cattle	4745	4821	4871	4993	5000	5200	3905
Sheep	1384	1453	2035	1602	1674	1680	1682
Goats	2671	2804	1979	3091	3246	3300	2503
Pigs	196	206	233	227	238	250	470
Poultry*	176	324	1000	1200	3000	5000	8330

* Total number of birds on commercial farms including chickens, ducks, turkeys and geese.

Source: Ministry of Economic Planning and Development; Background to the Budget, 1988/89

Table 2: Major crops, field residues and by-products

Crop	Field residue	By-Product
Banana	Pseudostem, leaves	Reject fruit, peels
Cassava	leaves	peels
Sweet potato	vines	peels
Coffee	-	husks/pulp
Cotton	stalks	oilseed cake
Groundnut	haulms	oilseed cake/shells
Beans & other legumes	haulms	-
Cereals	stover	bran, cobs
Pineapple	leaves	pulp
Sugarcane	tops	molasses, bagasse

Source: Bareeba and Mugerwa (1987)

Table 3: Estimated crop residue yields in Uganda, in 1986 ('000 tonnes)

Crop	Dry Residue
Finger millet	464
Maize	354
Sorghum	312
Rice	19
Wheat	10
Potatoes	764
Beans	285
Peas	49
Groundnuts	90
Soybeans	7
Simsim	22
Coffee	140

Source: Ministry of Economic Planning and Development: Background to the Budget, 1988/89.

Table 4: Chemical composition of crop residues and agro-industrial by-products.

	DM%	CP %	Cell Wall%
<u>Crop residues:</u>			
Banana pseudostem	10	5	35
Banana leaves	20	16	50
Banana peel (dried)	90	8	20
Cassava leaves	30	19	40
Maize stover	90	5	75
Maize cobs	90	3	85
Rice straw	90	3	70
Sugarcane tops	30	5	70
Soybean straw	90	6	55
Groundnut haulms	20	15	40
Sweet potato vines	30	18	20
Fingermillet straw	90	9	60
Sorghum straw	90	6	65
<u>By-Products</u>			
Coffee husks	90	9	55
Pineapple pulp	10	5	30
Maize bran	90	10	25
Molasses	25	4	-
Bagasse	50	1.5	85

Source: Anon (1985). Composition and nutritive value of Uganda Feeds. Department of Animal Science, Makerere University

Table 5(a): Effect of NaOH treatment on the chemical composition and *in vitro* digestibility of fingermillet straw.

Item (%)	% NaOH			
	0	1	1.5	2.5
CP	9.1^b	8.2^b	8.2^b	7.1^a
ADF	42.6	48.8	46.7	43.0
Ash	10.8^a	17.2^b	20.7^b	25.1^b
IVDMD'	47.9^a	49.8^a	66.1^b	65.5^b

IVDMD - *In vitro* DM digestibility

a,b means in the same row with different letters are significantly different ($p<0.05$)

Source: Senoga (1982)

Table 5(b): Effect of NaOH treatment on the chemical composition and *in vitro* digestibility of sorghum straw.

Item (%)	% NaOH			
	0	1	1.5	2.5
CP	5.7^a	6.8^b	6.6^b	6.2^b
ADF	55.8	55.7	51.5	55.5
Ash	5.6^a	11.8^b	15.4^c	16.3^c
IVDMD	49.1	53.4	55.6	47.9

IVDMD - *in vitro* DM digestibility

a,b,c: Means in the same row with different letters are significantly different ($p<0.05$)

Source: Senoga (1982)

Table 6: Formulae of molasses/urea blocks on trial.

Ingredient	A %	B %
Molasses	50	50
Urea	10	10
Salt	5	5
Maize bran	25	25
Binder	10	10

Binder in A = Clay;
Binder in B = Anthill soil

Table 7: Chemical composition of litter material and poultry litter.

Item (%DM)	Wood Sawdust	Sawdust litter	Coffee husks	Coffee husks litter
CP	1.8	21.1	9.1	21.9
True protein	1.5	13.6	7.5	13.3
ADF	86.9	26.2	52.3	45.6
Ash	2.36	27.7	8.6	20.1
Ca	0.41	5.22	0.56	2.94
P	0.04	2.44	0.26	0.80
K	0.37	1.25	0.27	0.45

Source: Kato, (1985)

Kato (1985) determined the accumulation and yield of broiler litter by 150 broilers with a spacing of $0.1m^2$/bird in 3 months. Litter DM (kg) doubled and crude protein (kg) quadrupled in 3 months of litter formation. The results suggested that 100 broilers could produce 1.11 metric tons of poultry litter with 0.31 tons of crude protein in a year. The chemical composition of the litter material and the poultry litter are shown in Table 7. Although the litter has a high nitrogen content, about 40-50% of this is NPN. The poultry litter has a high ash content and high levels of Ca, P and K.

In a feeding trial, maize silages containing 0, 25 and 50% of coffee husks - based poultry litter were fed to weaned calves (Kato, 1985). There was a significantly higher $P<0.05$) DMI/day on the 50% litter silage compared to the others. (Table 8). However, live weight gain and feed efficiency were not affected. In another feeding trial, the poultry litter was mixed in a dry ration at 0, 15 and 30%. This concentrate mixture was used as a supplement to growing calves that were fed maize silage. Silage DMI and total DMI were not affected by levels of poultry litter in the supplement (Table 9). The daily live weight gains and feed efficiency were not different among the treatments.

The results of this work demonstrated the potential of poultry litter as a feedstuff for ruminants. It can be used in formulating concentrate mixtures by replacing soybean or cottonseed cake or it can be used to enrich maize silage. Ensiling the poultry litter appears to be the most feasible processing method to inhibit potential bacterial pathogens and parasites in animal wastes prior to feeding.

FORAGE CONSERVATION

There is need for forage conservation in the country to bridge the nutrient gap during the dry seasons when pasture is scarce. In addition, intensive methods are the recommended farm practices for dairy farming. Work so far done has been mainly concerned with silage making with little attention to hay making.

Bareeba (1977) studied the ensiling characteristics of maize, maize - amaranthus (1:1) and sorghum silages preserved with molasses (5%) or formalin (0.25%) (Table 10). The low pH values indicated a lactic fermentation in ll silages but formaldehyde tended to reduce the lactic acid content. Kato (1985) studied the fermentation pattern of maize mixed with poultry litter up to 50% in laboratory silos (Table 11). Litter addition at 30% and beyond tended to reduce lactic acid and increased pH and NH_3-% (% total N). However, DM losses were reduced by the 40% and 50% level.

Bareeba (1977) fed the silages to determine the nutritive value and milk producing potential of the silages. Maize silage showed an overall nutritive superiority over other silages as indicated by higher TDN (Table 12). Digestible energy intake from silage was enough for maintenance plus at least 5 kg FCM/day.

Table 8: Animal performance on poultry litter/Maize silage.

	Litter % (DM basis) in silage		
Item	0	25	50
Mean liveweight (kg)	77.1	77.5	74.5
<u>DM intake</u>			
Kg/day	1.05^{a}	1.29^{a}	1.69^{a}
$g/KgLWG^{0.75}/day$	39.8^{a}	47.5^{a}	63.3^{b}
<u>Digestibility</u>			
DM	40.5^{a}	44.6^{b}	37.5^{a}
OM	46.3	48.5	42.3
LWG(Kg/day)	0.13	0.18	0.17
DMI kg/kgLWG	8.1	7.3	9.7

a,b Means in the same row with different letters are significantly different ($P<0.05$)
Source: Kato (1985)

Table 9: Performance of growing cows fed concentrate mixtures containing poultry litter*.

Item	% Litter in ration		
	0	15	30
Average liveweight (kg)	157	187	175
Silage DMI (Kg/day)	2.75	2.61	3.30
Total DMI (Kg/day)	5.38	5.11	5.86
Digestibility (%)			
DM	73.5	67.6	72.8
CP	81.6	77.4	80.0
LWG (Kg/day)	0.85	0.73	0.92
DMI (kg/kg LWG)	3.53	4.11	3.26

* Animals were fed silage ad lib plus 3 kg/day of the concentrate mixture

Source: Kato (1985)

Table 10: Fermentation pattern and chemical composition of maize and sorghum silages.

Item	Type of Silage			
	MM	FM	MAM	MS
pH	4.0	4.10	4.05	4.0
Butyric acid (%DM)	1.23	1.14	1.27	2.38
Lactic acid (%DM)	7.85	3.18	6.74	3.29
Acetic acid (%DM)	5.67	2.47	5.23	2.56
NH_3-N (%DM)	0.096	0.045	0.94	0.095
DM Loss (%)	11.04	14.04	13.24	13.06
CP (%)	6.9	6.7	11.6	7.0
ADF (%)	41.3	41.4	39.3	47.4
GE (Kcal/g)	4.25	4.30	4.30	4.35

* MM = molasses-maize; FM = formalhydyde - maize; MAM = molasses - amaranthus/maize; MS = molasses-sorghum

Source: Bareeba (1977)

Table 11: Fermentation pattern and chemical composition of maize silage treated with poultry litter.

Item	Litter % (DM basis) in silage					
	0	10	20	30	40	50
pH	3.8[a]	3.9[a]	4.1[a]	4.7[b]	5.6[c]	5.8[a]
Butyric acid (%DM)	0.43[a]	0.41[a]	0.88[b]	1.34[c]	1.68[c]	1.33[c]
Lactic acid (%DM)	4.03[a]	4.72[a]	4.14[a]	2.32[b]	2.70[b]	0.76[c]
Acetic acid (%DM)	4.34	4.36	4.78	4.12	4.62	4.88
NH_3-N (% total N)	5.1[a]	6.3[ab]	7.7[b]	7.6[b]	9.6[b]	11.1[c]
DM loss (%)	22.9[a]	20.6[a]	20.0[a]	19.3[a]	17.7[b]	16.7[b]
CP (%)	7.5[a]	8.7[b]	9.7[bc]	10.4[c]	13.5[d]	13.7[d]
ADF (%)	47.6	44.6	46.2	47.1	51.7	51.3

abc Means in the same row with different letters are significantly different ($p<0.05$)

Source: Kato (1985)

Table 12: Silage DM intake and milk production potential of maize and sorghum silages.

Item	Type of silage*			
	MS	FM	MAM	MS
Silage DMI (kg/day)	10.3	9.2	9.6	9.7
Silage TDN (%)	66.1	64.6	63.2	60.7
Silage TDN Intake (kg/day)	6.8	5.9	6.0	5.9
Excess TDN intake				
Overmaintanance energy (kg)	2.64	1.78	1.86	1.75
Estimate milk production				
from silage (kgFCM/day)	8.0	5.4	5.5	5.3

* Estimates based on US - NRC 1971

MM = molasses-maize; FM = formaldehyde-maize; MAM - molasses-amaranthus/maize; MS - molasses-sorghum

Source: Bareeba (1977)

This work was in agreement with that of Mugerwa et al (1974) working with pasture. It was concluded that silage could be fed in addition to pasture to supplement the low digestible energy and protein intake from pasture especially in the dry season. Enrichment of maize and sorghum silages by ensiling them with high protein forages such as amaranthus or poultry manure was recommended to reduce protein level required in concentrate mixtures.

However, studies have not been done at the farm level to determine the labour requirements and the cost - benefit ratio of using silage. It appears silage making requires a lot more than family labour.

USE OF RESEARCH RESULTS

From the review, there is some information on the nutritive potential of crop residues and poultry litter and conservation of forage as silage. This information has been used by farmers for feeding livestock especially during the dry season only to a limited extent. Both the ministries of Agriculture and Animal Industry and Fisheries handle agricultural extension. The extension system has the following problems:-

i) Lack of clearly defined and focused agricultural extension policy as evidenced by multiplicity of unco-ordinated extension approaches and use of methods without farmer consideration.

ii) Lack of sufficient training in extension methodology which leads to lack of mission objectives and insufficient sound technical information.

iii) Lack of planning by extension workers resulting in haphazard choice of extension methods and poor teaching and transfer of innovations to farmers.

iv) Budget limitations which lead to limited funds for transportation in the field. There is poor supervision and guidance.

v) Poor research-extension linkage. As such there is lack of information from the field to the headquarters and research stations or vice versa. There is therefore need to document research results in the form of extension bulletins which can be passed on to the farmer.

CONCLUSION

Research conducted so far has demonstrated the usefulness of crop residues and poultry litter as feedstuffs for ruminant livestock in Uganda. Successful results have been obtained with silage making. Whether this practice can be adopted by farmers will depend on the costs and benefits involved. The use of these research results by farmers has been limited by the weak agricultural extension system. Efforts are underway to strengthen the research-extension linkage through the proposed establishment of an autonomous National Agricultural Research organisation (NARO).

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FEEDING SYSTEMS FOR MILK PRODUCTION IN THE HIGH POTENTIAL AREAS OF KENYA: ON-FARM TRIALS

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ABSTRACT

Composition of various types of feeds offered to Friesians, Ayrshires or their crosses were studied in several farms practicing zero-grazing, semi-zero-grazing and grazing systems of milk production. The experiments were carried out in the high potential areas of Kenya during the wet season. There was uniformity in the chemical composition of concentrate fed within and across farms except for the level of phosphorus (P) which differed significantly ($P<0.01$) between farms. Composition of fodder varied significantly ($P<0.01$) between farms with regard to crude protein (CP), fibre (ADF), calcium (Ca) and P. Farms differed significantly ($P<0.05$) only in the level of P in pastures. Pasture or fodder contributed most to dry-matter (DM) intake averaging about 12.1 kg per animal each day under grazing and about 10.0 kg when animals were fed in confinement. A wide range of fodder was fed under semi-zero-grazing and intake of DM from such supplements averaged 1.9 kg per animal per day. Fodders fed under semi-zero-grazing were superior to that fed under zero-grazing in terms of levels of critical nutrients. Daily concentrate consumption differed significantly ($P<0.01$) between farms and was highest (4.3 kg DM) and least (0.44 kg DM) per animal under zero-grazing and grazing respectively. Average milk production per farm was 12.0, 11.6 and 10.2 kg for zero- grazing, semi-zero-grazing and grazing systems respectively. Given the level of production, all the feeding systems were deficient in at least one nutrient. It was concluded that for all systems, protein, Ca and P supplementation seem desirable particularly when milk production per animal is in excess of 10 kg per day.

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INTRODUCTION

The high potential areas of Kenya are defined as those characterised by between 1200 and 2000 mm of rainfall per annum with dairying as a major farm activity carried out in small holdings. The historical development and ecological distribution of the systems of milk production in these areas have been reviewed (Chema, 1984) and corresponding milk output including measures for increased yields discussed (Abate et al., 1987b). There is also information on the economics of the different production features of small holder dairying (Stotz, 1983). The type of feeding practised in each system is generally known but data on the quality and quantity of material fed particularly fodder are lacking (Abate et al., 1987a). This study was initiated to assess the wet season variation in nutrient supply to milking animals managed under different systems of production.

MATERIALS AND METHODS

The experiments were carried out in 5 farms representing 3 systems of production as summarised in Table 1. Friesians, Ayrshires or their crosses were selected on the basis of age, parity and production and used in the experiments. The zero-grazing trial was divided into two 28 day and two 18 day periods. All other experiments consisted of 3 periods each of 30 days.

Table 1: Features of production system and experimental conditions.

Farm	Production systems	n	Days on trial	Labour	Water frequency per day
1	Zero-grazing	4	92	Hired	x 3
2	Semi-zero-grazing	5	90	Family	x 4
3	Semi-zero-grazing	3	90	Family	x 2
4	Semi-zero-grazing	3	90	Hired	x 2
5	Grazing	3	90	Hired	x 2

Types of feed offered in each system are given in Table 2. Under zero-grazing, each animal was fed individually from concrete troughs twice a day at 08.00 and 15.00 hours. Each time concentrate was first fed after which chopped Napier grass was fed to appetite; the amount offered was weighed using a spring balance of a 50 $\pm$ 0.5 kg capacity. Little concentrate was also fed at milking. Refusals were weighed every afternoon and morning and samples accumulated over a week or 5 days.

In the semi-zero-grazing and grazing treatments animals were individually fed from half-cut drums or basins. Feeding of fodder was once a day either in the morning or afternoon; the rest of the time, the animals grazed. All fodder was chopped into 3-8 cms lengths before feeding. A balance similar to the one described above, was used to weigh feeds offered and those rejected daily. Concentrates, were rationed and fed twice a day at milking. Intake from pasture was estimated based on the acreage available for grazing, grass cover, time spent on grazing and ranged from 2.0 to 3.0% of body weight. A mineral supplement Baymix maziwa, was mixed in the concentrate and provided in all trials to each animal. The frequency of watering from piped, bore hole and standing rainwater is as shown in Table 1.

Table 2. Types of feed offered in each feeding system

	Zero-grazing	Semi-zero-grazing			Grazing
Feed type	1[a]	2	3	4	5
	Napier grass[b]	Cabbage Maize fodder Weeds Potatoes Kale	Cabbage Maize fodder Potatoes Oat fodder	Napier grass + molasses Banana stems and leaves + molasses Green bananas	
Pasture		Mixed species Kikuyu grass	Mixed species	Kikuyu grass Mixed species	Kikuyu grass *Chloris gayana*
Cocentrate	Daily meal	Wheat bran Dairy meal + maize germ + wheat bran	Daily meal + wheat bran	Crushed maize + fodder yeast	Crushed maize + daily meal Wheat bran + daily meal Wheat bran + dairy meal + crushed maize

[a]Farm
[b]Usually maize fodder is also fed.

Samples of Napier grass offered and rejected in the zero-grazing trial were taken once a week and prepared for analysis. In the other treatments, samples of all feeds offered and rejected were collected once a month. Grazing was sampled by clipping grass from randomly selected areas once monthly. All concentrates were sampled periodically, accumulated over each period and sub-sampled for analysis. Milk produced was weighed and recorded daily for each animal. Heart girth measurements were taken once in each period to estimate animal weight changes.

ANALYSES

Samples were assayed for dry matter (DM), crude protein (CP), fibre (ADF) and lignin using approved methods (A.O.A.C., 1980; Van Soest, 1965). Calcium (Ca) and phosphorus (P) were determined after wet ashing using atomic absorption spectrophotometry and a Beckman Spectrophotometer respectively. Only data for 3 periods were subjected to least square analysis and separation of means using the mixed model package of Harvey (1987).

RESULTS

Types of feed offered to animals in each feeding system are presented in Table 2. They included a variety of fodders, pasture and a number of concentrates. In some farms fodder was fed without additives, in others it was mixed with molasses. Concentrates consisted of cereal grains, commercially compounded feeds and by-products of industrial processing. Very often a number of concentrates were mixed together before feeding as a meal or in the crushed form as in the case of maize grains. Some form of rotational grazing was practised during the day; at night animals were grazed nearer the homesteads.

The DM content of fodder increased with period in all farms except where a fodder of particularly low DM was introduced into the feeding system (Tables 3 and 4).

Chemically, the nutrient content of fodder varied with time within a feeding system but the differences were not significant ($P>0.05$). Under zero-grazing (Table 3) where Napier grass was the only fodder fed this variation was in the direction of lower CP. There was no recognised pattern of change in nutrient levels under semi-zero-grazing; only in one farm was there a significant ($P<0.05$) difference in the levels of ADF with period (Table 4). The trend of higher DM content with time was consistent in pastures of all farms (Tables 4 and 5). Since only one observation was recorded per period no statistical test was possible to detect period differences with regard to nutrient content of pasture. There were, however, fluctuations of differing degrees in all nutrients. Concentrate DM content was about uniform from period to period (Tables 4 and 5). The CP content of the concentrates was also uniform throughout the experimental period; mineral levels, however, varied.

Table 3: Variation with period in the chemical composition of feeds offered under zero-grazing.

Feed type	Period	DM	CP	ADF	Ca	P
		%	---------% DM----------			
Fodder	1	12.4	10.4	45.2	0.13	0.27
	2	15.7	9.4	41.2	0.26	0.21
	3	17.4	7.0	44.3	0.28	0.18
Concentrates	1	88.9	17.0	-	0.88	0.67
	2	86.2	16.4	-	0.89	0.64
	3	86.7	16.1	-	0.83	0.65

(-) denotes not determined

Table 4: Variation with period in the chemical composition of feeds offered under semi-zero-grazing.

Feed type	Farm 1			Farm 2			Farm 3		
	1[1]	2	3	1	2	3	1	2	3
<u>Fodder</u>									
Dry matter, %	14.3	17.3	17.7	16.3	16.6	21.2	31.1	14.6	10.9
[2]CP, %	11.3	12.9	13.2	10.6	10.6	9.6	7.3	6.3	3.1
ADF, %	27.8	31.8	27.8	28.3	27.3	30.0	44.6a	27.2b	17.1bc
Ca, %	0.56	0.48	0.55	0.34	0.35	0.88	1.08	1.40	1.34
P, %	0.26	0.22	0.21	0.31	0.33	0.32	0.25	0.10	0.08
<u>Pasture</u>									
Dry matter, %	21.2	26.0	36.3	26.5	31.8	37.1	16.3	24.5	25.6
[2]CP, %	6.9	8.6	7.2	7.8	8.5	7.1	8.0	6.3	7.2
ADF, %	30.9	35.2	39.7	32.6	37.5	36.3	32.4	43.4	36.4
Ca, %	0.46	0.46	0.45	0.45	0.41	0.32	0.43	0.42	0.48
P, %	0.10	0.10	0.09	0.24	0.28	0.18	0.29	0.18	0.21
<u>Cocentrate</u>									
Dry matter, %	89.0	90.8	88.6	89.6	90.2	89.0	89.1	89.6	90.5
[2]CP, %	16.1	16.0	16.0	16.8	17.0	16.5	16.3	16.2	16.4
Ca, %	0.16	0.47	0.71	0.58	0.61	0.54	0.78	1.45	0.44
P, %	1.61	0.94	1.12	1.04	1.03	1.06	0.50	0.50	0.39

[1]Period
[2]% DM
Means with different superscripts along the same row are significantly different ($P<0.05$).

Table 5: Variation with period in the chemical composition of feeds offered under grazing.

Feed type	Period	DM %	CP	ADF	Ca	P
			----------% DM----------			
Pasture	1	17.0	13.7	33.9	0.35	0.67
	2	26.1	7.8	43.5	0.20	0.64
	3	31.8	7.2	45.7	0.62	0.65
Concentrate	1	69.1	17.0	-	0.58	0.82
	2	89.6	17.3	-	0.31	1.09
	3	91.7	15.0	-	0.62	0.24

(-) denotes not determined.

Differences between farms in the levels of nutrients in feeds offered are shown in Table 6. Crude protein, ADF, Ca and P of fodder varied significantly ($P<0.01$) between farms. Crude protein was significantly higher ($P<0.01$) under semi-zero-grazing than in zero-grazing and grazing systems. Analysis of variance showed that, overall, nutrient concentrations in pastures of all farms was fairly similar (Table 6). Linear contrasts of the farms showed them, however, to differ significantly ($P<0.05$) in the content of P. The CP and Ca levels in the concentrate were not significantly affected ($P>0.05$) by farm but P concentrations were ($P<0.05$).

In Table 7 are shown animal weights, DM intake and milk production per animal in each farm. In all systems, fodder or pasture contributed most of the DM ingested. Intake of DM from concentrate differed significantly ($P<0.01$) being highest under zero-grazing and least under grazing. System of feeding also significantly affected ($P<0.01$) the quantities of fodder consumed per animal daily. Dry-matter intake from pasture was similar in the semi-zero-grazing farms and significantly lower ($P<0.05$) than under grazing. Animals in farm 4 were the lightest and produced the least milk.

Animal requirements were met for protein and P but not Ca in the zero-grazing system. Under semi-zero-grazing feeding, animals were deficient in all nutrients when they produced at least about 11 kg of milk, their requirements were, however covered with production of about 6 kg of milk. Under grazing the animals experienced protein and Ca deficits but had sufficient intake of P.

Table 6: Variation with farm in the chemical composition of feeds offered.

	Farm				
	1[1]	2	3	4	5
Fodder					
Dry matter, %	15.2	16.5	18.0	18.9	-
[2]CP, %	9.0[ac]	12.5[b]	10.2[ab]	5.6[c]	-
ADF, %	43.6[a]	29.1[b]	28.6[b]	29.6[b]	-
Ca, %	0.22[a]	0.53[b]	0.52[a]	1.3[b]	-
P, %	0.22[a]	0.23[a]	0.32[b]	0.14[a]	-
Pasture					
Dry matter, %	-	27.8	31.8	22.1	25.0
[2]CP, %	-	7.6[a]	7.8[a]	7.2[a]	9.6[a]
ADF, %	-	35.3[a]	35.5[a]	37.4[a]	41.0[a]
Ca, %	-	0.46[a]	0.41[a]	0.44[a]	0.39[a]
P, %	-	0.10[a]	0.23[ab]	0.23[ab]	0.33[b]
Concentrate					
Dry matter, %	87.3	89.5	89.6	89.7	83.5
[2]CP, %	16.5[a]	16.0[a]	16.8[a]	16.3[a]	16.4[a]
Ca, %	0.84[a]	0.45[a]	0.58[a]	0.89[a]	0.50[a]
P, %	0.65[a]	1.07[b]	0.04[b]	0.46[ac]	0.72[ab]

[1]period

[2]% DM

Means with different superscripts along the same row are significantly different (P<0.01 and P>0.05).

Table 7. Variation with farm in DM intake, animal weights and milk production

	Farm				
	1[1]	2	3	4	5
Animal weight, kg	438.9 ± 56.7	392.4 ± 40.4	385.3 ± 45.8	369.3 ± 25.6	401.8 ± 63.2
Dry matter intake, kg/d					
Concentrate	4.3a	0.27bc	0.67b	1.80c	0.44d
Fodder	10.0a	1.2b	0.8bc	3.7d	-
Pasture	-	9.8a	9.6a	7.4a	14.1b
Total	14.3	11.7	11.1	12.9	14.5
Milk production, kg/d	12.0 ± 1.2	12.1 ± 1.4	11.2 ± 3.1	5.7 ± 1.5	10.2 ± 3.3

Means with different superscripts along the same row are significantly different (P0.05).
Mean ± SD

DISCUSSION

The results of the present study show that in the high potential areas of Kenya, there are differences in the range of feeds offered to animals at farm level during the wet season. These differences are often environmentally determined so that farmers do not necessarily feed sufficient amounts of the types of feeds that would produce maximum performance in their animals in accordance with feeding standards. As a fodder, Napier grass has been popularized by the extension service (Stotz, 1983; Wouters, 1986; Abate et al., 1987a) and this explains its use in zero -grazing and semi-zero-grazing systems. The feeding of other fodders has developed over time through farmers own observations and exchange of ideas with each other. Cabbage was, for example, fed because it grew well in the area, was cherished by cows, was fed by other farmers in the neighbourhood and was believed to increase milk yield. Our observations, showed that many small holders, fed cabbage at least during milking. The farmers are, however, possibly unaware of the goitergenic effects of feeding large quantities of brassicas. At maturity, cabbage DM was still below 10% and this would limit the intake of DM from this fodder. Weeds were fed because it was noticed that during grazing cows concentrated around weed-dominated areas. On analysis the weeds were found to contain on average about 16% CP which is useful in the maintenance of the N economy of animals largely dependent on pasture. The farmers also fed potatoes and molasses as sources of readily available carbohydrates in addition to the wide range of concentrates offered. Mixing of concentrates was a common feature of the farms practising semi-zero-grazing in this study. For some farmers the practice developed in an attempt to cut down costs by combining cheaper concentrates with expensive ones. For others it was simply a result of resource availability.

Dry matter of fodder offered to animals can be influenced by feeding at early stages of growth. Thus the increase in DM levels of fodders with time is an indication that in these experiments, farmers knowingly avoided the feeding of high moisture young fodders. This was achieved, in one instance, through a time-staggered planting regime so that not all fodders reached maturity at the same time. The near uniformity in the chemical content of fodders fed with time (Table 4) has practical implications. It shows that nutritionally, it is advisable to feed a combination of fodders inorder to maintain a high concentration of critical nutrients throughout the wet season. To prevent the alteration of such a favourable nutrient balance, it is desirable for farmers to plant and feed sufficient quantities of each fodder.

The increases in DM content of the pastures in these experiments were a reflection of maturity and consistent with results reported elsewhere in Kenya (Said, 1971; Karue, 1974; Abate, 1978). Fluctuations in chemical composition were a result of new regrowths induced by precipitation within a given period. Abate (1978) has shown similar changes in the protein and fibre components of a predominantly Chloris gayana pasture. By practising some form of rotation the farmers allowed young vegetative growth to mature and hence showed that they had consideration for nutritive quality.

As purchased feeds, the DM content of concentrates can only be influenced at the point of formulation. A farmer can, however, affect the DM content by the method of feeding. Addition of water or molasses to concentrates to reduce dustiness etc., will reduce feed DM content (Table 5). Changing of the type of concentrate with period was responsible for the variation in the mineral levels with time.

In terms of nutrient concentration fodders fed under semi-zero-grazing were superior to that offered in zero-grazing. However, semi-zero-grazing resulted in intake of low DM from the fodders mainly because the content of DM of the fodders was often very low. Cabbage and banana stems were examples of such material. Intake under this feeding system can be improved by planting more fodders like maize and oat which are capable of accumulating DM with time.

Generally, all the pastures reported here were of sufficient nutrient level to promote satisfactory milk production if adequately consumed. Only in one farm was the level of P near the deficiency margin (Table 6); all other farms contained concentrations that are similar to those reported by Howard et al. (1962). Calcium levels were satisfactory and above the minimum below which deficiency is likely to occur.

The differences in P levels in concentrates with farm were because type of concentrate fed differed. There are also several possible reasons to explain the variation with farm in the intake of concentrate DM. These include farmers ignorance as to the importance of concentrate as a production ration, cost and availability, distance from source and the purchasing power of individual farms. Stotz (1979) noted an inverse relationship between the feeding of concentrate to cows and the distance from the supply centre. Efforts should, therefore, be made to produce concentrates nearer to the farmers and to encourage them to feed higher amounts. The animals used in these studies have higher genetic potential than was shown by their milking performance and would, therefore, respond to improved nutrition.

While it is true that feeding standards have no relevance under certain feeding conditions, the results of this study show at least one nutrient to be deficient in any one feeding system. The effects of low dietary CP are manifested in decreased yields which is undesirable since it affects farmers' income. Supplemental protein is, therefore, recommended in the semi-zero -grazing and grazing systems except where the animals are poor milkers. Protein concentrates are expensive and this may militate against their use as supplements. Establishment of shrubs like Leucaena leucocephala on the farm is cheaper and can supply some of the protein required by the animals. Leucaena has been known to promote feed intake, utilisation and production in ruminant animals. If minerals were not provided in these experiments, the feeding systems were such that supplementation would be necessary for Ca and also P particularly when animals produced at least 10 kg of milk. This is important so that mineral deposition may be favoured during the wet season for use in periods of stress. If farmers are educated on the merits of supplementation, they are likely to adopt the practice. In these experiments, farmers who previously fed fodder in the long form agreed to continue chopping it because they realized it increased intake and reduced wastage. Kategile (1986) has noted that farmers acknowledge the benefits of improved feeding.

CONCLUSION

The following conclusion can be made from the results of the present study:

a. A variety of fodders, some of them with as low as 5% DM are fed during the wet season in feeding systems practised in the high potential areas of Kenya.

b. Feeding a number of fodders together is superior to feeding only one type in terms of concentration of critical nutrients.

c. Concentrate fed under semi-zero-grazing is little but the amount could be improved by producing compound feeds nearer to the farmers and making the farmers aware of the benefits of concentrate supplementation.

d. All the feeding systems are deficient in at least one nutrient particularly when animals are good milkers.

e. For all systems protein and Ca supplementation seem desirable particularly at high levels of milk production.

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ON-FARM EVALUATION OF MAIZE BRAN AND COTTONSEED CAKE AND INTRODUCTION OF IMPROVED FORAGE TECHNOLOGIES FOR MILK PRODUCTION IN MZUZU MILKSHED AREA OF MALAWI

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ABSTRACT

On-station research work has developed promising animal feed resource technologies for increasing milk production and these are being evaluated on-farm with both research resources and those of farmers. Preliminary results show that the inclusion of cottonseed cake in maize bran-based dairy rations would raise dairy farmers' gross margin/cow. If the programme will be successful, the utilisation of research results will eventually lead to more feed resources of high quality resulting in increased livestock productivity with the end result of attaining food security and improved farm income of the smallholder farmers.

INTRODUCTION

In Malawi, smallholder dairy farming was initiated by the Food and Agriculture Organisation (FAO) through the agency of the United Nations Development Programme (UNDP) in the early 1970s. The programme was set up in order:

1. to provide fresh milk for the increasing population

2. to reduce imports of milk by-products, and

3. to provide alternative sources of income to farmers

The national aim of the dairy development programme is to achieve self-sufficiency in milk and milk products. Recent figures show that production and consumption of milk and milk products remains low; per capita consumption from the national herd is estimated at approximately 6 kilogrammes (kg) per year compared to 28kg per year for the Eastern and Southern African region as a whole, and to 100 kg per year for European countries (Anonymous, 1987). At the same time, there is an urgent need to improve national human nutrition levels. The pressure on land is increasing, and the population continues t increase rapidly at the annual growth rate of 3.0% (Anon, 1988).

The government of Malawi has responded to these problems by promoting smallholder dairying. The dairy programme is concentrated in places designated as milkshed areas. There ar three such milkshed areas: Blantyre in the Southern region wit 700 dairy farmers, started in 1970; Lilongwe in the Central region with 400 dairy farmers started in 1972; and Mzuzu in th Northern region with only 80 farmers, started in 1977 (Nkhonjera, personal communication).

Mzuzu milkshed area is situated on the Viphya plateau at an altitude of 1200 metres. The area has a mean maximum temperature of 21°C; and a mean minimum temperature of 18°C. The rainfall which is influenced by the South East Trade winds blowing across the lake Malawi ranges from 1200 - 2300 millimetres (mm) annually. About 70% of the rain falls betwee December and March while 125-250mm falls between May and October in most places of the milkshed area (Anonymous, 1982). This extended rainfall season provides an ideal environment fo evaluating late maturity legumes which tolerate acidity (Msiska, personal communication). The weather for this area i also conducive for silage making; and it makes the pastures remain green throughout the year. The area is characterized b Brachystegia woodland savanna vegetation while the soils which are fairly acidic (pH.5.1) are mostly deep dark red uniform sandy-clay ferrisols.

Crop production systems and animal feed resources in Mzuzu

Major crops grown in the area include maize, beans, citrus fruits, and bananas; whilst cassava, groundnuts, potatoes, coffee and finger millet are grown in small hectarages. Table 1 contains estimated average cultivated areas of the crop enterprises for a few selected farms in Mzuzu.

Table 1: Estimated average cultivated areas of crops enterprises for selected farms in Mzuzu

Crop enterprise	Average cultivated area (ha)
Maize	2.5
Beans	1.7
Fruits (citrus)	2.2
Bananas	0.7
Groundnuts	0.4
Cassava	0.5
Fingermillet	0.3
Potatoes	0.2
Coffee	0.4

Sources: Cusack,. T.J. 1988. Report of a Reconnaissance Survey in Mzuzu milkshed area (unpublished).

Apart from dairy cattle, farmers in Mzuzu also keep poultry, goats and rabbits. For dairy production, two systems of grazing are practised. One system is based on zero-grazing (cut-and-carry) in which dairy animals never leave the stalls and fodder/crop residues are taken to them throughout the year. This system is not common in Mzuzu because the majority of the farmers graze their animals on natural pastures. The other system is 'open' grazing. In the case of Mzuzu, this system is inefficient because animals have to walk long distances to grazing areas from the homestead. They are taken back to the homestead for milking. However, the majority of farmers practice both systems, especially those with some established improved pasture plots in addition to natural pastures.

Feed resources available in the area fall into three classes:

1. Pastures:
   (a) Natural
   (b) Improved planted
2. Agro-industrial by-products and crop residues and
3. Other agricultural products e.g. Banana leaves and pseudostems

Pastures

(a) Natural grazing

This represents the major feed resource in the milkshed area. Grazing on natural pastures is commonly practised; as a result not much effort, is made to establish improved pastures. Farmers consider that pasture establishment is not essential since there is unlimited natural grazing land.

(b) Improved established pastures

Very few farmers have improved pastures; such that they practice both zero-grazing and 'open' grazing on natural pastures. For those farmers who have improved pastures, grass is cut-and-carried to the stalls for a short period of time. After having exhausted these resources animals are taken out to natural lands. The reason for this is that farmers establish small plots of pasture which do not match with the size of their herd.

The use of Napier (*Pennisetum purpureum*) is proving most productive for those farmers who are able to utilise it properly; however, many farmers are wasting this resource by subjecting it to overgrazing or letting it overgrow and later cut for bedding material in the stalls. Other grasses grown in this area include Rhodes grass (*Chloris gayana*), Hamil panic (*Panicum maximum*) and Guatemala (*Tripsacum laxum*). In this area Rhodes grass does not seem to be persistent and is not productive enough under present smallholder management conditions. Legumes commonly grown in the area include Glycine (*Neonotonia wightii*), Greenleaf (*Desmodium intortum*), Silverleaf (*Desmodium uncinatum*) and Stylo (*Stylosanthes guianensis*). However, farmers rarely have these forage legumes on their farms. Those who have them have planted them as small plots of pure stands of one or several species.

Agro-industrial by-products and crop residues

Feed resources included in this category are:

(i) Maize bran

(ii) Cottonseed cake

(iii) Groundnut cake

(iv) Maize stover and groundnut haulms

Other agricultural products: In this category there are banana leaves and pseudostems; and small quantities of potato vines. A commercial concentrate, dairy mash from Limbe in the southern part of the country when available is used in the feeding systems.

Feed shortages during the dry seasons and sometimes during the wet seasons constrain dairy production in the Mzuzu milkshed area. A large portion of this area is under natural pastures whose nutritive values are very low. In addition, the main constraints for natural pastures are:

- seasonal and low productivity including the conspicuous absence of legume species,

- lack of proper management, including serious overgrazing

- the traditional communal land tenure systems which hamper efforts to improve the grasslands; and

- the inability to effectively carry out destocking

Improved pastures can increase milk production in the region. However, farmers lack the skills in managing these pastures once established. Weeds are left to grow together with the pastures; and the pastures are not fertilized. In most cases the blame is laid on the farmer, but the extension workers take the leading role in the improper management of the pastures because of lack of proper advice and guidance given to farmers. To resolve the constraints, the following could be done:

- need to device a production system that will ensure a continuous supply of forage throughout the year

- need to device suitable technology of forage conservation for the small-scale farmer, and

- need to intensify the production of pasture seeds for both promising grasses and legumes

All these should go along with training of both extension workers and farmers on the proper management of these improved feed resource.

The high costs of commercial supplements and also their scarcity at certain times limit their use in dairy rations. Once these supplements are bought the feeding is not properly done. They are fed in such limited amounts that farmers do not reap the full benefits of supplementing. Farmers also lack facilities for preparing feeds such as cottonseed cake in the form that could be utilised by the animal.

REVIEW OF RESEARCH TO DATE

Most experiments on dairy production in Malawi have been conducted to investigate alternative sources of nitrogen (N) to be fed with maize bran. Maize bran is one of the most easily obtainable and cheap feeds available in Malawi. It is low in crude protein (10% CP) and if fed alone, it cannot meet the nutritional demands for protein of high milk producing animals. One of the agro-industrial by-product feeds that has been found to give favourable milk yields when fed in combination with maize bran, is cottonseed cake. Cottonseed cake is a valuable high protein feed for mixing with carbohydrate feeds for cattle. It is high in fat content. It is one of the richest feeds in phosphorus, containing 1.0% or more of that important mineral (Topps, 1961).

All previous work on the utilisation of maize bran alone and in combination with other concentrates such as cottonseed cake has been done on government research stations. With high quality grass forages fed ad libitum, a ratio of maize bran to cottonseed cake that has been found most economical is four to one, respectively. A series of feeding trials involving different proportions of maize bran and cottonseed cake has shown that as cottonseed cake levels in the maize bran-based dairy rations increase, concentrate feed costs also increase. The aim of varying the proportions of maize bran and cottonseed cake was to come up with a higher crude protein level of the proportion than that of maize bran alone and at the same time arriving at the maize bran and cottonseed cake ratio that is cost-effective. Although the current mixing proportion of maize bran and cottonseed cake is four parts of maize bran to one part of cottonseed, this is not the final recommendation. Further studies are in progress to investigate the proportions of feeding maize-bran and cottonseed cake to lactating cows that could be cost-effective for small-scale dairy farmers. Although CP levels are increased with subsequent increases in levels of cottonseed cake (Table 2), the performance of cows in terms of milk production varies considerably depending on the quality of the forages fed. Table 2 contains the chemical composition of one batch of samples of different proportions of maize bran and cottonseed cake.

Table 2: Chemical composition of maize bran and a mixture of maize bran and cottonseed cake (% of DM)

Component	Proportions of maize bran and cottonseed cake*			
	1	2	3	4
Dry matter	90.0	90.3	91.3	93.0
Crude protein	10.9	18.8	20.3	25.1
Neutral detergent fibre	26.6	27.2	26.9	29.7
Acid detergent fibre	8.2	9.9	10.7	11.7

*1 = 100% maize bran, 2 = 80% maize bran plus 20% cottonseed cake, 3 = 60% maize bran plus 40% cottonseed cake; and 4 = 50% maize bran and 50% cottonseed cake

Source: Kumwenda and Munthali (1988)

The development of high quality feed resources in the form of improved forages is one of the research objectives of the pasture research programme in Mzuzu as well as in other parts of Malawi.

Past research work carried out at Lunyangwa Research Station and Choma Veterinary Livestock Multiplication Centre identified grasses (Napier, Bana and Giant panic cv Ntchisi) and legumes (Silverleaf desmodium, Tinaroo glycine, Cook stylo and Macrotyloma) which could be successfully grown on the acidic soils of Mzuzu. Work has also been conducted on agronomical practices of managing the improved pastures. These involved the use of fertilizers and manures. Table 3 contains dry matter yields of Rhodes grass with no fertilizer or manure applied, manure only, fertilizer only and manure plus fertilizer from the work done at Choma.

Table 3: Rhodes grass yields (dry matter 1st year) by four treatments

Treatment	Yield (kg DM/ha)
Control	1090
Manure only	1720
Fertilizer only	3420
Manure + fertilizer	3030

Source: Katuma (unpublished)

Results in Table 3 demonstrate that fertilizers and manure can play significant roles in increasing pastures dry matter production under these acidic soil conditions.

The available technology for pasture production is described in the Pasture Handbook for Malawi (1983 edition). A summary of crude-protein values and organic-matter digestibility of prominent pastures in Malawi is given in Tables 4 and 5.

The crude-protein content of young and improved grasses is higher than that of unimproved forages (Table 4) and that of legumes is even higher. Therefore, the inclusion of legumes in grass pastures would improve the overall nitrogen content of the forages. The digestibility of improved grasses is also much higher than that of unimproved grasses (Table 5).

Table 4: Crude protein contents of natural grasslands and improved forage species in Malawi

Species		Crude-protein content (% of DM)
Natural grasslands		
- dry grass	- wet season	11.0
	- dry season	2.0
- "Dambo" grass	- young	6.0
	- mature	3.0
Improved grasses		
Rhodes	- young	13.8
	- mature	4.2
Green panic	- young	14.4
	- mature	4.1
Ntchisi panic	- young	12.3
	- mature	4.1
Improved legumes		
Tinaroo Neonotonia	- young	23.1
	- mature	14.4
Endeavour stylo	- young	19.4
	- mature	13.6

Source: Ministry of Agriculture (1983). Pasture Handbook for Malawi, Lilongwe, Malawi

Table 5: Digestibility of some natural grassland species and improved forage species

Type of forage	Organic-matter digestibility at the end of wet season (% DM)
Natural grasslands	
Hyparrhenia spp.	31
Sporobolus spp.	30
Improved grasses:	
Giant Rhodes grass	63
Ntchisi panic grass	61
Common guinea grass	62
Bushmine panic grass	65
Mature forage (Standing hay)	
Buffel grass	35
Rhodes grass	40
Napier grass	35
Joint vetch	58
Siratro	47
Neonotonia	52

Source: Ministry of Agriculture (1983). Pasture Handbook for Malawi, Lilongwe, Malawi

Crude protein and organic-matter digestibility are all higher for improved pastures than natural pastures.

Bana Napier grass which grows very well in Mzuzu, could be one of the grasses to be pushed to farmers. Although data is not available in terms of its nutrient content, work done in Kenya shows that Bana Napier grass has crude protein percentages ranging between 8.6 - 14.0, acid detergent fibre 3.3 - 5.7; and digestibility of dry matter 56-72%. It yields at least two tons of dry matter per hectare and could support 0.4 kg/day of weight gains for heifers and 10kg of milk/day (Anonymous, 1985).

Another forage technology that has shown to provide a cheap feed resource of high nutritive value to dairy animals is the undersowing of forage legumes in cereal crops such as maize (Dzowela, 1987). The undersown legumes are utilised together with maize stovers during the dry season in situ or in feeding stalls.

Although the utilisation of maize bran and cottonseed cake in dairy rations has proved a promising technology on station this technology has rarely reached the farmer. Best-bet forages are available. These too have not been widely taken up by farmers. It is not surprising that in the Mzuzu milkshed area, milk yields per lactation are still low, and calving intervals are long. These are associated with poor nutrition. There is also critical feed shortages during dry seasons. The reasons for the failure of farmers to take up research generated technologies are not clear.

In view of the foregoing, it was proposed to undertake a study of smallholder dairy farmers. Initially the programme is aimed at evaluating the economic benefits and on-farm milk yield response to the utilisation of maize bran and cottonseed cake and introduce and evaluate the best-bet forages as animal feed resources. The overall objective is to promote or speed up the adoption rate of these technologies.

This paper reviews on-station research done in the use of maize bran and cottonseed cake in dairy rations and development of forages as animal feeds. On-farm evaluation work of these on-station generated technologies is outlined and the possible utilisation of the research results in dairy production and soil fertility maintenance contexts of the smallholder producers is discussed.

MATERIALS AND METHODS

Utilisation of maize bran and cottonseed cake in feeding trials: Farmers and location of trials

Farmers in the four bulking groups (dairy farmers associations) were selected and these were divided into two groups (1) a group of farmers with ten animals in total utilising pasture feed resources supplemented with maize bran, (2) a group of farmers with ten animals in total utilising pasture forage resources supplemented with a mixture of maize bran and cottonseed cake.

The criteria for farmer selection was based on:

a. a full time average farmer
b. willingness of farmer to participate in the research management to collect reliable data and exchange experiences with other animals
c. accessibility of his/her farm holding

Experimental animals and feed resources

Each treatment involved ten animals. The animals were those that calved at about the same time. The animals were between two and three lactations averaging seven years in age. Most of them were 3/4 Fr x MZ (Friesian x Malawi zebu). Farmers provided the forage feed resources, whereas the researchers provided maize bran and cottonseed cake. The farmer got these feeds free. The supplements were fed at milking time at the rate of 1kg per 2.5 kg of milk produced per cow. All animals were supplemented with maize bran two weeks before calving. The mixtures of maize bran and cottonseed cake was in the ratio of four parts to one part, respectively.

Experimental measurements

Farmers had their buckets calibrated for the quantities of the supplements to be fed based on milk production. Most farmers had calibrated cups for measuring milk. Those who did not have, had to use cups that they used for their drinking water; these had to be calibrated too. Daily milk yields were measured and the amount of supplements offered and consumed were recorded.

Feed and forage samples were taken for chemical analyses. Labour costs were estimated. The farmers were given folders with forms in which records were entered. The forms had columns for recording any activity done by the veterinarian and an Artificial Inseminator.

Gross margins were calculated to assess the economic benefits of utilising maize bran and cottonseed cake.

Evaluation of improved forages on-farm

Best-bet forage resources will be established on the farmers' fields involved in the feeding trial and feed budgeting to ensure a continuous supply of forage throughout the year and suitable technologies for forage conservation for dry season feeding will be developed. Production of pasture seeds for both promising grasses and legumes will be another activity for the researchers in the milkshed area.

RESULTS

This programme has just started and the results included in this paper are for one phase of a series of trials, of which the second trial is in progress. Data is collected for a period of five months for each trial.

Utilisation of maize bran and cottonseed cake

Data collected on milk production and concentrate consumption, estimates on transport and labour costs were used to calculate gross margins of the two treatments. However, milk production on these farms was affected by several factors that were difficult to quantify.

Major problems with on-farm testing include;

a. several levels of factors cannot be implemented within a farm

b. limited number of animals

c. the animals may vary in breeds/crosses, age and number of lactations

d. the basic management by the farmer vary considerably, and

e. success of the testing depends on willingness of the farmers

With the first feeding trial, a few problems were experienced. Some farmers gave the feed for the animal on trial to other animals in the herd. Some irregularities in recording were experienced. It was not possible for researchers to visit every farmer at least every week. The dairy extension assistants (DEA) were given the responsibility of closely monitoring and supervising of the trials, since each bulking group has its DEA. DEAs' visits to participating farmers was very irregular. However, there was good cooperation from the farmers and a lot of interest in the programme. Tables 6 and 7 present results of gross margin analysis based on current production organisation in the milkshed area. The prices used are those that are currently in force. Revenue on milk sales assume that all milk was sold to Malawi Dairy Industries (MDI) which infact is not the case.

Table 6: Gross margin for the dairy with animals fed maize bran.

<u>Animal numbers and performance</u>	
Average number of cows in milk	3
Average milk yield per cow/day (litres)	9.7
Average lactation length (months)	4
<u>Revenue</u>	
Milk (3,533 litres) at Malawi Kwacha (MK) 0.45 per litre	1589.85
<u>Variable costs</u>	
Concentrates: 30 bags of maize bran at MK4.70 per bag (MK)	141.00
Transport costs of feed at MK 0.50/bag	15.00
Labour costs (family)	2.50
<u>Total variable costs (MK)</u>	
Gross margin (revenue-costs) MK	1431.35
Gross margin per cow (MK)	477.11

Table 7: Gross margin for the dairy farmer with animals fed a mixture of maize bran and cottonseed cake.

<u>Animal and performance</u>	
Average number of cows in milk	3
Average milk yield/cow/day (litres)	10.7
Average lactation length (months)	1
<u>Revenue</u>	
Milk (3,913.8 litres) at MK0.45 per litre (MK)	1761.21
<u>Variable costs</u> <u>Concentrates</u>	
(a) 8 bags of cottonseed cake at MK8.50/bag (MK)	58.00
(b) 30 bags of maize bran at MK4.70/bag (MK)	141.00
Transport costs of feed at MK0.50/bag (total of 30 bags)	19.00
Labour costs (family)*	12.50
<u>Labour variable costs</u> (MK)	240.50
Gross margin (revenue-costs) (MK)	1520.71
Gross margin/cow (MK)	506.90

* includes costs of milling and mixing the cottonseed cake.

The gross margins/cow in Tables 6 and 7 show that the farmer could get an additional MK29.79 by including cottonseed cake in his maize bran-based dairy ration. Other sets of data are being collected for the other trials. It is still early to make any deductions based on these data.

Crude protein contents of the feed and forage resources utilised by the animals in the study

Samples of maize bran, a mixture of maize bran and cottonseed cake, and improved pastures collected were analyzed for crude-protein content. Samples of natural pastures were taken but the chemical analyses are not completed. Crude protein values of the feeds issued to dairy farmers and the forage resources available on their farms are presented in Table 8. Maize bran contains less crude protein than maize bran mixed with cottonseed cake. Crude protein values for forage resources did not vary much among the different pastures. Values for Rhodes grass were less than crude protein values of other grasses (Hamil panic, Ntchisi panic, Napier and Guatemala in Table 8). In general, the crude protein values of legume forages were much higher than the protein values of grass forages (Table 8).

Table 8: A summary of crude protein contents of maize bran mixtures of maize bran and cottonseed cake, and forage samples collected from dairy farmers' fields (% of DM).

Sample	Number of samples	Range	Mean
Maize bran	8	11.5 - 15.3	12.9
Maize bran + cottonseed cake	6	18.7 - 25.8	20.1
Hamil panic grass	2	12.5 - 15.5	14.0
Napier grass	6	12.5 - 14.5	13.4
Rhodes grass	3	10.0 - 15.3	11.8
Guetamala grass	1	-	12.5
Silverleaf desmodium	1	-	18.8
Common centrosema	1	-	15.6

DISCUSSION

On-station animal feed resource technologies have been generated in Mzuzu. But a very small proportion of these technologies is utilised by the small-scale farmers. This is shown by the low levels of milk yields in the area because natural pastures are the feed resources that are commonly used. Lack of researchers-extension workers and farmers interaction has been common so that the technologies developed have not found their way to the farmer. With the formation of bulking groups (dairy farmers associations) things are likely to improve. Work is done on a group basis and inputs required for utilisation of results are not a problem since the associations have funds that cater for purchases of feeds and other inputs involved in the dairy production system. Thus, these associations are acting as instruments for promoting the adoption of technologies. Farmers will be able to buy cottonseed cake and with proper feeding management and the utilisation of improved forage resources milk production levels will be increased.

The inclusion of legumes into the farming systems and the encouragement of farmers to practise zero-grazing system, feed CP levels will be increased, leading to the efficient utilisation of the feeds, and soil fertility maintenance will be enhanced.

If the testing of the on-station generated technologies will be successful on-farm level, farmers will see increased levels of milk production, reduced calving intervals and reduced animal mortality rates. This will speed up the rate of dairy development because there will be more replacement animals. At present there is a critical shortage of dairy animals in Mzuzu milkshed area.

CONCLUSION

Although there are some problems being experienced in carrying out this programme, there are prospects for its success. The successful adoption of the technologies will lead to use of adapted high yielding forages. This will lead to more feed resources of high quality, better utilisation of feed resources resulting into:

- improvement of livestock

- reduced calving intervals

- increased milk production

- increased rate of replacement heifers

- increased reproductive efficiency of animals

- enhanced soil fertility maintenance with the final attainment of food security and improved farm income

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ADOPTION OF FORAGE INNOVATIONS BY MALAGASY SMALL-SCALE DAIRY PRODUCERS

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ABSTRACT

A survey of 38 smallscale daily farmers in the Malagasy highlands was carried out in the 1987 dry season to assess the extent of adoption of two innovations introduced by the material extension service. These innovations were the growing of improved perennial grasses for hay and for green fodder and oats. The farms averaged 1.4 ha in size with 6.5 heads of cattle of which 2.2 were daily cows. More than 80% of the daily cows were Norwegian Red and their crosses. During the dry season all of the farmers fed their cattle with oats which had been raised as a catch crop on rice fields. Forty-eight percent of them made hay with Chloris gayana and Setaria sphacelata. The reasons for the adoption of these innovations are discussed.

SESSION III

FEED RESOURCES EVALUATION

LEGUME SUPPLEMENTATION OF MAIZE STOVER

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ABSTRACT

The value of legumes *Lablab purpureus*, *Lablab*, (LL). *Vigna unguiculata*, Cowpea, (CP), *Cajanus cajan*, Pigeonpea, (PP) as supplements to maize stover were assessed in two experiments. In the first lambs received 0, 100, 200 or 300 g of legume, with or without cottonseed meal, and maize stover *ad libitum*. All the legumes increased total dry matter intake ($P<0.001$), digestibility ($P<0.05$) and nitrogen retention ($P<0.05$). Stover intake was not increased by the legumes but was by cottonseed meal.

In the second experiment CP was compared with early (EPP) or late (LPP) cut PP as supplements to lambs receiving a small concentrate allocation and maize stover *ad libitum*. Total intake ($P<0.001$), digestibility ($P<0.05$) and nitrogen retention ($P<.05$) were increased by all legumes, especially CP. In a further trial lambs showed a marked preference for CP compared to PP especially EPP. Yield of EPP per ha was markedly lower than LPP.

The results indicate improved nutritional status in lambs receiving legumes and differences between legumes in their nutritive value and acceptability. Some of the practical implications of underfeeding and the role of legumes are discussed.

INTRODUCTION

Crop residues are an essential resource for dry season feeding of ruminants in Zimbabwe. Maize stover is the most plentiful (Sibanda, 1986; GFA, 1987) but as with all cereal stovers it has a low crude protein and high fibre content. Treatment with urea and supplementation with protein have been found beneficial when feeding cattle or sheep (Smith et al, 1988). However, oilcakes and urea are expensive and often in short supply and so other sources of nitrogen must be considered.

The addition of a small quantity of green forage residues was suggested as a means of improving rumen function (Preston and Leng, 1984). This is not practical in regions with a clearly defined long dry season. Blaxter et al (1961) showed that substitution rates of one feed for another were much lower when a good quality forage (straw) was offered with concentrates than when a good quality (hay) was offered. This concept together with the predictable response of a poor quality roughage to protein supplementation (ARD. 1984) have been brought together in the recommendations for the use of legumes as a component of dry season grazing (Rukanda, 1982; Maclaurin and Grant 1987). Mombeshora, Maclaurin and Reh (1987) discussed the establishment of fodder legumes in communal areas of Zimbabwe.

The use of legumes in intercropping with either temperate or tropical cereals has long been accepted. Dzowela (1987) summarized the effects on the cereal crop (maize) of this technique. In a series of trials the acceptability of legume stover mixtures has been assessed in sheep and cattle, using legume species known to grow in a high rainfall area (1000 mm/yr) of Zimbabwe (Clatworthy and Nziramasanga, pers comm).

MATERIALS AND METHODS

Three legume species, Lablab purpureus (Lablab, LL) Vigna unguiculata (Cowpea, CP) and Cajanus cajan (Pigeonpea, PP) have been used in trials with sheep and cattle to assess their value as supplements to maize stover. For the two experiments the legumes were grown separate from the maize to allow control of the legume: stover ratio in the diet. Legumes were also fed separately to the stover in order to give accurate estimates of intake.

Experiment 1

The three legumes (LL, CP, PP) were each fed as supplements (0, 100, 200, 300 g fresh material per day) to lambs receiving *ad libitum* maize stover with or without cottonseed meal (CSM, 140 g fresh feed per day). Seven intake, digestibility and DM retention studies were made, in the first six each legume being tested in the presence or absence of CSM and in the seventh all legumes being fed at 300 g with CSM. The degradability of the legumes was measured using nylon bags (Orskov and McDonald, 1979) suspended in the rumens of mature fistulated steers, receiving a fixed amount of a standard diet.

The legumes and maize stover were cut at the end of the wet season, dried, baled and subsequently milled through a 14 mm screen. Chemical composition of the feedstuffs is shown in Table 1.

Initially 16 recently castrated crossbred lambs (Merino & Dorper) weighing between 20 - 30 kg (average 24.9 kg), were ranked according to liveweight and randomized to the first set of treatments. Throughout the trial losses of lambs were heavy (9 deaths) and replacements were made as appropriate. After each dietary change there was a 21 - day adaptation period followed by five days of intake measurements together with total collection of faeces and urine.

Each legume was also offered to two yearling Friesian heifers in amounts upto 2 kg/d. They also received 2 kg/d of medium quality veld hay and 2 kg of the maize/urea concentrate. This was a short study (14d) to gauge the acceptability of the legumes fed to cattle.

Table 1: Dry matter (g/kg), nitrogen and ash concentration (g/kg DM) and *in vitro* O.M. digestibility (DOMD%) of the feeds used in Experiments 1 and 2.

	Dry matter*	Nitrogen	Ash	DOMD%**
Expt 1:				
Maize stover	928	3.8	24	48.4
Lablab	923	13.4	48	58.5
Cowpea	915	23.7	38	74.3
Pigeonpea	900	17.4	92	43.8
Cottonseed meal	930	63.3	136	
Expt 2:				
Maize stover	920	4.7	45	42.4
Cowpea	898	26.2	100	65.0
Early cut Pigeonpea	908	28.0	38	36.4
Late cut Pigeonpea	913	21.2	55	32.5
Urea/maize meal (1 : 10)	885	24.3	34	

* mean values during the experiment
**Tilley and Terry (1963)

Statistical analysis

The data was subjected to analysis of variance and regression analysis when appropriate by use of the Genstat statistical package. Data derived from the nylon bag technique was fitted to the model of Orskov and McDonald (1979).

RESULTS

Variation between groups in liveweight increased, especially in the later stages of Expt 1, and so intake and N retention data are presented on the basis of metabolic liveweight ($g/kg^{0.73}$).

Experiment 1

Both LL and CP were readily eaten but there was initial resistance to PP. To overcome this, PP was mixed with CSM for the first study with this legume. The results will be presented in chronological order although for simplicity Table 4 follows the same format as Tables 2 and 3.

Lablab In the absence of CSM, successive increments of LL increased daily total intake ($P<0.001$) but reduced intake of stover above 100 g of LL ($P<0.05$) (Table 2). Dry matter digestibility was increased and that of acid detergent fibre decreased by the increments. Lablab increased N intake and retention ($P<0.05$).

Table 2. Daily intake (gDM/kg$^{0.75}$), N retention (g/kg$^{0.73}$) and digestibility (%) of diets based on maize stover supplemented with Lablab and offered to lambs.

	No cottonseed meal					Cottonseed meal (140 g/d)				
Lablab (g/d)	0	100	200	300	SED	0	100	200	300	SED
Total intake	19.7^{a}	29.5^{b}	31.4^{bc}	37.0^{c}	1.95	47.2^{a}	55.3^{b}	60.4^{bc}	66.5^{c}	1.68
Stover intake	19.7bc	21.0c	15.4ab	12.1a	1.39	35.1c	34.2bc	31.5b	27.6a	1.01
DM dig	47.9a	52.8a	55.2a	54.8a	3.81	53.4a	55.4a	55.5a	55.4a	1.09
Acid detergent fibre dig	56.1a	53.8a	50.8a	46.9a	4.34					
N retention	-0.104a	0.002b	0.036b	0.036b	0.131c	0.0226	0.466a	0.553ab	0.571ab	0.0421
Crude protein % of diet	2.4	4.1	5.5	6.4		11.9	11.5	11.3	11.6	
Change in stover intake (g)/g legume	x	0.15	-0.27	-0.31		x	-0.10	-0.21	-0.28	
Change in total intake (%)	x	49.7	59.4	87.8		x	17.2	28.0	40.9	

Means in the same row with different superscripts are significantly different ($P<0.05$).

The addition of CSM to the diet substantially increased stover intake, N intake and N retention but did not affect the pattern of response. Without LL the digestibility of DM was increased by CSM but where LL was fed the changes due to CSM were small.

Cowpea: Successive increments of CP, with or without CSM, increased total intake (P<0.001), digestibility of DM (P<0.05) and N intake. In the absence of cottonseed meal organic matter digestibility (P<0.05) and N retention (P<0.01) were increased by CP. Faeces samples collected when the lambs were receiving CSM were wrongly bulked and, therefore, organic matter digestibility and N retention data is not available. The addition of CSM increased stover intake. There was also a change in the pattern of intake, without CSM a small non-significant increase as CP increased was changed, with CSM, to a small non-significant decrease (Table 3).

Pigeonpea: Total intake was increased by the addition of PP (P<0.05) and generally stover intake fell (P<0.05) (Table 4). The higher total intake with CSM was due entirely to the CSM. Digestibility of dry and organic matter was unaffected by the addition of legumes or CSM. However, N intake and retention were increased by both legumes and SCM, the differences without CSM being significant (P<0.001).

Three legumes: When the three legumes were offered at 300 g/d with CSM they all increased total intake compared to maize stover with CSM and legume (P<0.001) (Table 5). Stover intake was greatest with CP and least with PP (P<0.05). Digestibility of dry and organic matter was increased by all the legumes especially LL and CP (P<0.05). All legumes increased N intake and retention especially CP (P<0.001).

Dry matter and N disappearance: The loss of DM and N together with estimates of degradability constants a, b and c are shown in Table 8. Cowpea had the greatest extent of DM and N loss followed by LL and PP. Rates of degradability (dg) of CP and LL were similar.

Experiment 2

Total intake was increased by all the legumes ($P<0.05$) (Table 6) and especially CP ($P<0.001$). Stover intake was reduced by the inclusion of LPP ($P<0.01$). Early cut pigeonpea was not readily eaten. Improvements in the digestibilities of dry matter ($P<0.05$) and organic matter occurred with all legumes especially CP and LPP. Nitrogen retention was also increased by all the legumes ($P<0.05$).

Table 3: Daily intakes (gDM/kg$^{0.73}$), N retention (g DM/kg$^{0.73}$) and digestibility (%) of diets based on maize stover supplemented with Cowpea and offered to lambs.

	No cottonseed meal					Cottonseed meal (140g/d)				
Cowpea (g/d):	0	100	200	300	SED	0	100	200	300	SED
Total intake	26.9^{a}	36.4^{b}	45.0^{b}	54.3^{c}	2.92	54.5^{a}	58.2^{a}	68.1^{b}	72.1^{a}	3.13
Stover intake	26.9a	28.1a	28.5a	29.8a	2.70	42.1a	38.6a	40.0a	37.9a	2.52
DM dig	33. 4a	45.9b	51.1b	55.7b	3.20	48.9a	49.8ab	52.1b	53.2b	1.14
Organic matter dig.	38.7a	48.9b	53.1b	57.1b	2.70					
N retention	-0.243a	-0.080b	0.030c	0.139d	0.0258	x	x	x	x	x
Crude protein % of diet	2.4	5.2	6.9	8.0		10.8	11.5	11.7	12.0	
MEMJ/d	0.158	0.269	0.362	0.469						
Change in stover intake (g)/g legume	x	0.14	0.10	0.12		x	-0.43	-0.13	-0.18	
Change in total intake (%)	x	35.3	67.3	101.9		x	6.8	25.0	32.3	

Means in the same row with different superscripts are significantly different ($P<0.05$)

Table 4. Daily intakes (g DM/kg$^{0.73}$), N retention (g/kg$^{0.73}$) and digestibility (%) of diets based on maize stover supplemented with Pigeonpea and offered to lambs.

	No cottonseed meal					Cottonseed meal (140 g/d)				
Pigeonpea (g/d):	0	100	200	300	SED	0	100	200	300	SED
Total intake	34.2^{a}	37.a^{ab}	45.9^{bc}	52.7^{c}	3.28	42.1^{a}	45.0^{ab}	64.6^{c}	59.7^{bc}	5.28
Stover intake	34.2a	29.0a	31.3	31.3a	3.39	30.6a	26.2a	35.0a	25.5a	3.92
DM dig	42.0a	39.4a	42.4a	40.4a	2.83	35.5a	39.5a	36.0a	4.38	
Organic matter dig	40.6a	37.7a	40.7a	38.6a	2.91	347.8a	35.2a	39.5a	38.5a	4.22
N retention	-0.145a	-0.078ab	0.012bc	0.027c	0.0282	0.356a	0.428a	0.535a	0.400a	0.0790
Crude protein % of diet	2.4	4.2	5.0	5.8	12.6	13.0	11.8	12.7		
MEMJ/d	0.211	0.210	0.278	0.300		0.235	0.232	0.373	0.331	
Change in stover intake (g)/g legume	x	-0.64	-0.2	-0.14		x	-0.57	+0.26	-0.22	
Change in total intake %	x	8.5	34.2	54.1		x	6.9	53.4	41.8	

Means in the same row with different superscripts are significantly different ($P<0.05$)

When the lambs were allowed to select their diet CP was the preferred forage. When CP was omitted LPP was eaten more readily than EPP and maize stover intake increased substantially (Table 7). Water intake was approximately 2.7 l/kg DM. Yearling heifers ate EPP more readily than the lambs but CP was the most readily eaten.

Table 5: Daily intakes (gDM/kg$^{0.73}$), N retention (g/kg$^{0.73}$) and digestibility of diets based on maize stover plus cottonseed meal (130 gDM/d) and supplemented with Lablab, Cowpea or Pigeonpea (300 g fresh/d) offered to lambs

	Treatments				
	Control	Lablab	Cowpea	Pigeonpea	SED
Total intake	52.5^{a}	75.0^{bc}	80.1^{c}	71.5^{b}	2.47
Stover intake	41.4^{ab}	41.6^{ab}	43.8^{b}	37.2^{a}	1.95
DM dig (%)	53.5^{a}	60.3^{b}	60.0^{b}	57.9^{ab}	1.72
Organic matter	55.7^{a}	60.0^{b}	61.9^{b}	58.8^{ab}	1.93
N retention	0.339^{a}	0.600^{b}	0.831^{b}	0.571^{b}	0.0386
Crude protein % of diet	10.2	9.6	11.7	10.9	
MEMJ/d	0.434	0.689	0.739	0.615	
Change in stover intake (%) (g)/g legume	x	0.01	0.10	-0.18	
Change in total intake (%)	x	42.9	52.6	36.2	

Means in the same row with different superscripts are significantly different (P<0.05).

Table 6: Daily intakes ($gDM/kg^{0.73}$), N retention ($g/kg^{0.73}$) and digestibility of diets based on maize stover and supplemented with early cut pigeonpea (EPP), late cut pigeonpea (LPP) or cowpea (CP) and a urea maize mix (177 g DM/d) offered to lambs.

	Treatments				
	Control	CP	EPP	LPP	SED
Total intake	48.7[a]	64.4[c]	58.0[bc]	53.9[ab]	2.41
Stover intake	34.6[b]	31.0[b]	32.4[b]	22.2[a]	1.57
DM dig (%)	49.3[a]	55.3[b]	51.2[b]	56.0[b]	1.79
Organic matter dig(%)	50.7[a]	56.4[a]	52.4[a]	53.1[a]	2.91
N retention	0.132[a]	0.381[b]	0.319[b]	0.311[b]	
Crude protein % of diet	6.5	9.7	8.8	9.5	
MEMJ/d	0.369	0.532	0.449	0.426	
Change in stover intake (%) (g)/g legume	x	-0.18	-0.18	-0.69	
Change in total intake (%)	x	32.2	19.1	10.7	

Means in the same row with different superscripts and significantly different ($P<0.05$).

Table 7: Total daily intake (gDM; gDM/kg$^{0.73}$) and % contribution of individual feeds to the total.

	Pen Number			
	1	2	3	4
Total intake: (g/d)	1213	1303	1159	665
(g/kg$^{0.73}$)	97.4	99.3	88.0	53.1
Urea-maize mix[x]	14.6	13.6	15.3	26.6
Cowpea	72.0	71.1	73.1	x
Early cut Pigeonpea	x	3.3	5.3	8.1
Late cut Pigeonpea	7.0	4.8	x	23.1
Maize stover	6.4	7.2	6.4	42.2

[x]Fed at a fixed amount of 177 gDM/lamb/day

Dry matter and N disappearance from nylon bags suspended in the rumens of fistulated steers was in the order: LPP EPP CP (Table 8).

Table 8: Drymatter (DM) and nitrogen (N) loss (%) from legumes incubated in nylon bags in the rumen of fistulated steers.

		Fitted constants for model $P = a + b\,(1-e^{-ct})$+			Loss % of DM and N Incubation time (hours)					
		a	b	c	3	6	12	24	36	48
Experiment 1										
Lablab	DM	24.0	37.0	0.06	x	35.3	44.5	49.8	58.3	61.0
	N	58.8	26.2	0.08	x	66.9	77.9	77.2	84.0	84.6
Cowpea	DM	42.8	34.2	0.06	x	53.0	59.0	66.0	73.0	77.0
	N	61.5	26.6	0.06	x	70.2	75.2	80.2	87.3	87.6
Pigeonpea (PP)	DM	26.6	23.4	0.04	x	32.3	35.8	36.3	43.3	49.8
	N	32.8	32.2	0.03	x	38.7	41.0	45.0	50.8	64.4
Experiment 2										
Cowpea	DM	36.4	34.6	0.06	42.8	46.6	54.4	63.2	x	70.1
	N	66.4	22.6	0.09	71.0	75.9	81.8	84.6	x	88.9
Early cut PP	DM	24.3	27.7	0.05	28.0	32.5	35.7	42.2	x	52.0
	N	53.0	29.0	0.06	56.0	64.8	66.4	74.0	x	81.8
Late cut PP	DM	21.3	24.7	0.07	24.2	31.3	35.1	39.0	x	45.9
	N	48.9	26.6	0.10	53.9	66.4	67.9	70.0	x	75.3

+ Ørskov and McDonald (1979).

DISCUSSION

When fed in fixed amounts all the legumes used in both experiments increased total DM intake, digestibility and N retention. Substitution of stover by legumes was highest with PP, the mean effect of PP in Expt 1 and LPP in Expt 2 being a reduction in stover intake of 0.3 g DM per g of PP consumed. Digestibility of DM and organic matter was consistently increased when LL and CP were fed, especially with the lower levels of supplementation in Expt 1. With PP the pattern was not so clear. Generally CSM increased stover intake and digestibility of those diets not containing LL or CP. The reasons for the lack of response to CSM when PP was fed in the first phase of Expt 1 (Table 4) are not clear. It was not possible to carry out acid detergent fibre analysis on all samples. The results are similar to those observed in goats receiving maize stover supplemented with leucaena hay (Banda and Ayoade, 1986).

Energy requirements of lambs fed indoors are 0.414 MJ per $kg^{0.73}$ (ARC, 1980). By converting digestible organic matter intake (DOMI) to ME (DOMI (kg) x 15.6 (ARC, 1980) inspection of the available data show that lambs received maintenance only with CSM, concentrates or 300 g CP, although by increasing total intake all legumes raised ME intake.

Nitrogen retention was increased by all legumes and CSM. Broster et al. (1978) reported excess N to be excreted in the urine and N supplements to have little effect on faecal N,in steers receiving fixed amounts of energy. In these experiments faecal N was increased by the legumes suggesting that although N loss after a fixed time, from nylon bags was high, turnover rates were also high resulting in low digestibility.

Regression analysis showed that N retention (NRg/d) was affected by N intake (N/g/d) and DOMI (kg/d) as follows

$NR = -1.90 + 0.603\ (\pm 0.0233) NI\ (r=0.885)$ (1)

$NR = -3.26 + 0.022\ (\pm 0.0013)\ DOMI + 0.634\ (\pm 0.0337) NI$
$(r=0.936)$ (2)

Equation 1 was derived from all NR data of Expt 1 and equation 2 from the same data where estimates of DOMI were also available. Using equation 1 the missing NR data for CP = CSM (Table 4) becomes: 0.389, 0.477; 0.601; 0.677 (g N/$kg^{0.73}$/d) for 0, 100, 200, 300 g CP respectively.

The low intakes of ME and low NR in the first phase of Expt 1 and equation 2 from the same data where estimates of DOMI were also available. Using equation 1 the missing NR data for CP + CSM (Table 4) becomes: 0.389; 0.477; 0.601; 0.677 (g N/$kg^{0.73}$/d) for 0, 100, 200, 300 g CP respectively.

The low intakes of ME and low NR in the first phase of Expt 1 probably contributed to the high rate of lamb mortality. Two thirds of the original lambs under 25 kg initially and one third over 25 kg died. Although most of the deaths were explainable it is likely that nutritional stress increased susceptibility to disease in young animals. Subsequently a small concentrate allowance removed the problem.

In Expt 2 EPP had a higher N content and in vitro DMD% than the LPP but was less readily eaten, especially by lambs. This could be caused by either a very low level of mould, reflecting the difficulties of making hay in the wet season, or toxins. The yields (kg/ha) of DM and crude protein for EPP and LPP were respectively: 2113, 394 and 2974, 370. A second cut of the area used for EPP was not possible because of insufficient regrowth. In Expt 2 the preferred legume was CP (Table 7) but in the absence of CP intakes of maize stover and LPP increased. Water intake during this period was 2.7 1/kg DM eaten, higher than the 2 1/kg DM suggested for growing lambs in temperate climates (ARC, 1980).

The data suggests that the legumes were used as supplements and had little effect on the utilisation of the stover. This probably reflects their bulkiness and relatively low crude protein concentration compared to CSM, which did increase intake of stover. However, legumes are relatively cheap to grow and often occur as by-products of human food or cash crops. These factors together with the agronomic advantages of growing legumes must be compared with other methods of supplementing and upgrading roughages (Sundstol and Owen, 1984; Smith et al, 1988). The cost of new technologies must be recovered from extra produce for sale (Orskov, 1987) or for the farmer's own use. In practice a combination of upgrading and supplementation will probably be most beneficial.

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NUTRITIVE VALUE OF CROTALARIA OCHROLEUCA: I CHEMICAL COMPOSITION AND IN VITRO DRY MATTER DIGESTIBILITY AT DIFFERENT STAGES OF GROWTH

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ABSTRACT

A study was carried out to determine dry matter (DM) yield, chemical composition, and *in vitro* dry matter digestibility (IVDMD) of *Crotalaria ochroleuca* ("marejea") at different stages of growth. "Marejea" was planted and harvested at 2 weeks intervals up to 16 weeks stage of growth.

The DM yields increased from 60 kg/ha at 2 weeks to 4670 kg/ha at 16 weeks. The total digestible dry matter (DDM) increased from 38.8 at 2 weeks to 3007 kg/ha at 10th weeks and then decreased to 2624.5 kg/ha at the 16th week. The crude protein content decreased with advancing plant growth while crude fibre increased. The IVDMD for the whole plant and leaf increased with advancing stage of growth, peaked at the 10th week, and declined thereafter. The IVDMD for the stem decreased with advancing plant growth. From this study it was concluded that, the best stage of maximum yield and nutrient content for "marejea" is during the 10th week of growth.

INTRODUCTION

Crotalaria ochroleuca is widely distributed in Africa as an indigenous legume (Pohill, 1982). The plant has been adopted in the farming systems of the southern part of Tanzania particularly for the purpose of improving soil fertility and weed control in the farms. According to Gerold (1984) the legume was first sown in 1942 by German missionaries who were actually the force behind its adoption in this part of the country. Since then the legume has been integrated in the farming system by the farmers in many

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parts of the country, and the legume "marejea" is locally named. The potential of "marejea" as a livestock feed has been well reviewed by Sarwatt and Mkiwa (1987; 1988). Its toxic effects have also been pointed out. Although people have been feeding "marejea" to goats and dairy cattle (Gerold, 1984) there are no documented studies in Tanzania and only very limited elsewhere on the feed value of this plant for livestock. In a series of experiments designed to evaluate the nutritive value of "marejea" as a feed for livestock it was decided to first determine dry matter yield, chemical composition and IVDMD of "marejea" at different stages of growth. This paper reports on the initial stages of this work.

MATERIALS AND METHODS

During the rainy period of March, 1986 an area of one hectare was ploughed, harrowed and "marejea" seeds broadcasted at a rate of 15 kg/ha and 40 kg/ha of triple superphospahte (TSP) was applied. The seeds were neither scarified nor innoculated.

Samples for determination of dry DM yield, chemical composition and IVDMD were collected at two-weeks intervals. A 1 m^2 quadrat was thrown at random six times in the field. All the plants which were enclosed in the quadrat were cut, collected and weighed to obtain the fresh matter yield. Sub-samples were oven-dried to obtain DM content and other chemical components in the plant. Other sub-samples were separated into leaf and stem fractions which were later weighed, oven-dried and analysed in the same way as for the whole plant samples.

Chemical analysis for the DM organic matter (OM), crude protein (CP), crude fibre (CF), ether extract (EE), total ash, calcium and phosphorus contents of the forage samples were carried out according to A.O.A.C. (1965). The IVDMD was determined according to the procedure of Tilley and Terry (1963). Statistical analysis of variance was done according to Snedecor and Cochran (1980). Differences among treatment means were determined using LSD.

RESULTS AND DISCUSSION

DM and OM contents and yields of "marejea" with advancing plant growth are shown in Table 1. Both the DM and OM contents increased with advancing plant growth. The DM yield of 4.5 tons/ha observed on the 10th week in this study is lower than that of 5.2 tons/ha (Mkiwa, 1988) and 12 tons/ha (Mukurasi, 1986). However, these differences would be due to seeding rate and environmental conditions e.g. weather and soils. During the 10th weeks of growth a few of the plants were observed to flower. For feeding purposes cutting on the 10th week should be the best time when the yields are maximum. Rocha (1965) and Martin *et al* (1976) reported that the DM yield of *Crotolaria* species peaks at early flowering period. Yields of leaf and stem with advancing plant growth are shown in Table 2.

The stem yields were lower during the first four weeks and increased rapidly and remained high throughout the experimental period. Crowder and Cheddar (1982) observed that stems yield more DM than leaf. This is normally the case because with advancing plant growth, the proportion of stem increases at the expense of leaf due to an increase in the proportion of lignified structural tissues.

Table 1. OM and OM contents and yields of "marejea" with advancing plant growth.

Contents	WEEKS								
	2	4	6	8	10	12	14	16	Mean
OM contents (%)	5.4	11.3	15.5	17.5	243	26.4	30.2	33.4	20.7
DM yield (kg/ha)	60	450	1800	3364	4515	4210	4486	4670	2919.4
OM content (%)	6.8	8.5	10.7	11.8	15.1	19	25.7	29.7	15.7
OM yield (kg/ha)	58	430	1774	3180	3712	3217	3415	3528	2262.1

Table 2. Yields and proportions of plants parts of "marejea" with advancing plant growth.

Plant part	WEEKS								
	2	4	6	8	10	12	14	16	Mean
OM yields (kg/ha)									
Green leaf	50	250	880	1520	1820	1530	1345	1136	1066.4
Stem	52	244	1167	1300	3044	2451	2814	2948	1873.8
Proportions of plant parts O(% of total OM yield)									
Green leaf	27.7	60.8	52.2	46.3	38.1	37.8	36.5	33.6	47.3
Stem	27.3	39.2	47.8	53.7	61.9	62.2	63.5	66.4	58.8

Table 3. Chemical composition of "marejea" whole plant with advancing plant growth (%/ DM.

Nutrient (%)	WEEKS								
	2	4	6	8	10	12	14	16	Mean
Crude protein	38.8	33.7	30.2	28.6	26.9	18.4	14.2	9.9	25.1
Crude fibre	18.4	22.7	25.3	32.1	36.5	38.2	40.4	42.7	32.1
Ether extract	4.3	2.7	3.3	3.2	3.0	2.4	1.9	1.8	2.9
Ash	2.6	4.8	5.9	8.2	7.4	4.5	3.6	4.9	4.9
Phosphorus	0.38	0.36	0.37	0.32	0.35	0.27	0.23	0.32	0.32
Calcium	1.2	1.1	0.72	0.73	0.80	1.26	0.85	0.77	0.93

Table 4. Chemical composition of "marejea" leaf with advancing plant growth (% DM)

Nutrient (%)	WEEKS								
	2	4	6	8	10	12	14	16	Mean
Crude protein	38.4	36.2	35.0	34.1	34.6	30.5	28.3	24.7	32.7
Crude fibre	10.5	11.9	12.6	13.8	14.6	17.2	21.5	23.6	15.7
Ether extract	9.5	9.3	8.7	8.3	7.2	6.1	4.7	4.6	.
Ash	3.8	4.4	6.7	7.3	8.8	8.2	6.9	6.2	6.5
Phosphorus	0.32	0.34	0.34	0.32	0.36	0.34	0.38	0.30	0.29
Calcium	1.30	0.92	0.81	0.75	0.84	0.92	0.62	0.76	0.77

Table 5. Chemical composition of "marejea" stem with advancing plant growth (% DM)

Nutrient (%)	WEEKS								
	2	4	6	8	10	12	14	16	Mean
Crude protein	12.7	12.2	9.2	7.8	6.4	6.0	5.4	5.2	8.1
Crude fibre	30.6	34.7	39.2	44.7	52.4	52.7	53.1	53.5	45.1
Ether extract	3.8	3.1	2.1	1.4	1.2	1.1	1.0	4.7	5.2
Ash	4.7	5.2	5.8	6.1	6.8	6.4	4.2	4.0	5.4
Phosphorus	0.14	0.13	0.16	0.20	0.22	0.17	0.15	0.14	0.16
Calcium	0.92	0.81	0.74	0.78	0.80	0.74	0.70	0.83	0.79

Table 6. *In vitro* DM digestibility of "marejea" plant parts with advancing plant growth

Plant part	WEEKS								
	2	4	6	8	10	12	14	Mean	
Dry matter digestibility (%)									
Whole plant	64.6	65.9	66.2	66.5	64.8	58.4	56.2	64.7	
Green leaf	66.4	66.8	67.2	68.2	70.2	68.5	65.8	62.3	58.4
Stem	62.7	60.1	59.2	56.4	54.7	40.9	38.7	34.6	44.1
Digestibility DM yield (DDMO) (kg/ha)									
Whole plant	38.8	296.5	1191.6	2237.1	3007.	2728.1	2619.8	2625.5	1842.9
Green leaf	33.2	167	591.4	1036.6	1277.6	1048.1	885	707.7	718.3
Stem	13.8	146.6	690.8	1297.2	1665.1	1002.5	1089	1020	865.6

The chemical composition of the "marejea" plant, leaves and stem with advancing plant growth is shown in Tables 3, 4 and 5 respectively. The CP contents were observed to decrease with advancing plant growth. The decrease was remarkably higher in the whole plant and stem. Reddy et al. (1970) observed a decrease in the CP content of the whole plant sunnhemp from 29.3% at 2.6 days to 24.8% at 35 days. Krishna et al. (1985) reported a decrease in the CP content of sunnhemp plant from 22.6% at week 4 to 17.8% at week 8. The mean CP content of the "marejea" plant in this study was 25.1%. This is in close range with those of 24.9% reported by Balaraman and Venkatakrishnan (1974) and 23.7% by Mkiwa (1988), at about flowering stage. The CF content in the whole plant, leaf and stem increased with advancing plant growth. The same trend has also been observed by Krishna et al. (1985) who reported a CF increase of 28.9% at week 4 to 44.5% at week 8. The ash content was also observed to increase with advancing plant growth while the ether extract was declining. The same trend for both ash and ether extract has been observed by Whiteman (1980). Advancing plant growth had no consistent effect on the calcium and phosphorus contents.

The results of IVDMD and the yield of DM of the whole plant, leaf and stem as influenced by advancing plant growth is shown in Table 6. The DMD in the plant and leaf was observed to increase with advancing plant growth, reaching a peak value at 10th week and declining thereafter. The DMD of the stem was observed to decline from 62.7% at the 2nd week to 34.6% at the 16th week. The results agree with those by Terry and Tilley (1963) who showed that the in vitro digestibility of lucerne stems declined from 85 to 56% at maturity. The low digestibility of the stem is attributed to indigestible components which increase with advancing plant growth (Minson, 1977). The DDM yield increased with advancing plant growth. Chauhan and Tiwana (1983) using cowpea reported a DDM yield increase from 19 kg/ha on day 45 to 25 kg/ha on day 94.

From the results of this experiment, harvesting "marejea" at early flowering stage (corresponding to 10th week under Morogoro conditions) seems to offer the maximum yield of digestible nutrients.

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NUTRITIVE VALUE OF CROTALARIA OCHROLEUCA: II THE EFFECT OF SUPPLEMENTATION ON FEED UTILISATION AND PERFORMANCE OF GROWING SHEEP

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ABSTRACT

A study was carried out to determine chemical composition of *Crotalaria ochroleuca* ("marejea") at three stages of growth - pre-anthesis, anthesis and post-anthesis. Feeding trials were conducted to study the effect of "marejea" supplementation of low quality *Chloris gayana* hay on the growth rate and feed utilisation of growing sheep. In the feeding trials 12 young male sheep were randomly allocated to four treatments: hay only (T_1), hay + 150g "marejea" (T_2), hay + 300g "marejea" (T_3) and hay + *ad lib* "marejea" (T_4).

The crude protein (CP) content was highest (30.5%) at pre-anthesis and decreased with advancing plant growth. The leaves with a CP of 34.5% were observed to be the most nutritious part of the plant. The crude fibre (CF) content was lowest at pre-anthesis (36.7%) and increased to 40.0% at post-anthesis stage of plant growth. Calcium and phosphorus contents were highest at pre-anthesis.

Supplementation had a significant ($P<0.01$) effect on total and daily weight gain. Total and daily weight gain increased with increasing level of "marejea" supplementation in the diet but there was no significant differences ($P>0.01$) among supplemented animals in treatments T_3 and T_4. Supplemented animals as a group had significantly ($P<0.01$) higher daily gain than their unsupplemented counterparts.

"Marejea" supplementation increased dry matter digestibility (DMD) of hay but only significantly ($P<0.01$) with treatment T_4.

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CP digestibility in T_4 was about three times that of the unsupplemented group (T_1). The organic matter digestibility (OMD) increased with supplementation but was significantly ($P<0.01$) higher only in treatment T_4. Both faecal N and and urinary N excretion increased with increased N intake and level of supplemention. The nitrogen balance value increased with increasing level of "marejea" supplementation. It was negative in treatment T_1 and highest in T_4.

From the study it was concluded that "marejea" hay at pre-anthesis stage had the highest nutritive value and can be used as a cheap alternative protein supplement for growing sheep in areas where conventional proteins are expensive or not available.

INTRODUCTION

Tropical grasslands support low levels of production due to their low nutritive value of the forages (Humphreys, 1978). The potential for much greater production are obvious but first the problem of nutritional deficiency must be solved. Among the ways of improving the nutritional status of these grasslands is the incorporation of forage legumes into the grasslands through oversowing or direct inclusion of the legume in the diet of livestock. Supplementation of forage legumes in the diet of livestock seems to offer a better alternative for small-scale farmers.

One legume that is used in the southern part of Tanzania for improving soil fertility and combating weeds is Crotalaria ochroleuca locally known as "marejea". Efforts of introducing this legume in the southern part of the country are through the hard work of the Benedictine Fathers at Peramiho particularly Fr. Gerold Rupper. It is interesting to note that the people in this area adopted the use of "marejea" before any research information about the legume was known. The motive behind the quick adoption of the legume as suggested by Lupanga et al (1987) was monetary value from either the sale of the seeds or money saved by using "marejea" as a substitute for fertilizers which are expensive. Another reason was the incentive and small presents given by Fr.

Gerold during his visits (Lupanga _et al_, 1987). According to Lupanga _et al_., 1987, if markets for seeds had dried up, the farmers might have discontinued the use of "marejea". Few farmers who have goats and/or dairy cows feed "marejea" to their animals. Although no quantified data is available on the feeding value of "marejea" to livestock, the performance of the animals is reported to be good. The potential of "marejea" in the farming systems of Tanzania and particularly as a feed for livestock has been pointed out by Sarwatt (1986); Sarwatt and Mkiwa (1987); and Sarwatt and Mkiwa (1988).

This study was, therefore, undertaken to determine the chemical composition of "marejea" and evaluate its feeding value through digestibility, growth and intake trials.

MATERIALS AND METHODS

Forage production and preparation

During the long rains in March, 1987 an area of 0.5 ha was ploughed, harrowed and "marejea" seeds broadcasted at a rate of 10 kg/ha. A triple super phosphate (TSP) fertilizer was applied at a rate of 40 kg/ha. At three stages of growth i.e. at pre-anthesis, anthesis and post-anthesis random samples were collected for chemical analysis. The forage used in the feeding experiment was harvested at anthesis. The forage was air dried under shade in a barn. When the material was well dried, the less woody stems were separated from the rest of the plant, collected and stored in gunny bags.

Rhodes grass hay was prepared from established plots at the University Farm. The hay was cut at post-flowering stage using a forage chopper. The material was wilted for a day in the sun and final drying was done in the barn. The hay was then stacked in the barn ready for the feeding trials.

Digestibility study

Twelve male adult Black Head Persian sheep of an average weight of 30.4 kg were used for the digestibility experiment. The animals were randomly alloted to the four dietary treatments (T_1 - T_4) in a completely randomized design. The animals were weighed before and after each experimental period which consisted of a 7-day preliminary period followed by a 7-day collection period. All the animals were dewormed before the trial began.

The volume of urine was recorded daily, and 10% aliquots were combined for each sheep in each period. Daily faecal samples were dried at 60°C, samples from sheep on the same treatment were composited for analysis.

Intake study

Fourteen days after the digestibility study, the same animals and treatments were used to determine intake. The animals were weighed at the beginning and end of the preliminary period of 10 days, and at the beginning and end of the 10 day collection period. Rations were offered *ad libitum* so as to allow for a minimum of 20% refusals. During the preliminary period the animals were allowed to attain the highest DM intake. All the refusals were collected and weighed. From the weight of the refusals intake per metabolic body weight (g/kg $W^{0.75}$) was determined.

Growth study

Twelve male Black Head Persian sheep of an average weight of 17.2 kg were assigned at random in a completely randomized design to the four treatments (T_1 - T_4). The animals were grazed for 8 hours daily on paddocks consisting mainly of Rhodes grass and then subjected to the four treatments. All the animals were in addition, given 4g mineral mixture and water *ad libitum*. The animals were weighed at weekly intervals during the experimental period of 90 days. From day 88 to day 90 all the animals were weighed daily in order to determine the final average live weight.

To determine the quality of the pasture on which the animals were grazing, the animals were followed twice every week during the whole experimental period. Forage samples were plucked from the grazing sites oven dried and bulked. At the end of the study, the bulked forage was sub-sampled for the analysis of its chemical composition.

Chemical and data analyses

All the dried samples of feeds, refusals and faeces were milled through a 1-mm screen before they were analysed. Analyses for dry matter (DM), organic matter (OM), crude protein (CP) and fibre (CF), ash and either extract (EE) were conducted according to the standard procedures (A.O.A.C. 1960; 1965). The urine samples were analysed for nitrogen by the routine Kjeldahl method (A.O.A.C., 1960). Some of the samples were sent to the National Institute of Animal Science in Denmark for detailed analysis of the plant parts. The results are presented in Table 2.

The data from the digestibility, intake and growth studies were analysed in a completely randomized design as described by Snedecor and Cochran, (1980). Differences among treatment means were analysed using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

The chemical composition of the forages

The chemical composition of "marejea" harvested at pre-anthesis, anthesis and post-anthesis, Rhodes grass hay and that of pasture grazed by sheep in the growth study is shown in Table 1. The CP was noted to decrease with advancing stage of growth while CF increased with advancing growth. Mkiwa (1987) reported crude protein values of 28.2%, 25.6% and 17.1% when "marejea"s were harvested at 6th, 10th and 12th weeks, respectively. These values do not differ much from those obtained in this study. Rhodes grass hay was of low nutritive value as indicated by the low CP of 5.8% and high CF of 36.5%.

Table 1: Chemical composition of "marejea" hay at pre-anthesis, anthesis and post-anthesis, rhodes grass hay, and pasture fed to sheep in the growth study (DM basis).

Nutrient	Pre-Anthesis	Anthesis	Post-Anthesis	Rhodes grass hay	Pastures
DM content (%)	81.2	85.4	87.3	88.0	90.0
Organic matter (%)	73.8	76.9	81.1	80.2	88.3
Crude protein (%)	30.5	25.1	18.5	5.8	14.7
Crude fibre (%)	36.7	38.4	40.0	36.5	24.6
Ether extract (%)	2.3	3.0	1.9	1.6	2.7
Ash (%)	7.4	8.5	6.2	8.7	8.4
Calcium (%)	0.77	1.54	1.21	0.1	0.3
Phosphorus (%)	0.30	0.38	0.26	0.01	0.1

The high CP values in the pasture could be attributed to the hand plucking of pastures that consisted of several grass species, leguminous plants and shrubs. Hand plucking of the pasture after the grazing animals does not accurately represent what the animal consumes. But this was the best alternative estimation that could be used when there were no fistulated animals.

Detailed chemical composition of "marejea" plant parts is given in Table 2. The CP of the leaves of 34.5% and CF of 14.3% indicates that the leaves are the most nutritious part of the plant. The amino acids lysine and methionine in "marejea" leaves are much higher than in lucerne, though when expressed as a percentage of protein, the values are more or less the same in the two forages. The Ca and P contents in "marejea" leaves are not as high as in in lucerne, but the levels are adequate to meet most of the livestock requirement (NRC, 1979).

Table 2: Detailed chemical composition of "marejea" plant parts (% DM)

Nutrient	Leaf	Leaf stalk	Stem
DM	19.1	20.2	25.4
CP	34.5	13.9	6.3
EE	7.2	2.5	1.4
CF	14.3	42.7	59.5
Ash	8.6	10.1	6.8
Insoluble fibre	34.4	60.7	76.1
Soluble fibre	3.9	5.4	3.5
Starch and Sugar	2.9	2.9	1.7
g calg	4.9	4.2	4.4
Lysine g/16g N	4.7	4.1	2.4
Methionine g/16g N	1.5	1.0	0.9
Ca	0.80	0.36	0.20
Mg	0.50	0.33	0.16
P	0.35	0.30	0.20
Fe	0.04	0.02	0.02
Mn	0.009	0.003	0.002
Zn	0.004	0.003	0.002
Cu	0.001	0.0007	0.0005

Table 3: Effect of "marejea" hay supplementation on nutrient intake and apparent digestion coefficients of the rations.

Parameters	rations			
	T_1	T_2	T_3	T_4
Number of animal	3	3	3	3
Mean weights (kg)	21.5	26.1	24.1	24.5
Mean weight (kg $W^{0.75}$)	9.25	11.2	10.4	10.5
Daily intake (g/day)				
Dry matter	412.8^{a}	487.3^{b}	491.7^{b}	510.2^{b}
Dry matter (g/kg $W^{0.75}$)	49.5^{a}	58.5^{b}	59.0^{b}	61.2^{b}
Crude protein	18.2^{a}	40.5^{b}	58.7^{b}	120.5^{b}
Crude protein (k/kg $W^{0.75}$)	2.2^{a}	4.7^{a}	7.0^{b}	14.5^{c}
Digestibility coefficients				
Dry matter	50.7^{a}	56.6^{a}	56.2^{a}	64.3^{b}
Crude protein	22.1^{a}	48.3^{b}	55.7^{b}	62.4^{c}
Crude fibre	59.8	58.2	57.3	51.2
Organic matter	57.1^{a}	57.6^{a}	58.2^{a}	66.6^{b}

abc = means in same row with different superscripts are significantly different ($P<0.05$)

Intake and digestibility study

Results on intake and apparent digestibility are given in Table 3. The total dry matter intake (DMI) increased with increased supplementation of "marejea". While there was a significant difference ($P<0.05$) between the unsupplemented and the supplemented diets, there was no significant difference ($P<0.01$) among the supplemented diets.

Kitaly (1982), and Mero (1985) observed an increase in DMI when Rhodes grass was supplemented with increasing levels of protein supplement. The increasing level of "marejea" resulted in a decline in the hay intake as observed in the growth study. Robles et al (1981) reported that as the fibre content in the diet decreased DMI increased because the animals increased intake when the quality of the leaf is high. Dietary protein supplementation is known to improve intake by increasing the supply of N to the rumen microbes. This has a positive effect of increasing microbe population and efficiency thus enabling them to increase the rate of breakdown of the digesta. As the rate of breakdown and passage of the digesta increases, feed intake is accordingly increased (Van Soest, 1982). The crude protein intake (CPI) and organic matter intake (OMI) increased with increasing "marejea" supplementation.

The results have shown that dry matter digestibility (DMD) increased with increasing level of "marejea" supplementation but only significantly in T_4. Several workers have reported that the DMD improves when a roughage is supplemented with a legume or concentrates (Elliot and Topps, 1963; Minson and Milford, 1967; Gordon 1979; Butterworth, 1985). The crude protein digestibility (CPD) and organic matter digestibility (OMD) increased with increasing level of "marejea" supplementation. These results compare favourably with those reported by El Haq (1976), Kitaly (1982) and Massae (1984) and others who observed increases in CPD and OMD with increased supplementation of protein. However, the crude fibre digestibility (CFD) decreased with increased supplementation. The low CFD observed in this study could be due to increased DMI brought about by increased CP contents. Increased DMI could lead to increased rate of passage of digesta hence less time for rumen microorganisms to digest the crude fibre.

Growth study

Results of feed intake and growth performance of the sheep used in the growth experiment are given in Table 4 and 5 respectively. The total DMI (g/day and g kg $W^{0.75}$) were observed to take the same trend as those observed in the digestibility study. The DMI, CPI and OMI increased level of "marejea" supplementation. Elliot (1967) and Orskov et al (1971) observed similar trends with cattle and sheep supplemented with different levels of protein.

Both the total weight gain and daily gain increased with the level of "marejea" supplementation. Total weight gain was significantly different ($P<0.05$) between the unsupplemented group and the supplemented. The growth rate increased from 34.2 g/day for the unsupplemented group to 69.1 g/day for the sheep fed "marejea" ad libitum. The daily gain of 50g for the unsupplemented Black Head Persian sheep has been reported by Nyaki (1981) using Rhodes grass hay as a basal diet. The big difference observed with this study could be due to the high crude protein content of the pasture grazed. Nyaki's experiment was conducted during the short rains and extended to the onset of long rains in march.

Nitrogen balance

Nitrogen intake, excretion and retention increased significantly ($P<0.05$) with increased level of supplementation (Table 6). This is in accordance with the findings of Akinsoyinu (1974); Reynolds, (1981); Kitaly, (1982); and Massae, (1984). Unsupplemented animals were in negative nitrogen balance indicating that the nitrogen content of mature Rhodes grass hay is not sufficient for maintenance needs of sheep. It is thus necessary to supply protein supplements when feeding such low quality roughages as suggested by Gihad (1976) and Reynolds (1981).

Table 4: Effect of "marejea" hay supplementation on nutrient intake in the growth study

Parameters	Rations			
	T_1	2	T_3	T_4
Number of animals	3	3	3	3
Dry matter intake (DMI g/day)				
Rhodes grass	172.6[a]	160.4[a]	100.2[a]	100.6[b]
"Marejea"	-	75.4[a]	140.8[b]	152.9[b]
Total	176.6[a]	235.8[b]	240.2[b]	253.5[b]
Intake g/kw $W^{0.75}$	56.9[a]	27.6[b]	79.3[b]	83.6[b]
Organic matter intake (OMI)				
g/day	160.3[a]	226.4[b]	212.1[b]	230.5[b]
g/kg $W^{0.75}$	20.4[a]	27.6[b]	28.2[b]	30.4[b]
Crude protein intake (CPI)				
g/day	10.2[a]	26.5[b]	35.6[c]	40.6[c]
g/kg $W^{0.75}$	1.34[a]	3.4[b]	4.6[c]	5.3[c]

abc = means in same rows with different superscripts are significantly different ($P<0.05$)

Table 5: Effect of "marejea" hay supplementation on the growth performance of sheep

Parameters	Rations			
	P1	2	3	4
Number of animals	4	4	4	4
Initial liveweight (kg)	23.5	24.0	21.5	22.4
Final liveweight (kg)	26.6	27.8	27.2	28.6
Mean liveweight (kg)	25.1	25.9	24.35	25.5
Total weight gain (kg)	3.1^{a}	4.8^{b}	5.7^{b}	6.2^{b}
Growth rate (g/day)	34.2^{a}	42.4^{b}	63.7^{c}	69.1^{c}

abc = Means in same rows with different superscripts are significantly different ($P<0.05$)

Table 6: Effect of "marejea" hay supplementation on nitrogen utilisation

Parameters	Rations			
	T_1	T_2	T_3	T_4
Number of Animals	3	3	3	3
Nitrogen intake g/day	3.1^{a}	5.6^{b}	11.3^{c}	18.4^{d}
g/kg $W^{0.75}$	0.3^{a}	0.5^{a}	1.3^{b}	1.8^{b}
Nitrogen Excretion (g)				
Faecal	2.2^{a}	3.3^{a}	4.7^{b}	8.3^{c}
Urine	1.1^{a}	1.8^{a}	2.5^{b}	4.9^{c}
Total	3.3^{a}	5.1^{a}	7.26^{b}	13.2^{c}
Nitrogen retained				
g/day	-0.2^{a}	0.4^{b}	4.04^{c}	5.2^{c}
g/kw $W^{0.75}$	-0.03^{a}	0.04^{a}	0.11^{a}	0.35^{c}
% of N-intake	-6.4^{a}	8.2^{b}	35.7^{c}	28.4^{c}
% of N-digested	-29.4	14.8	64.2	72.3

abc = Means in same rows with different superscripts are significantly different ($P<0.05$)

CONCLUSIONS

From the results obtained it can be concluded that "marejea" hay improved DMI, CPI and OMI of low quality rhodes grass hay, resulting in increased daily gain and total weight gain. It could therefore be used as a cheap alternative protein supplement for small livestock keepers in the rural areas which have little or no access to conventional protein supplements.

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RESEARCH ON MAIZE STOVER AS LIVESTOCK FEED ON SWAZI NATION LAND

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ABSTRACT

The problem of feed shortage for grazing livestock in the communal areas of Swaziland has been widely recognised and many attempts have been made to rectify the problem. This paper highlights some of the research results that have been obtained relating to the potential contribution of maize stover to the feed budget of the livestock. Hybrid maize varieties produce higher stover yields than traditional varieties but have comparable quality constraints to their adoption in the farming system and strategies to improve their quality are discussed.

INTRODUCTION

Crop residues are a useful source of supplementary feed for ruminant livestock in the tropics and sub-tropics. Topps (1977) reported that in the southern Africa region, animals grazing natural pastures without supplementary fodder may lose up to 30% of their maximum summer body weight in winter which obviously has an adverse effect on their reproductive rate and general performance.

In Swaziland, crop residues are used extensively in winter by smallholder farmers. These farmers live on what is known as Swazi Nation Land (SNL), rearing some 80% of the national herd under a strongly traditional system of management characterized by communal grazing. Because stock numbers are not controlled in this sector, most of the communal grazing areas are overstocked and annual losses of livestock due to malnutrition are believed to be generally high. The remaining 20% of the ruminant animals are raised under more favourable conditions on private and parastatal farms or on government ranches.

Although crop residues should and probably do play a critical role in meeting the winter feed deficit on SNL, their use tends to be somewhat haphazard and their contribution to the annual feed budget of grazing livestock have not been studied. The data presented in this paper is drawn mainly from a survey of rural homesteads which was conducted between 1985 and 1987 in the middleveld. The middleveld is one of the four major topographical regions of Swaziland. It has an environment which is ideal for mixed farming and a wide variety of crops are grown in association with over 1/3 of the national cattle population (Anonymous, 1987). Some data from current on-station studies of crop residue yield and quality are also included.

CROPPING PATTERNS

Almost all small-scale farmers on SNL grow crops mainly for domestic consumption. The major crops grown are presented in Table 1. The table shows that maize, which is the staple food in Swaziland, occupies the bulk of the total cropped area (currently estimated at some 58,362 ha) compared to the next important crop, cotton, which occupies a relatively small fraction (13%) and is confined almost exclusively to the lowveld.

Table 1: The percentage of cropped areas by region for major crops on SNL

	High veld	Middle veld	Low veld	Lubombo	Swaziland
Maize	85	85	56	84	76
Cotton	1	2	34	2	13
Beans	5	2	-	6	2
Cowpeas	1	3	3	1	2
Groundnuts	1	4	2	3	2
Sorghum	2	1	3	1	2
Jugo beans	1	1	1	1	1
Sweet potatoes	2	1	-	1	1

Source: Survey of SNL during 1982/83 cropping season, Central Statistics Office, Mbabane, Swaziland

The current survey which covered 350 homesteads in the middleveld revealed a similar trend (Table 2). Maize, often intercropped with pumpkins, was the dominant crop, taking as much as 88% of the total arable land in comparison to the next crop, beans, which occupied only 4% of the land.

Table 2: The proportion of homesteads growing each crop and the area allocated to the crop per homestead.

Crop	% of homesteads growing crop	% of total area occupied by crop
Maize	99	88
Beans	29	4
Groundnuts	20	3
Sweet potatoes	20	2
Others	13	3

The dominant position of maize in the farming system constitutes the basis for the current research thrust on maize stover as a feed resource on SNL.

ANIMAL PERFORMANCE ON NATURAL PASTURES IN SWAZILAND

The performance of animals grazing natural pastures is usually affected by rainfall patterns and available vegetation. The body weight changes of beef cattle presented in Figure 1 is typical of the trend to be expected from livestock grazing natural pastures in Swaziland. Maximum weight gains occur in summer (December to February): much of this weight being lost in winter (June to September) when there is insufficient amount of good quality forage. The weight changes in Figure 1 were monitored on Nguni cattle, the common breed, which is of the Sanga Zebu type. However, due to understocking at Luyengo University farm, the performance of the cattle was probably much better than that of livestock grazing on SNL.

THE PATTERN OF CROP RESIDUE UTILISATION ON SNL

The pattern of crop residue utilisation was examined by monitoring cattle grazing activities in 20 homesteads in the middleveld over a period of 8 months. It was observed that during summer (October to March), the cattle spend almost all the grazing hours on the the veld (natural) pasture in the communal grazing areas). For the rest of the year, the animals graze partly on the veld and partly on maize stover (Table 3).

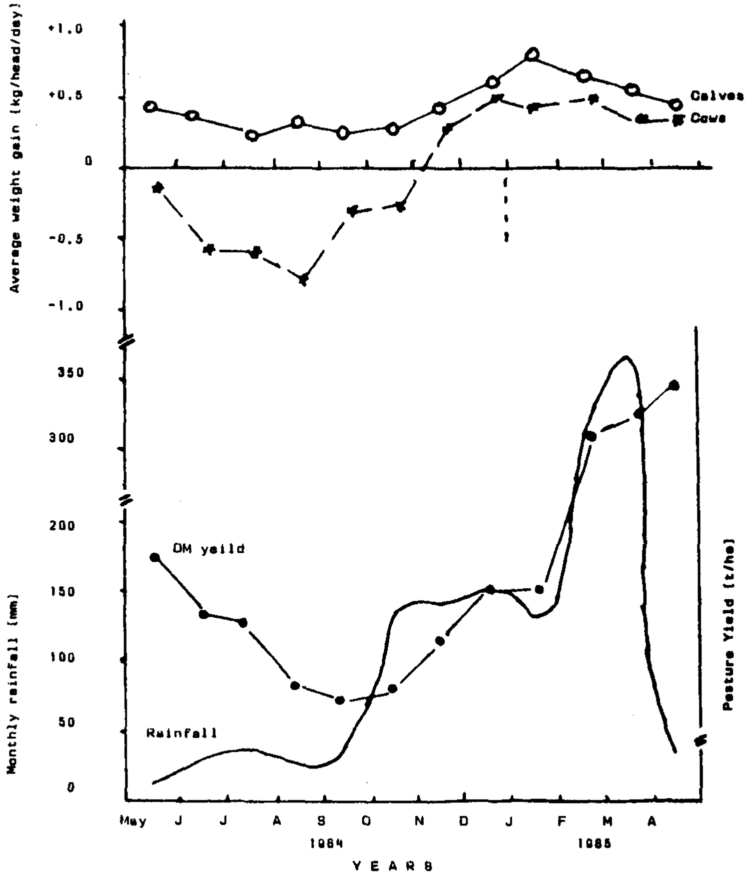
Table 3: Total and crop residue grazing times (N=20).

Month	Total grazing time (hours/day)		Crop residue grazing time (hours/day)		% of total time spent on crop residues
	Mean	SD	Mean	SD	
March	9.1	0.91	0	-	0
April	8.8	1.09	0.2	0.04	2
May	9.3	0.84	3.1	0.27	33
June	9.2	0.92	6.5	0.55	71
July	8.4	0.96	4.6	0.39	55
August	8.7	0.97	1.7	0.33	19
September	9.2	0.93	0.5	0.03	5
October	9.4	0.89	0	-	0

The period of intensive stover utilisation is between May and July. When most of the stover has been consumed, the animals will normally be left to graze on weeds, on fallow land and in river valleys until they become completely dependent on natural pasture in the communal grazing areas.

These results indicate that maximum utilisation of maize stover takes place during the critical winter months although the stover does not provide adequate grazing for the entire period. That livestock continue to lose weight even while grazing on the stover is probably a reflection of the quantity produced, its quality as well as the form in which it is consumed.

Figure 1. Some pasture parameters affecting the livestock gain of cattle at Luyengo.



Strategies to maximize stover yield on SNL

SNL farmers use many modern production practices and cash inputs such as tractor hire for ploughing, on-drawn planters, hybrid seed, pesticides and chemical fertilizers. Table 4 shows the percentages of crop fields that receive some of these inputs.

Table 4: The use of modern inputs on SNL farmers' fields (includes only RDA's).

Season	Use of ox-drawn planter	Use of hybrid maize seed	Use of fertilizer basal application
1980/81	46.9	61.4	72.6
1981/82	54.1	63.8	72.9
1982/83	50.9	69.5	70.2
1983/84	48.6	74.0	77.0

Source: RDA Management Unit (1984)

It is clear from Table 4 that the use of modern inputs for maize production in rural Swaziland is relatively high compared to other countries in the southern Africa region. The increasing trend in the use of hybrid maize, which yields higher than traditional varieties, prompted the current investigation on stover yield potential as well as its quality. During the 1987/88 cropping season, stover yields of 15 high ranking maize hybrids currently grown in a trial by Malkerns Research Station were measured. The trials were carried out at two locations; one in the highveld (Mangcongco) and the other in the middleveld (Malkerns Research Station). The means for these two locations are presented in Table 5.

Table 5: Grain yield, stover yield, stover/grain ratio and leaf yield of 15 hybrid maize varieties (means for Malkerns and mangcongco during 1987/88 cropping season).

Variety	Grain yield t/ha	Stover yield t/ha	Stover/ grain ratio	Leaf yield t/ha
PNR 6549	6.3	7.1	1.1	2.9
*PNR 6429	5.7	5.8	1.0	2.3
CG 4305	5.7	5.7	1.0	2.1
*CG 4403	5.4	5.1	0.9	1.7
*SNK 2147	5.3	7.7	1.4	3.1
*RO 415	5.3	6.9	1.3	2.6
CG 4609	5.2	6.2	1.2	2.4
*TX 379	4.9	10.1	2.1	4.2
*PNR 473	4.8	6.7	1.4	2.7
*A 323W	4.8	6.5	1.4	2.9
*AX 305W	4.5	4.7	1.0	2.1
*SR 52	4.3	11.8	2.7	3.7
*SSM 2039	4.3	6.3	1.5	2.6
*S 201	4.3	5.9	1.4	1.2
SAM83 TZRW	3.5	7.8	2.2	3.6
MEAN	5.0	7.0	1.4	2.7

* Recommended varieties for 1988/89 cropping season by Malkerns Research Station, Ministry of Agriculture and Cooperatives.

When the proportion of hybrid maize seed used by small-scale farmers is ignored, the average maize grain yield on SNL is around 1.4 t/ha (FAO, 1984) with a stover yield of 5.0 t/ha (Ogwang, 1988). By using hybrid seed, the farmer can almost quadruple his grain yield and at the same time significantly increase his stover yield (Table 5). The stover/grain ratio for the hybrids average 1.4:1 while traditional varieties have ratios in the region of 2.5:1 (Ogwang, 1986, unpublished data). It appears that as selection progresses towards maximum grain yield, there is a reduction in the quantity of stover produced. This would seem to suggest the need to encourage the use of hybrids such as SNK 2147 and TX 379 which have superior leaf yields since this component has a higher quality compared to the stem fraction in crop-livestock production systems.

Malkerns Agriculture Research Station is responsible for the conduct of national maize performance trials and subsequent variety release recommendations. Selected varieties are multiplied by the Seed Multiplication Project of the Ministry of Agriculture and Co-operatives for distribution to growers. An efficient, mainly private sector distribution network exists in the country which allows the maize to get close to the farming communities. Once the stover component becomes an important selection criterion at the Research Station, it should be possible to get high stover yielding varieties to farmers within a reasonably short time through this distribution network.

One of the major drawbacks in the use of hybrid maize has so far been inability of SNL farmers to obtain yields close to those presented in Table 5. Although the rate of fertilizer use is increasing (Table 4), it appears as if many farmers apply it at sub-optimal levels (de Vletter, 1983). The situation is probably similar with other inputs. Factors contributing to these practices need to be investigated.

THE NUTRITIVE VALUE OF MAIZE STOVER

A large number of researchers have evaluated untreated cereal stovers and have concluded that they cannot maintain an animal when fed alone. Although chemical analyses are still in progress in this study the crude protein figures given in Table 6 indicate that the quality of our hybrid stovers is likely to be comparable to that of others reported elsewhere.

Table 6: The CP content of hybrid maize varieties (means for Malkerns and Mangcongco during 1987/88 cropping season)

Variety	CP (DM basis)
PNR 6549	3.5
PNR 6429	3.2
CG 4305	3.2
CG 4403	3.4
SNK 2147	3.7
Ro 415	3.3
CG 4609	4.0
TX 379	3.6
PNR 473	3.3
A 323W	3.6
AX 305	3.4
SR 52	3.4
SSM 2039	3.3
R 201	3.4
SAM83 TZRW	3.7
*CHECK	3.8

*Average CP content of maize stover sampled from 20 homesteads on SNL.

The low crude protein levels raise the question of stover treatment and supplementation, a subject which has received wide coverage in recent years. These preliminary studies have indicated positive results when the stover is treated with NaOH (Table 7) or when supplemented with urea, molasses and maize grain (Table 8).

Table 7 shows that the addition of NaOH to maize cobs improves their *in vitro* organic matter digestibility and Table 8 shows that supplementing maize cobs with urea, molasses and maize grain has a similar effect.

Table 7: The effect of varying concentrations of NaOH on the *in vitro* organic matter digestibility of maize cobs (Zwane 1988)

Concentration of NaOH (g/100 ml water)	maize cob organic matter Digestibility (%)
0	18.4
5	31.2
7	36.1
10	51.9
20	55.0

Table 8: The effect of supplementation with various ingredients on the *in vitro* dry matter digestibility of maize cobs (Adapted from Hlophe, 1987)

Maize cobs	Proportion of Urea	Molasses	Yellow maize	% digestibility
100%	-	-	-	6.3
98%	2%	-	-	29.2
90.5%	2%	7.5%	-	34.2
83%	2%	-	15%	30.3
75.5%	2%	7.5%	15%	50.5

It remains to be seen if these trends will hold true in actual feeding trials. A lot of emphasis will be put on molasses in particular since it is a by-product of Swaziland's number one export crop, sugar. During 1985, 127,200 metric tonnes of molasses were produced and 72,400 tonnes were exported (Lebbie, 1988) leaving a very generous balance which, at the current factory price of 7 US dollars equivalent per metric tonne, could be very attractive for livestock feeding.

Moving to the feeding phase, will be met with numerous constraints to the adoption of any subsequent stover technology. Some of these constraints were identified from the 1986/87 survey of rural homesteads in the middleveld and are presented in Table 9.

Table 9: Summary of constraints identified in a survey of rural homesteads in the middleveld.

Technical:	
	Inadequate use of hybrid maize seed
	Improper agronomic practices
	Site specific problems
	Very few farmers store the stover (15%)
Economic:	
	No money for inputs
	Credit hard to get
	Inputs not available
	Seeds not easily available
Social:	
	Inadequate labour for harvest, transport and storage
	Lack of farming orientation
	Livestock reared for economic and intangible values
	Communal grazing of stover

Although the constraints are divided into 3 distinct categories it should be pointed out that there are few problems that will fall in only one category. But these constraint groups should provide a guideline on the research direction needed to improve the utilisation of crop residues by grazing livestock on SNL. A practical and systematic feeding package needs to be developed based particularly on hybrid maize varieties.

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RESPONSES OF WEST AFRICAN DWARF SHEEP FED CASSAVA PEEL AND POULTRY MANURE BASED DIETS

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ABSTRACT

Five diets containing 0, 13, 25, 35 and 45% dried poultry manure (DPM) were formulated such that DPM replaced 0, 25, 50, 75 and 100% of the wheat offals and groundnut cake contained in the control diet 1. The diets were fed to 20 growing ewes in a 104 days growth study. Dry cassava peels and water were also provided *ad libitum*.

The intake of the animals fed the 0, 13, 25, 35 and 45% DPM diets were 87.1, 94.0, 88.6, 102.8 and 107.8 g/kg 0.75/day. The differences were not statistically significant. Also no statistical differences were observed in the growth rate of sheep which varied from 84.5g/head/day for sheep fed the 25% DPM diets to 100.6g/head/day for the animals on the 35% DPM diet. Efficiency of feed utilisation decreased from 8.7kg feed/kg gain to 10.5 as the level of manure in the diets increased from 0 to 45%. The growth performance of al the animals showed that sheep can be reared on diets containing poultry manure as the sole protein supplement, with dried cassava peels constituting 40 to 60% of the total diet. Sheep supplemented with poultry manure diets had higher intake of the dried cassava peel than sheep fed unsupplemented control diet.

INTRODUCTION

In 1986, Nigeria produced 14.7 million tonnes of cassava (FAO, 1986) while the demand for this crop was put at 25 million tonnes for 1988. It is therefore safe to suggest that feeding cassava meal to livestock is not likely to be an attractive economic proposition. Cassava peel however, has been shown to form a constant part of household waste-product traditionally offered to sheep and goats in Southern Nigeria (Obioha, 1977). There are a large number of village-level , small-scale and large-scale "garri" processing factories which generated an estimated 2.9 million tonnes of cassava peel in Nigeria in 1986. Considerable research effort is being put into processing cassava peel for use by small ruminants at village level (Obioha, 1977; Adegbola and Asaolu, 1986). The bulk of this waste product produced at "garri" and starch processing factories will only be useful if the peel can be incorporated into livestock diet formulation. If such new feed packages can be developed, they may find a market with household owners of small ruminant stock as well as urban livestock owners of store-animals.

Compared to non-ruminants, very little work seem to have been reported on the utilisation of cassava peels by small ruminants. Walker (1951) reported feeding cassava peels to sheep and goats in Equatorial West Africa with poor response. Adebowale (1981) fed fermented cassava peels to sheep at 0, 20, 40 and 60% levels of inclusion to replace equivalent amounts of maize in the control diet. He recorded growth rates of 60.0, 38.3, 30.6 and 66.7 g/head/day and feed/gain ratios of 7.8, 10.9, 11.8 and 7.4 kg feed/kg gain respectively. He concluded that incorporating 20, 40 and 60% cassava peels in the control diet increased economic returns by 15, 15 and 19% respectively. Fomunyan and Maffeja (1987) reported that sheep fed 0, 35 and 70% cassava peel-based diets complimented with elephant grass and using cottonseed cake as the protein source gained 45, 107 and 227 g/day. They concluded that liveweight gains of sheep increased with increasing levels of cassava peels intake and that the peels show promise as dry-season feed for sheep. In an earlier work Okorie, Obioha, Anyaekie and Ahamefule (1981) showed that poultry manure can replace groundnut cake in the diet of goats without any depression in growth rate and efficiency of feed utilisation. Given a good source of carbohydrates such as cassava peel, small ruminants ought to be able to make good use of the readily available N source as poultry manure. The objective of this study was to determine the response of sheep fed a basal diet of dried cassava peels supplemented with concentrates containing varying levels of hen-caged poultry manure as the main source of N with a view to developing acceptable simple feed compounds which can be made and sold at village production level.

MATERIALS AND METHODS

Hen-caged manure was collected within two days of being voided by birds. The manure was sundried for two days by spreading to a thickness of about 2 cm on polythene sheets on a concrete base. Drying was terminated when the manure felt dry and gritty to touch with a dry matter content of 85-91%. The cassava peels were collected fresh from a "garri" processing plant, air-dried for 8 days on a concrete slab and sun-dried for one additional day to produce a dry matter content of 85-87%.

Five experimental diets were formulated so that poultry manure would replace 0, 25, 50, 75 and 100% of the conventional protein supplements (groundnut cake and wheat offals) contained in the control diet 1 (table 1).

Table 1: Comparison of supplemental diet fed to sheep

Ingredients (%)	Levels of DPM in supplement feed (%)				
	0	13	25	35	45
Maize	74.0	67.0	61.0	57.0	53.0
Poultry manure	0.0	13.0	25.0	35.0	45.0
Wheat offals	20.0	15.0	10.0	5.0	0.0
Groundnut cake	4.0	3.0	2.0	1.0	0.0
Bone meal	1.0	1.0	1.0	1.0	1.0
Vit/Min. premix*	0.5	0.5	0.5	0.5	0.5
Common salt	0.5	0.5	0.5	0.5	0.5
	100.0	100.0	100.0	100.0	100.0

* Each kg of the vitamin mineral premix contains Vit. A., 640,000 I.U.,
Vit, D_3, 120,000 I.U., Vit. E, 640 I.U., CU, 360mg, Se, 8mg, Mo, 60mg

Twenty growing ewes from a flock of WAD sheep, with an average weight of 14.3 $\pm$ 3.7kg were selected such that 4 animals were randomly alloted to each experimental diet. Each animal was treated as a replicate. Each animal was offered 55.0g of the experimental diet per kg metabolic size per day. Half of the daily ration was offered each animal at 9.00 hours and the remaining at 15.30 hours. Dried cassava peels and water were provided ad libitum. The orts from the cassava peels offered to each animal the previous day were removed at 7.00 hours and weighed, and about 30% more than the previous day's level of intake were offered at 8.00 hours every day.

The animals were housed individually in pens measuring 1.8 x 0.5m. An adaptation period of 14 days was allowed before data was collected for 90 days during which time the animals were weighed weekly. The weight of an animal at the end of a particular week was used to calculate the weight of the concentrate feed that will be offered to that particular animal the following week.

The chemical analyses for proximate components of the experimental diets of dried poultry manure and dried cassava peels were carried out using the methods outlined in AoAC (1975).

Data obtained on the growth rate, average dry matter intake of cassava peels alone, and of cassava peels plus the experimental feed, and the feed, as well as the efficiency of feed utilisation of the different animals were subjected to a two-way analyses of variance (Steel and Torrie, 1980).

RESULTS

Dried cassava peel and 75.4mg/kg content of HCN compared with 317.2 mg/kg for the fresh cassava peel (Table 2). The crude protein content of the dried peel was 4.2% compared with 1.2% for the wet peel. Sun-dried hen-caged manure contained a crude protein (CP) of 20.7% crude fibre of 10.7% and an ash content of 19.9% (Table 2).

Table 2: Proximate composition of poultry manure and peels used in the experiment (% of dry matter)

Feedstuff	Crude Protein	Crude Fibre	Ether Extract	Ash	NFE	HCN (mg/kg)
Sundried hen-cage manure	20.7	10.7	0.9	19.9	37.8	-
Fresh cassava peel*	1.2	2.3	0.4	1.1	23.0	317.2
Air-dried cassava peel**	4.2	7.8	1.5	1.5	79.3	75.4

* Determined on the fresh sample with a dry matter content of 28%

** Air-dried for 8 days and sun-dried for one more day

The proximate composition of the experimental diets showed that the control diet contained a crude protein content of 12.3% compared with 14.4% CP contained in the diet supplemented with 45% DPM (Table 3). With the exception of the ash and energy levels, there were no significant differences in the proximate composition of the diets. Further, diets in which the main protein source was completely replaced with DPM had energy content of 3.6 kcal/g compared with 4.5 kcal/g for the control diet (Table 3).

Table 3: Proximate composition of supplemental diets fed to sheep (% of dry matter)

Chemical analyses	Levels of DPM				
	0	13	25	35	45
Dry matter (%)	87.3	87.4	87.6	87.7	87.9
Crude protein (%)	12.3	12.9	13.7	14.1	14.4
Crude fibre (%)	1.9	2.2	2.5	2.8	2.9
Ash (%)	3.2	8.1	11.0	14.4	16.9
Ether extract (%)	2.5	1.5	1.4	1.1	1.1
Nitrogen free extractives (%)	68.3	62.8	59.0	55.3	52.6
Gross energy (Kcal/g dry matter	4.5	4.1	4.1	3.9	3.6

Average dry matter intake of cassava peels by animals fed the control diet was 355.8g/day, while the intake by animals fed the 13, 25, 35 and 45% dry poultry manure (DPM) diets were 406.3, 371.0, 512.8 and 526.5g/day respectively (Table 4). Differences were however, not statistically significant. The average daily dry matter intake of 790.1g for the animals on the control diet increased generally to 952.3/head/day as the level of the manure in the experimental diets increased from 0 to 45% (Table 4). No statistical differences were observed in the growth rate of the animals fed the different diets. The fastest rate of growth rate of 107.8g/head/day were recorded for animals fed 45 DPM diet, while those on the 25% DPM diet grew the least gaining only 84.5g/head/day. The efficiency of feed conversion (kg feed gain) increased from 8.7/kg gain for animals fed the control diet to 10.5kg/kg gain for animals on the 45% DPM supplement diet. The differences were however not statistically significant.

Table 4: Response of West African dwarf sheep fed diets containing different levels of dried poultry manure (DPM) and cassava peels provided *ad libitum*

	Levels of DPM in diet supplement(%)				
	0	13	25	35	45
Drymatter offer of experimental diet (g/kg metabolic weight/day)	47.3	47.3	47.8	47.9	48.0
Average dry matter intake of cassava peels (g/kg metabolic weight/day)	39.8	46.7	40.8	54.9	59.8
Average total dry matter intake (g/kg metabolic weight/day0	87.1	94.0	88.6	102.8	107.8
Average dry matter intake of cassava peels (g/head/day)	355.8	406.3	371.0	512.8	526.5
Average dry matter offer of the experimental feed (g/head/day)	434	412.6	424.0	445.6	426.8
Average total dry matter intake (g/head/day)	790.1	818.9	795.0	958.4	952.3
Average growth rate (g/head/day)	91.4	90.6	84.5	100.6	91.1
Efficiency of feed utilisation (kg feed/kg gain)	8.7	9.0	9.4	9.5	10.5

DISCUSSION

All the animals grew fairly well and no statistical differences were observed in the growth rate of the animals fed the different diets. This observation is in agreement with the reports of Hadjipanayiotou (1984) who observed no differences in growth rate between growing heifers, fattening kids, and fattening calves fed 30% DPM diets and the control animals fed soybean meal and cottonseed cake diets. El-Hag and Kurdi (1986) reported that animals consuming a 30% DPM diet performed better than those consuming a 30% cottonseed cake diet. Adu and Lakpini (1983) on the other hand observed that rams fed diets containing 0, 10, 20, 30 and 40% DPM diet recorded growth rates of 100, 83, 52, 41 and 32g/head/day respectively. It is very likely that the hay Adu and Lakpini (1983) used as the energy source for their animals were not as well utilised as the cassava peels were in this study. Further it was observed that sheep on 45% DPM diets had 55% of their total dry matter intake from dried cassava peels compared to 45% dried cassava peel intake for animals on the control diet. The higher intake of dried cassava peel by animals on DPM diets may be due to the fact that the 45% DPM diets had lower energy of 3.6 Kcal/g compared with 4.5 Kcal/g for the control diet and the animals had to take in larger quantities of the dried cassava peels to meet their energy needs.

Feeding up to 55% cassava peels as the main energy source of the animals in this study did not depress growth rate which averaged 90-100g/day for the entire experiment. Adebowale (1981) replaced maize with cassava peel and obtained a progressive depression on growth rate of animals. Fomunyan and Maffeja (1987) on the other hand observed improvements in growth rate, dry matter and crude protein digestibilities when cassava peels were used to replace elephant grass in the diets of sheep with cotton seed as the main source of N. The lack of agreements in these studies may be due to the fact that sheep utilise maize better than cassava peels, and the peels better than the elephant grass.

The efficiency of feed conversion figures ranged between 8.7 and 10.5 which is higher than the values (4.0 - 6.7) observed by Okorie et al (1981) but less than 19.8 reported by El-Hag and Kurdi (1986). The sheep used in this study and that of El-Hag and Kurdi (1986) had much higher average dry matter intakes than was reported by Okorie et al (1981) in their study. Also the different energy sources used to make up the energy requirements in the different studies may have affected the level of utilisation of ingested feed differently, and consequently have different effects on feed efficiency.

This study has shown that it may be worthwhile to investigate the feasibility of compounding a growers diet for sheep[based on dried cassava peel and up to 45% DPM. The next phase in this study is designed to test the acceptability of preparing and using such a diet at a village production level.

It is suggested that this technology of feed compounding using 45% poultry manure can be transferred to a village in which households raising small ruminants are prevalent or where the village is near a commercial poultry unit generating waste. The feed package can also be produced and sold on the shelf by entrepreneurs with access to feed grains and dried poultry manure. Farmers who own or keep small ruminant stock with access to dried cassava peel should find such feed supplements adequate for their sheep production enterprises.

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EFFECTS OF MANAGEMENT ON FEED AVAILABILITY, BODY WEIGHT, AND BODY CONDITION OF THE INDIGENOUS GOATS IN CENTRAL REGION OF MALAWI

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ABSTRACT

A survey of goat management systems was carried out in the Central Region of Malawi on two sites. The first was Lilongwe on six adjacent villages surrounding Bunda College of Agriculture. The second site was Salima at Lifidzi ranch. Goats were weighed and condition scored in March, June, September and December for a period of two years. It was found that goats had higher weights and were in best condition in September and in poorest condition in March in both years. While at the ranch the loss in weight was attributed to disease associated with intensification of the production system, in the villages tethering and grazing in limited areas during the wet season were the major constraints.

INTRODUCTION

The importance of the goat in Malawi is borne out of its popularity as well as its numbers. Twenty eight percent of the rural households in Malawi keep goats as compared to 13%, 8% and 2% keeping cattle, pigs and sheep respectively. The population of goats is 1.6 million (National Sample Survey of Agriculture 1981/82). Half of the national flock is found in the Central Region while a quarter is found in Lilongwe Agricultural Development Division (Table I).

Table I. National sample survey of Agriculture 1981/82 Goat figures - thousands in 8 Agricultural Development Divisions.

Agricultural Development Divisions

Malawi	Karonga	Mzuzu	Kasungu	Salima	Lilongwe
1.575.7	24.0	137.6	309.5	106.6	414.4

Liwonde	Blantyre	Ngabu
211.3	212.6	159.8

Malawi, a landlocked country with a population of 8 million which is said to be increasing at the rate of 3.0% annually. At a density of 85 people/km^2 (NSO, 1987) per capita land availability to smallholder farmers is 0.95 ha (Munthali, 1986). Agriculture is the backbone of the country's economy. The smallholder subsector predominates the industry contributing about 77% of agriculture GDP (Reserve Bank of Malawi, 1988). However, livestock production has been lagging behind. The major constraints are poor management practices, breed types, inadequate extension efforts and feed shortages just to mention a few.

Natural pasture is the most important source of feed in almost all ruminant livestock in Malawi. The success of the smallholder goat production therefore largely depends on how the farmers produce and manage their forage resources throughout the year.

The objective of this work was to assess the goat management practices, with a view to singling out the existing management of feed resources in goat feeding and production.

METHODOLOGY

STUDY AREA

A study was carried out in the Central Region of Malawi at two sites. The first site was six adjacent villages around Bunda College of Agriculture in Lilongwe (14'35'S; 33°50'E; 1200 m). The second was Lifidzi ranch in Salima (13°55'S; 34°28'E; 500 m).

The Central region like the rest of Malawi has a cool dry season (May to August); a hot dry season (September to November) and a hot wet season (December to April) which is also a crop growing season, (mainly maize, groundnuts, beans and tobacco as a commercial crop). In Lilongwe the soils are ferrogenous and the vegetation is mostly open canopy woodland. In Salima, soils are alluvial and vegetation is thicket savanna.

Animals and their management

A total 417 and 323 Malawi local goats in Lilongwe and Lifidzi ranch respectively, were used in the study for a period of 2 years (1985 and 1986). All goats were identified by plastic tags and all village goats were treated as one herd as were those at the ranch.

Both in the Lilongwe area and at Lifidzi ranch, goats were kept in night enclosures from which they were released in the morning for grazing on natural pastures. In Lilongwe, goats were left to roam freely during the day with no deliberate attempt to herd them in the cool dry and the hot dry seasons. During this period apart from grazing and browsing, goats were observed to have an access to crop residues such as maize bran, maize grain left in the harvested fields, pumpkins and pumpkin leaves, bean pods and haulms, groundnuts and groundnut haulms and husks, tomato fruits and leaves, potato shoots and tubers, cassava leaves, banana fruits, peels and leaves and green vegetables discarded from vegetable gardens (dimba). During crop growing season (hot wet season) goats were restricted to prevent crop damage. The common practice was to tether the goats (93%) on the grazing site for the whole or part of the day. The other 7% of the goats were herded by small children after school.

At Lifidzi ranch goats were herded on natural bush land from 7.00 to 11.30 hours and from 13.00 to 17.00 hours every day and in all seasons.

Data collected

All goats were weighed in March, June, September and December during the period of study. Ages of the goats were unknown and were estimated using dentition (Wilson and Dunkin, 1984). In Lilongwe, in addition to weighing, the goats were condition scored from 1 to 5 (Appendix I). The data was analysed using Advanced Statistical Analysis Package (ANAPAK) available at the Bunda TRS 80 Model 1 computer unit.

RESULTS

Liveweight

Male and female goats having only one pair of permanent incisors had a mean liveweight of 21.7 $\pm$ 4.6 kg in Lilongwe. In Salima, mean liveweight was 22.0 $\pm$ 2.0 kg for females. Figures for males in Salima were not available (Table 2).

Liveweights for goats had increased to 31.5 $\pm$ 5.0 kg in Lilongwe and 29.5 $\pm$ 5.2 kg in Salima among those with a full set of permanent incisors (Tables 2 and 3). Likewise, withers height changed from 47 $\pm$ 2.2 cm and 45 $\pm$ 5.0 cm to 55 $\pm$ 3.6 cm and 52 $\pm$ 2.0 cm in Lilongwe and Salima, respectively for goats with first pair and full set of permanent incisors. This indicates that the goats were growing until they had developed a full set of permanent incisors which takes place at the age of 32 months or later (Table 2).

Seasonal weight changes

In Lilongwe as well as in Salima (Lifidzi ranch) the common pattern in seasonal weight changes showed highest weights of goats obtained in September (hot,dry season) and lowest in March (hot,wet season). While in Lilongwe these differences were statistically significant in both years ($P<0.05$), in Salima the difference was significant only in the second year. On both sites, weights obtained in June and December were intermediate of the two extremes (Table 3). Although weights of bucks were confounded by the fact that most of them were young and still growing, the results still show lowest weight in March on both sites (Tables 4 and 5).

On the whole, goats in villages were heavier than those in Salima (Lifidzi ranch). In all seasons, this difference was not statistically significant.

Table 2. Withers height (cm) and liveweight (kg) of Malawi local goats in Lilongwe and Salima.

Pairs of permanent incisors	Age (months)	Sex	Lilongwe No	Lilongwe Mean withers Height	Lilongwe Mean Body weight	Salima No	Salima Mean Withers Height	Salima Mean body weight
1st Pair	14-18	M	7	47 ± 2.2	19.2 ± 6.5	-	-	-
		F	50	47 ± 6.0	22.0 ± 4.0	2	45 ± 5.0	22.0 ± 3
		M & F	57	47 ± 4.5	21.7 ± 4.7	-	-	-
2nd Pair	19-23	M	-	-	-	1	60 ± 0.0	40.0 ± 0.0
		F	36	51 ± 4.0	25.0 ± 5.0	15	49 ± 2.0	25.0 ± 4.0
		M & F	-	-	-	16	49 ± 3.5	26.2 ± 5.2
3rd Pair	26-31	M	1	53 ± 0.0	28.0 ± 0.0	-	-	-
		F	41	53 ± 5.0	26.0 ± 4.0	67	51 ± 2.0	26.0 ± 4.2
		M & F	42	53 ± 4.1	26.0 ± 4.2	-	-	-
4th Pair	32	M	-	-	-	2	57 ± 2.5	43.2 ± 3.8
		F	142	55 ± 4.0	31.5 ± 5.0	109	52 ± 2.0	29.3 ± 4.7
		M & F	-	-	-	111	52 ± 2.8	29.5 ± 5.3
Broken Mout	Very old	M	-	-	-	-	-	-
		F	11	54.9 ± 4.0	32.0 ± 4.0	-	-	-
		M & F	-	-	-	-	-	-

Table 4: Seasonal changes in weight of bucks of 3 and 4 pairs of permanent incisors in Salima (Lifidzi ranch).

Buck No.	March 1985	June 1985	Sept 1985	Dec 1985	March 1986	June 1986	Sept 1986	Dec 1986
1	39.0	41.5	43.0	42.0	40.0	44.0	47.0	40.0
2	32.0	35.0	36.5	39.5	38.0	39.5	40.0	43.0
3	35.5	34.5	41.0	44.0	39.0	40.5	47.5	47.5
4	32.5	40.5	36.5	40.0	37.5	36.0	42.0	46.0
5	38.0	41.0	44.5	44.5	38.0	46.0	52.0	52.0
Mean	35.4	38.5	40.3	42.0	38.5	41.2	45.7	47.3

Body condition

Body condition scoring was carried out only in animals kept under traditional system in Lilongwe. Results indicate that almost all goats were in better condition in September (hot, dry season) than in March (hot, wet season) (Table 6).

Table 6. Body condition of goats in Lilongwe in different seasons.

Condition Score	Percent of animals scored			
	December (Hot, wet)	March (Hot,wet)	June (Cool, dry)	September (Hot, dry)
1	0	0	0	0
2	0.69	1.5	0	0
3	51.05	87.39	1.61	1.0
4	44.05	10.37	4.03	5.0
5	4.21	0.75	84.36	94.0

DISCUSSION

This study has shown that goats have lowest dry weights and are in poorest body condition in the hot wet season. The wet season in Malawi is characterised by a profuse growth of forage and herbage which ideally should enable goats to improve both in body weight and body condition but this is not the case. The situation is more grave in the traditional management system in the villages than in the commercial system at the ranch, although there too the pattern is the same.

While at Lifidzi ranch, the reason for loss in body weight and condition in the wet season is contributed by disease associated with intensification of the production system (helminthiasis, coccidiosis and abscesses) (Edelstein, 1988), tethering and the resultant poor nutrition seems the major cause in the villages. Studies done in the villages in Salima (Central Region) reported by Edelstein (1988), have shown that coccidiosis and abscesses are not major problems in village goats and that goats which were treated monthly with antihelmintics lost weight equally the same as those not treated. This led to the conclusion that antihelmintics besides being uneconomically expensive, have no effect on the performance of village goats in the wet season.

Grazing area for goats in Central Region seems abundant in the cool dry and hot dry seasons with crops harvested and goats left loose to roam freely. However, this area shrinks with the onset of rains when most of the land is used for cropping so that goat owners resort to tethering or grazing in limited areas. This results to inadequate herbage availability to the goats hence loss of condition and weight. The consequences are higher kid mortality and abortion rates, lower reproductive rates, birth weights and litter sizes (Karua, 1988) and reduced growth rate among weaners (Edelstein, 1988).

Tethering is a good management practice if properly done. However, tethering on the same place everyday regardless of wether forage is available or not, in addition to being conducive to build of helminthes and restriction of breeding activities, deprive the animal adequate nutrition. In the Central Region of Malawi, this seems to be a major constraint to goat production.

Body weights and condition for goats both in the villages and at the ranch improve after the rains because of unlimited availability of herbage which in the villages is due to change in management system coupled with reduced disease burden in both systems. Availability of crop residues during this time is an added advantage for the village goats although these dwindle as the dry season progresses.

While at the ranch, the solution to wet season loss of weight and the consequences in goats requires combined effort of veterinarians, nutritionists and agronomists; in the villages it lies mainly on proper management of feeding system. The present tethering system could be modified to include rotation of tethering sites both within and between days. Apart from having nutritional benefits, the system would help reduce build up of internal parasites at the tethering site. In intensively cultivated or densely populated areas, cut and carry systems would be adopted for wet season feeding. Such a system is successfully practised in parts of Nigeria (ILCA, 1979). This is particularly practicable in the Central Region of Malawi because the herdsizes are small (six per household) (Khaila and Itimu, 1985) so that labour demand for this exercise can be low.

Preservation of crop residues and supplementation with wastes from food processing e.g. maize bran are other feasible sources of feed for the goat. Ayoade (1985/86) found that both groundnut haulms and bean pods can significantly improve body weight and growth if supplemented with maize bran.

Figures on the national offtake of goats are not available. However a survey conducted by Khaila and Itimu (1985) found that goat meat is only second to chicken in terms of preference among the smallholder farmers in the Central Region. Per capita consumption of meat is 3.2 kg (Bookers Agriculture International, 1983) of which 78% is beef. This seems to indicate that contribution by other types of livestock is still very low. In case of goats this can improve if farmers are educated on the management of their feed resources.

Malawi government has a well organised extension service. However, like the rest of Africa, all along, goat development was not included in the extension packages. (Khaila and Itimu, 1985). It is more recently that the Malawi-German Livestock Development Programme has established an extension and marketing system for small ruminants in an effort to fill this extension gap. It is hoped that this will act as an incentive for higher goat production in Malawi.

Research on the goat suffered from the same neglect so that information which can be used for extension services is lacking. A study like the one reported here is only an initial effort to provide such information. More integrated research whose results can be generated into a system approach needs to be done.

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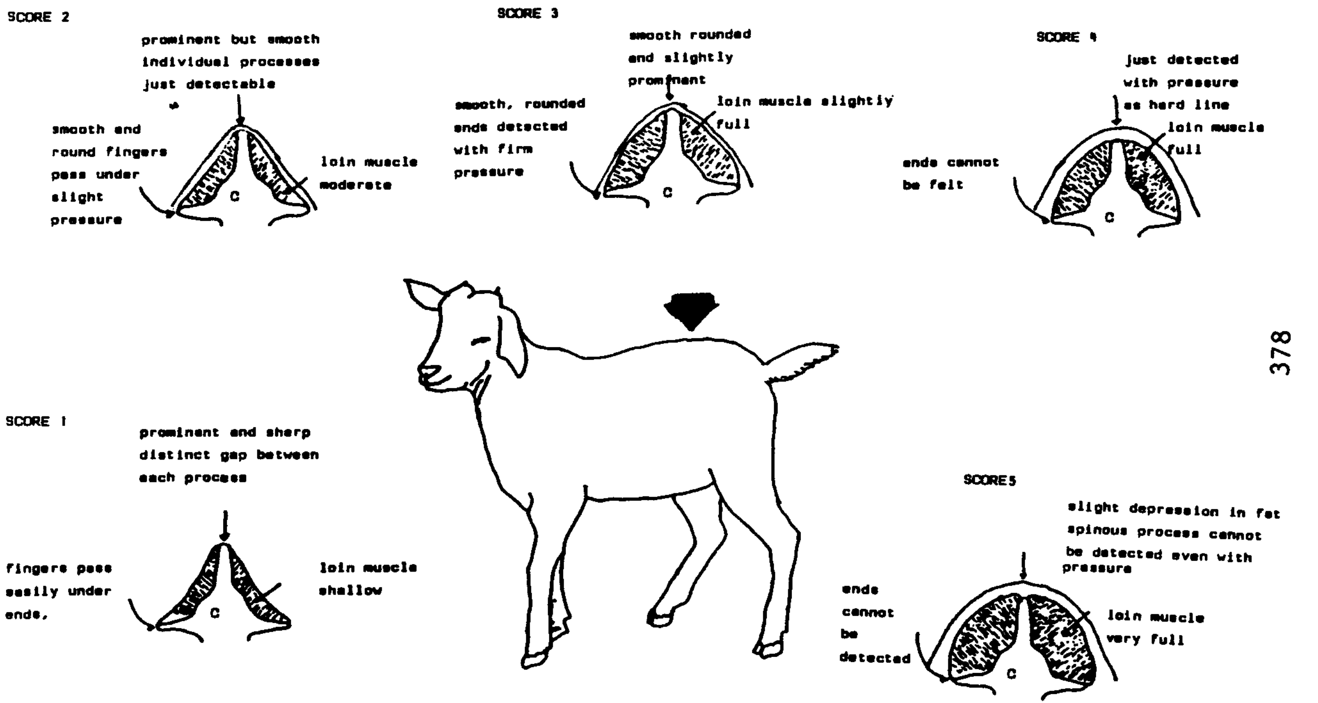
APPENDIX I. GOAT BODY CONDITION SCORING.



Source: Modified from Russel et all (1969).

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FEEDING VALUE OF SESBANIA AND LEUCAENA BROWSE

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ABSTRACT

Crossbred exotic x Barka and exotic x Boran milking cows in month 3-5 of lactation (mean initial yield 6-9 kg/d) were fed fresh-cut *Sesbania sesban* or *Leucaena leucocephala* to replace part of the concentrate ration normally given during dry season grazing of natural pasture. A concentrate was fed at the rate of 2 kg plus 0.5 kg per kg initial dairy milk yield to a control group of 3 cows; in 4 similar groups either 0.3 or 0.6 of this concentrate allowance was replaced by fresh-cut leucaena or sesbania browse (1 kg browse dry matter per kg concentrate replaced) during 1 week change-over, and 2 weeks experimental feeding with a final week on the original concentrate ration. All cows had access to dry season pastures. Leucaena was eaten more freely (max. 12 kg fresh, 4 kg dry weight per day) than sesbania (max. 8 kg fresh, 2.5 kg dry). Milk yield of the browse-fed groups was significantly higher in the two 7-day browse feeding periods than in the preliminary and final control feeding periods. Milk yield was higher in the experimental than the control periods by 0.45 kg/d in the controls, by 0.85 and 0.30 kg/d in the 0.3 and 0.6 sesbania groups, and by 0.76 and 1.18 kg/d in the 0.3 and 0.6 leucaena groups.

INTRODUCTION

Shortage of feed is the main constraint to livestock productivity in the arid and semi-arid zones. Almost all year round, the annual feed budget would not maintain the feed requirement of livestock rations. A large proportion of the rift valley's grazing lands have dry seasons lasting from six to eight months each year. With the advancing dry season, grazing animals turn

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more and more to browse to satisfy their daily needs for feed. The advantage of browse is its ability to maintain its feeding value into the dry season. (Skerman, 1977).

Being deep-rooted shrubs or trees, browses offer some drought tolerance and being leguminous they provide forage of higher nutritive value than dry season unimproved pastures. Jones (1979) reviewed the use of Leucaena as forage, while Jones and Jones (1984) reported that inclusion of leucaena in sub-tropical pastures gave better annual weight gains in beef cattle and supplementation with leucaena was shown to maintain production in milking cows (Plucknett, 1970).

As part of a study of the adaptability of browses to a range of environments in Ethiopia, Sesbania sesban and Leucaena leucocephala were established at the IAR cattle research centre at Adami, Tulu in the Rift Valley, 160 km south of Addis Ababa in March 1987. This is a semi-arid zone, with 400-600 mm rainfall in the months of March - July. Growth was studied under rainfed conditions and under intermittent irrigation, and sufficient amount of forage was available mainly from the latter area for a short feeding experiment in November - December 1987, the middle of the dry season, using cows in mid-lactation from the crossbreeding herd at the Centre.

MATERIAL AND METHODS

Both species were established in April with occasional watering. Sufficient forage was cut each afternoon for that evening and the following morning feeding. Records were kept of the total and of the usable material harvested from both leucaena and sesbania. Samples were taken for dry matter (DM) determination from the feeds offered and from the residues, since the latter contained much stemmy material of higher DM content.

Fifteen cows from the IAR crossbreeding study in months 3 to 5 of lactation were allotted to 5 groups of 3, each including offspring of Barka and Boran dams. Groups were balanced as far as possible for initial milk yields; group means ranged from 6.8

to 8.1 kg/d - and were then allocated at random to the control treatment and 4 experimental feeds.

All cows received the concentrate allowance in 2 feeds, at morning and afternoon milking times. Browse groups were tied for one to one and half hours to eat their browse ration after morning and afternoon milking. After morning milking, cows were allowed to graze. Browse was given to replace 0.3 and 0.6 of the concentrate. A surplus of about 30% was offered to ensure _ad libitum_ intake.

Milk records were taken as part of normai herd routine and yield in the week (November 24-30) was taken as the initial control value for calculation of concentrate entitlement, 2 kg/d plus 0.5 kg per kg of milk. The control group received this amount from December 3 until January 2, Browse was offered to the other groups in small amounts on December 1 and 2; from December 3 to 11 the concentrate was reduced and browse increased to the desired levels and then maintained for 2 weeks until December 25. From December 26 no browse was fed; all cows returned to their initial calculated concentrate entitlement until January 1 and then to normal station feeding.

Browse intakes and milk yields were studied by analysis of variance, milk yields were also adjusted by covariance on yield in the initial week.

RESULTS AND METHODS

Browse intakes results are summarized in Table 1. Intake was generally higher in the second experimental week (week 3) than in the first (week 2), but the intake of sesbania was only slightly higher in the 0.6 group offered about 12.5 kg/d than in the 0.3 group offered only 6.3 kg/d. Intake of the corresponding leucaena-fed cows increased to over 11kg/d when additional feed was offered, compared to the 12-14 kg/d reported by Plucknett (1970).

Table 1: Intake of cows offered sesbania and leucaena to replace 0.3 and 0.6 of their concentrate allowance*

	Mean intake of concentrate* and fresh browse (kg/d)			
	Week 2 (12-18/12)		Week 3 (19-25/12)	
Group	Concentrate	browse	Concentrate	browse
Control	5.7	-	6.7	-
0.3 Sesbania	3.7	4.8 * 0.5	3.6	4.9 * 0.5
0.6 Sesbania	2.2	5.6 * 1.7	2.2	6.1 * 1.3
0.3 Leucaena	3.5	4.7 * 0.7	3.5	5.1 * 0.6
0.6 Leucaena	2.0	10.4 * 1.1	2.0	11.3 * 0.4

* Lower concentrate intake of leucaena groups indicates that groups randomly assigned to leucaena had lower initial milk yields.

Dry matter (DM) intakes (Table 2) show that browse intake adequately replaced the planned 0.3 and 0.6 of the concentrate, except in the 0.6 sesbania group. Concentrate intake in that group was reduced by 3 kg DM but sesbania intake replaced only 2 kg of this amount.

Table 2. DM intake of cows fed browse to replace 0.3 and 0.6 of their concentrate ration.

	Mean intake of concentrates and browse (kg/DM/d)						
	Concentrate	Week 2 (12-18/12)			Week 3 (19-25/12)		
	entitlement	conc.	browse	total	Conc.	browse	total
Control	5.27	5.27	-	5.27	5.27	-	5.27
0.3 sesbania	4.85	3.44	1.69	5.13	3.44	1.73	5.17
0.6 sesbania	5.12	2.05	1.92	3.97	2.05	2.09	4.14
0.3 leucaena	4.65	3.26	1.41	4.67	3.26	1.58	4.84
0.6 leucaena	4.71	1.86	3.11	4.97	1.86	3.47	5.33

Leucaena DM intake averaged about 47% of the supplement, not including the additional intake of grazed pasture and straw offered overnight. There was no problem from the mimosine content of leucaena even though leucaena formed more than 40% of the total diet (Donaldson et al, 1970, Dharmaraj et al, 1984, Jones and Jones 1984). The mimosine content of mature leucaena foliage in the dry season is likely to be quite low.

Milk Production

Response of individual cows: Comparison showed that the mean yield in the 2 experimental periods in all groups exceeded the mean of the initial and final control periods. Calculation for each cow showed that mean milk yield was higher in the experimental than in the control periods by 0.45 kg/d in the controls, by 0.85 and 0.30 kg/d in the 0.3 and 0.6 sesbania groups and by 0.76 and 1.18 kg/d in the 0.3 and 0.6 leucaena groups respectively. The increase in yield of the control cows was because the experimental concentrate allowance was higher than the Centre's routine concentrate feeding level.

Comparison with controls: Milk yields in the 2 experimental and final control periods showed a significant correlation ($r = 0.82$) with yield in the initial week. Milk yields adjusted by covariance on initial yields are shown in Table 3, with results of the analysis of variance indicated by superscripts.

Table 3. Adjusted milk yields of control and browse-fed groups

	Mean yield (kg/cow/d) Initial and final control periods	2 expt. per
Control group	7.22	7.62a*
0.3 sesbania	7.40	8.25b
0.6 sesbania	7.31	7.70a
0.3 leucaena	7.40	8.25b
0.6 leucaena	7.51	8.65b

* Values with different superscripts differ significantly ($P<0.01$)

Whereas the 0.6 sesbania group milk yield was no higher than the controls, the other browse-fed cows all gave significantly higher yields; 0.3 sesbania and 0.3 leucaena gave similar yields and the 0.6 leucaena group, although highest, was not significantly higher than the 0.3 browse groups. This confirms the result of the individual comparison of unadjusted milk yields, above.

CONCLUSION

The original intention to feed browse to replace up to 75% of the concentrate had to be modified. It would have been possible with leucaena but not with sesbania. Except in the case of the high level of sesbania, milk yield increased under browse supplementation.

Whether response to browse supplementation is beneficial in economic terms clearly depends on the cost of growing the forage. 1kg browse DM can be viewed as nutritionally equivalent to 1 kg concentrate, but even with leucaena, there is likely to be some wastage in feeding.

The mandate of the Institute of Agricultural Research in Ethiopia is to conduct research and the extension activity is being carried out by the Ministry of Agriculture. Within the Ministry of Agriculture, the Fourth Livestock Development Project is responsible for the extension activity of the pasture and forage results (programme). The research-extension linkage of the country was limited until 1985. Since then research-extension linkage committees have been organised in various parts of the country. It is hoped that in future, research results could be easily disseminated to the farmers.

With regard to leucaena and sesbania utilisation the rate of acceptance of these browse plants by farmers is encouraging.

It was reported that leucaena has been used in Hararge region by farmers for fattening and in Gojan region farmers use sesbania for alley cropping. This indicates that leucaena and sesbania have been successfully adopted by farmers. Since more seeds could be produced from both species, farmers can easily get the seeds and in future it is likely that these browse species could be easily multiplied and used by farmer in most parts of the country.

The total cost of establishing 1 hectare of browse was about 30 cents per kg of forage harvested in the first year. In later years the cost could be reduced to maintenance and harvesting, and the yields from 3 to 4 harvests could be 9 to 10 tonnes/ha/yr. Hence the cost of forage should be not more than about 5 cents/kg and the cost of concentrate is over 30 cents/kg. This shows that sesbania and leucaena can replace the expensive and often unavailable concentrate.

The economic benefit of sesbania and leucaena in terms of milk and meat has shown considerable success both under research and in farmers' condition. In the long run this innovation has to be tested by farming system research unit which is now in its foundation stage.

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MOLASSES ENERGY BLOCKS FOR BEEF CATTLE

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ABSTRACT

The present trial was to investigate the possibilities of the farmer making his own concentrated energy blocks from the locally available ingredients and to determine at what cost he does so. The suitability and acceptability of the blocks by steers were also studied. 16 unreplicated blocks were made using molasses, urea, salt, cement, corncob meal and wheat bran in 2^4 factorial experiment. Block hardness was found to vary with block type, location, technique of manufacture and to some extent with temperature and humidity although there was no evidence that the blocks hardened any more beyond day nine. In a 15-minute intake observation, average consumption per 'visit' of molasses blocks containing wheat bran was 142 g which differed significantly ($P<0.05$) from the average consumption of 96 g for those containing corncob meal. Consumption of blocks containing wheat bran was not affected ($P<0.05$) by method of preparation, proportion of molasses or even the location of the blocks. Consumption of corncob blocks containing 50% molasses was 131 g which differed ($P<0.01$) from 68 for those containing 45% molasses. Placement of blocks containing corncob meal in the sun resulted into average consumption of 116 g, an amount different ($P<0.05$) from 77 g for those placed in the shade. In all cases, the cost of the blocks was between 20 and 25% the cost of Crystalyx, a standard commercial preparation.

INTRODUCTION

In beef cattle nutrition, energy among others can be limiting especially in the dry season leading to slow livestock development or indeed a reversal in livestock gains. In Kenya, beef cattle numbers are estimated at some 9.5 million (ISNAR,

1985) and occupy large tracts of land in the principally 79% of Kenyan rangeland. Beef cattle numbers given for 1983 through to 1985 (Owiro, 1985) would indicate that 11.5% of the animals were lost in the 1984 drought. Similar or worse losses have been reported in the Sahel region of West Africa (Bourn et al, 1987) and in Wollo, Shoa and Hararge provinces of Ethiopia (ILCA, 1986).

Pickstock (1985) has reported that in times of drought when the energy and protein reserves of animals fall to dangerously low levels, molasses - urea mixtures can be fed in amounts of upto 2 kg a day thereby helping to satisfy both energy and protein needs for maintenance. The use of liquid molasses and urea have had their problems (ILCA, 1986; Sansoucy, 1986). According to Sansoucy (1986) these problems are easily solved through use of molasses - urea blocks whose advantages are in the handling, storage, transportation and even in the actual feeding. The concept of energy blocks is not new and there are over 70 formulae adopted by various countries depending on the locally available ingredients. (Sansoucy, 1986).

Though the technology involved in block-making is both simple and practicable, such factors as ingredients used, mixing technique and environmental factors affect the block stability. The state of hardening is of particular interest from the point of view of transportation and consumption by the animals. It was for this reason that an investigation was carried out to study the technique of making energy blocks using the commonly available ingredients and to study the economics involved in addition to determining how acceptable the blocks are to the beef cattle.

MATERIALS AND METHODS

The methodology of making molasses blocks was based almost exclusively on the work of Sansoucy (1986). In a second set of blocks, corncob meal replaced wheat bran as suggested by Shenkute Tessema (personal communication). Sixteen unreplicated blocks were made each weighing approximately 6.5 kg. The trial was on a factorial layout with two different levels of molasses, (50% and

45%), two residues (wheat bran and corncob meal), two storage systems (in the sun and under shade). Table 1 shows the composition of the blocks.

Table 1. Composition of molasses blocks.

	Wheat bran		Corncob meal	
Block type	I	II	III	IV
		%		
Molasses	45	50	45	50
Urea	10	10	10	10
Salt	5	5	5	5
Cement	15	10	15	10
Wheat bran	25	25	n.a	n.a
Corncob meal	n.a	n.a	25	25

n.a. = not available

Mixing of the ingredients was carried out in a strict order starting with molasses followed by urea, salt, cement and ending with wheat bran or corncob meal. It was particularly suggested by Sancoucy (1986) that the hardening process is improved by mixing the cement with water first as the water contained in the molasses was considered insufficient to wet the cement. To investigate this, the cement was mixed with extra water (37 parts to 100 parts cement w:w) before further mixing with the other ingredients. It was also considered necessary to investigate the stability of the blocks when placed in the open and under shade to simulate the two conditions likely to prevail under real world farming conditions. The factors investigated were block quality, stability and block consumption by beef cattle.

Block quality

Nutrient content of the blocks was determined by proximate analysis for dry matter, crude protein, ether extract, gross energy and minerals such as calcium, phosphorus, magnesium, sodium and potassium using the accepted analytical standards (AOAC, 1975). The fibre fractions were analysed according to the procedures of Goering and van Soest (1970).

Block stability

Hardness of the blocks was used as an indicator of block stability. To determine hardness, a penetrometer, one of the Chatillon precision instruments (Chatillon - N.Y.-USA. GAUGE R. - CATL 719-20) was used. For every block there was determination of the relative force needed to sink the penetrometer to a preset depth. At any one time, four such determinations were made on a block at 9.00, 12.00, 15.00 and 18.00 hours. The process was continued daily for 12 days from 9/3/87 (day 5) to 20/3/87 (day 16). Data for days 5, 6, 10, 11 and 12 were excluded from analysis due to missing values. An analysis of variance on block hardness under various conditions was carried according to Steel and Torrie (1980).

Block consumption by beef cattle

Block acceptance and consumption by beef cattle was determined in a 15 minute observation. All the 16 blocks were weighed and placed in boxes arranged in a wide semi circle. Eight observers were assigned to watch over two blocks each. A herd of grazing hereford steers was then released to sample the blocks. The observers had to record the number of 'visits' by steers to all blocks as identified in Figure 1. After 15 minutes, block left overs were weighed and relative consumption calculated on 'per visit' basis. Major comparisons were carried out by paired 't' test (Snedecor and Gochran, 1967).

RESULTS

Block quality

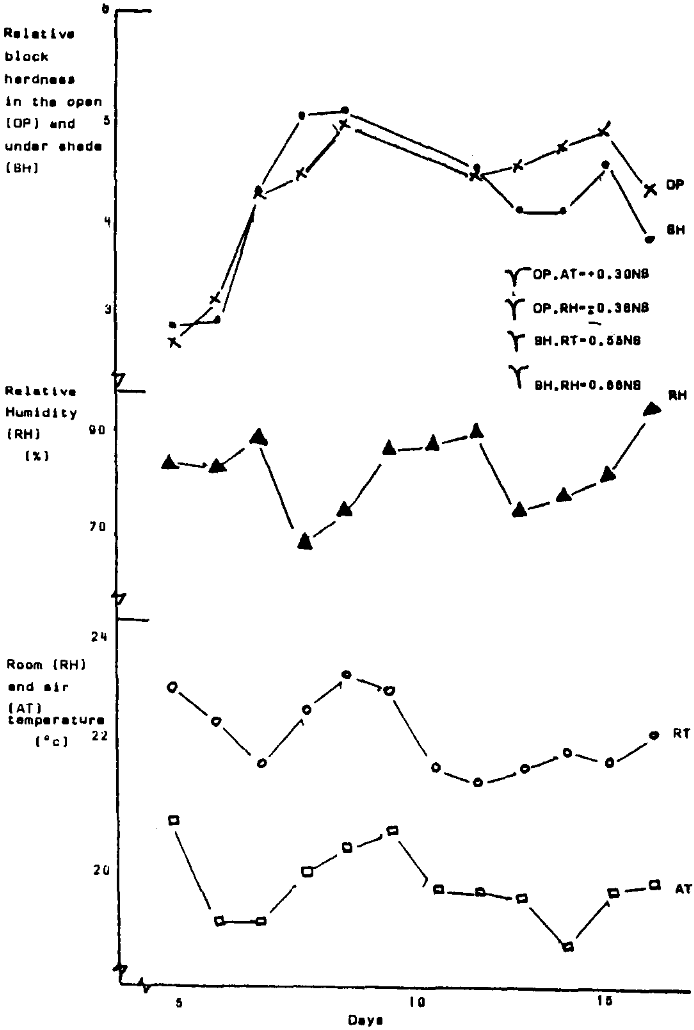
The chemical composition of the blocks and their ingredients is given in Table 2. The standard "Grystalyx" had higher dry matter than the other blocks and contained no fibre. The Ca:P ratio of "Crystalyx" is close to 2:1 whereas for the other blocks it ranged from 11:1 for block type II to nearly 26:1 for block type III. Except for calcium and crude protein, the crystalyx block contained higher quantities of other chemical components than the rest of the blocks.

Table 2. Chemical composition of the blocks and their ingredients.

	Wheat bran				Corncob meal				Ingredients*		
Block type	I	II	III	IV	Crystalyx	Molasses	Wheat	Corncob	Urea	Salt	Cement
Dry matter %	91.6	89.5	90.5	89.2	95.0	72.0	91.0	91.5	97.5		
As % of Dry Matter											
Crude protein	32.1	34.2	33.3	33.0	30.3	2.8		3.7	44.8		
Ether extract	3.54	1.81	2.52	1.05	3.78	0.07		1.82			
Neutral detergent fibre	16.2	12.9	22.2	23.3			54.4	87.1			
Acid detergent fibre	5.4	8.7	9.9	13.4			14.4	49.8	-	-	-
Acid detergent lignin	1.5	1.6	1.6	1.5	-	-	2.8	7.7			
Calcium	6.79	5.41	5.88	4.53	1.59						
Phosphorus	.48	.49	.23	.28	.86						
Magnesium	.67	.41	.58	.78	1.68						
Sodium	3.53	2.66	2.96	2.22	10.50						
Gross energy (Kcal/g)	2.97	3.10	2.90	2.95	3.18						

* Gaps indicate analyses that were never carried out.

Figure 1. Relative block hardness with changes in temperature and relative humidity.



Block hardness

Block hardness varied significantly (P<0.001) both within the day and also between the days (Figure 2). For those blocks kept in the shade, correlation coefficients of pressure with temperature and relative humidity were +0.55 ad -0.66 respectively. Although none of the correlation coefficients were found significant (P>0,05) there is a trend that would indicate that these two environmental factors had an effect on block hardness especially those in the shade. There was no evidence that the blocks hardened any more beyond day nine.

At a relative penetration pressure of 4.71, the blocks kept in the open were significantly harder (P<0.001) than those in the shade which recorded a mean pressure of 4.56 (Table 3).

By use of 't' test on figures in Table 3, it was shown that the mean pressure for wheat bran blocks was 5.39 which was significantly different (P<0.01) from the mean pressure of 3.87 for corncob blocks. There were significant (P<0.001) interactions demonstrated between treatments and sites. These interactions were shown among the corncob meal blocks K, L, O and P prepared without addition of water which unlike the others hardened more in the shade than in the open. At a mean relative pressure of 4.98, blocks with water added at mixing were significantly harder (P<0.001) than those without added water whose pressure was 4.28. 45% molasses blocks were harder (P<0.001) at a pressure of 5.13 than 50% molasses blocks at a pressure of 4.14.

Table 3. Relative block pressure

Sun		Shade		Mean
Block	Pressure	Block	Pressure	
A	5.89	B	5.76	5.83^{a}
C	5.93	D	5.91	5.92^{a}
E	5.68	F	4.71	5.20^{b}
G	5.05	H	4.22	4.64^{c}
I	5.23	J	5.15	5.19^{b}
K	2.75	L	4.40	3.58^{e}
M	4.54	N	3.44	3.99^{d}
O	2.57	P	2.87	2.72^{f}
Mean	4.71^{q}		4.56^{r}	

Subscripts a,b,c,d,e,f, different at $P<0.001$
Subscripts q,r different at $P<0.001$

Block consumption by beef cattle

Consumption of blocks is shown in Table 4 followed by comparisons of interest in Table 5. No differences were evident in the consumption of wheat bran blocks irrespective of composition, location or method of preparation. For the corncob blocks, placement in the sun resulted into significantly higher consumption ($P<0.01$) and so did inclusion of molasses at 50% level compared to 45%. Overall, the consumption of wheat bran blocks was higher ($P<0.05$) than for corncob blocks.

Table 4. Block consumption by yearling steers

Block	Total Consumption (kg)	Number of "visits"	Consumption per "visit" (g)
A	5.20	31	168
B	3.70	37	100
C	5.30	35	151
D	2.80	65	43
E	5.80	52	112
F	4.65	51	91
G	5.60	26	215
H	5.10	20	255
I	2.00	23	87
J	1.20	35	34
K	4.75	58	82
L	2.10	48	44
M	2.70	21	129
N	1.80	18	100
O	5.90	36	164
P	9.20	40	130

Block costings

The cost of making the energy blocks was compared with the current cost of other preparations appearing in the market (Table 6). Some of these preparations are not in block form and for that reason "Crystalyx" which is a trully commercial energy block was used as the standard. It is evident that under current prices block type I to IV cost between 20 and 25 percent the cost of crystalyx while the other commercial supplements, that is, molasses-urea mixture (MUM) and molafeed cost between 25 and 30 percent.

Table 5. Comparisons on block consumption

Variable		Wheat bran Mean	Wheat bran Mean difference	Wheat bran T-value	Corncob meal Mean	Corncob meal Mean difference	Corncob meal T-value
Location	Sun	162	40	1.23_{NS}	116	39	7.44**
	Shade	122			77		
Molasses	50%	168	52	0.90_{NS}	131	63	6.91**
	45%	116			68		
Water	without	166	40	0.94_{NS}	105	17	1.89NS
	with	118			88		
Wheat bran		142	46	2.57*			
Corncob meal		96					

NS = Non significant (P>0.05)
* = Significant (P<0.05)
** = Significant (P<0.01)

Table 6. Comparative cost of blocks and other supplements

Block type	Unit cost of/kg*		Cost of 100 kg block (US $)	As % of Crystalyx block
	Kshs	US $ Equivalent		
I	1.630	-	8.89	24.3
II	1.588	0.087	8.75	23.6
III	1.352	0.075	7.45	20.2
IV	1.310	0.072	7.21	19.5
MUM	1.800	9.91	9.91	26.8
Molafeed	2.000	0.110	11.01	29.7
Crystalyx	6.720	0.370	37.01	100.0

* Assumptions 1 US $ = KShs.18.158 as on Nov. 12, 1988

	Unit cost (KShs/kg)
Wheat bran	1.61
Salt	3.70
Molasses	0.76
Urea	4.60
Cement	1.60
Corncob meal	0.50

DISCUSSION

It has been demonstrated in this trial that it is possible to make molasses urea blocks using the commonly available ingredients. Both the dry matter and crude protein levels of the blocks compare very closely to those of the "Crystalyx" blocks (Table 2). One very big differences is that "Crystalyx" contains no fibre components whereas other block types notably III and IV contain more than 20% neutral detergent fibre. This could perhaps explain the relatively higher gross energy determined for the "Crystalyx" block. Wheat bran and corncob meal were the main contributors to the fibre fractions for block types I to IV (Tables 1 and 2).

Hardening and general stability is a crucial aspect of the blocks. According to Sansoucy (1986) too hard a block would result in inadequate intakes while too soft a block induce overconsumption with the possible consequences of urea toxicity. Those blocks containing wheat bran (blocks A through to H) demonstrated better compactness (Table 3) unlike the other blocks containing corncob meal which were inconsistently soft. The ideal block pressure is unknown and "Crystalyx" used as a standard here was so hard that the penetrometer could not penetrate it at all thereby raising doubts as to whether 250 kg animals could consume an average of 700 g per day considered ideal for maintenance (Sansoucy, 1986). Prior mixing of cement with additional water resulted into harder blocks in agreement with the suggestion of Sansoucy. Many factors may have contributed to the general softening of the blocks especially among those made out of corncob. Temperature and humidity are some of the suggested possibilities. Use of quicklime instead of cement is said to give harder blocks and so does the use of molasses with Brix degree (related to dry matter) equal to or more than 85 as suggested by Sansoucy. The dry matter of the molasses used here was 72% (Table 2). From the feed analysis tables NRC, (1978) cane molasses with a dry matter of 75% has a Brix degree of approximately 79.5.

It, therefore, follows that the molasses used in this trial had a Brix degree of approximately 76, a figure that is well below preference. The fact that 45% molasses blocks were harder than those containing 50% molasses indicates that the higher levels of cement in the latter blocks was an overiding factor in the determination of block hardness.

Consumption of the blocks by yearling steers indicated that the highest intakes were among the better compacted wheat bran blocks (Table 5). In a real performance trial this may not necessarily be a good thing. In a 15-minute period an average of 142 g of wheat bran blocks had been consumed. In a whole day this could probably result into dangerously high levels while corncob blocks containing 45% molasses, may on the other hand not provide enough energy and protein for optimum utilisation of crop residues. By manufacturing his own energy blocks using ingredients that are available at fairly controlled government prices the farmer would benefit from a saving of more than 75% the cost of company manufactured blocks. The practicability of utilisation of energy blocks at farm level is no longer in question (Preston and Leng, 1987) and an improvement in livestock performance is guaranteed (Sudana and Leng, 1987; Sansoucy et al, 1986). For Kitale, Kenya, conditions there is a realised need to investigate the performance of steers given a selected number of blocks. This is the next step of investigation especially in the relatively drier months of December and February.

CONCLUSION

The technology of making energy blocks for dry season feeding is both simple and practicable. However, getting the right kind of block is dependent on may things among them being environmental factors, ingredients used and manufacture technique. Although molasses-urea blocks containing wheat bran were shown to be more stable and were consumed at higher levels than those containing corncob meal, complexity in real-life utilisation of the blocks as a whole needs further investigation. The economic saving is considerable over purchased commercial blocks although the real benefit may turn out to be the improved livestock performance since the farmer can alter block composition to suit his needs.

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LIVEWEIGHT CHANGES IN SHEEP SUPPLEMENTED WITH SEED PODS OF TWO LEGUMINOUS TREES IN SOUTH KORDOFAN, SUDAN, DURING THE DRY SEASON

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ABSTRACT

This paper examines the effect of supplementing seed pods of kadad (*Dichrostachys cinera*) and haraz (*Acacia albida*) on sheep liveweight change during the dry season. Seed pods were collected after maturity in December. Diet selected by sheep was determined by the bite-count method and intake was estimated by the faecal index method, using 4 non-lactating sheep for the total faecal collection. Seed pods and the diet selected were analysed for nitrogen (N), neutral detergent fibre (NDF), *in vitro* dry-matter digestibility (IVDMD) and *in vitro* organic matter digestibility (IVOMD).

Three groups of non-lactating sheep, with 4 ewes in each group were selected randomly from the stock of sheep belonging to WSARP at the research farm. The first group was supplemented with kadad seed pods, the second group with haraz seed pods and the third group was the control, which survived on range forage only. Supplements were offered every other day for 7 weeks. Sheep in the three groups were then mixed in a corral and weighed at random.

Crude protein (6.25 x % N) and NDF constituents of kadad were 10.9% and 53.1%, of haraz 16.5% and 59.2% and of the diet selected were 12.3 and 68.1% respectively. *In vitro* dry matter digestibility and IVOMD were 50.5% and 48.1% for kadad, 43.9% and 45.8% for haraz and 31.5% and 28.7% for the selected diet respectively.

Dry-matter intake was 2.9 kg/100 kg body weight and crude protein intake was 8.4 g/$W^{0.75}$ kg/day. Kadad and haraz provided additional N supplements of 6.8 and 11.2 g/$W^{0.75}$ every other day, respectively and more energy that resulted in an increase in liveweight ($P<0.005$) for the supplemented group. Sheep supplemented with haraz, however, gained more liveweight ($P<0.05$) than sheep supplemented with kadad.

INTRODUCTION

Sheep rank second to cattle in importance within the transhumant production system in south Kordofan. They are slaughtered for various religious occasions and also sold in local markets to cover cash expenditures (Fadlalla, 1985 a).

The primary constraint limiting sheep productivity is the poor nutrition during the dry season, which extends from November to June. During this period, crude protein contents of range forage decrease from 19.3 - 13.3% in July to 6.6 - 2.9% in December and standing crop of herbage decreases from 3830 kg/ha in October to 1838.4 kg/ha in February (Fadlalla, 1982) and is almost consumed by the end of June. Under these conditions, supplemental feeding is often of primary importance during the dry season (Williamson and Payne, 1959). To address this problem, sesame cake was supplemented to sheep during this period (Cook and Fadlalla, 1985) but with a limited success since the supplemented sheep performed only slightly better than the control.

In the experiment reported herein, seed pods of kadad (Dichrostachys cinera) and haraz (Acacia albida) are being tested as an alternative supplement for sheep during the dry season. Kadad yields about 1 kg of seed pods per tree (Hashim, in prep) and haraz yields 125-135 kg/tree of seed pods that can be dried and stored for future use (NAS, 1979). Objective of this experiment were: (1) to quantify the nutritive value of sheep diet and seed pods of kadad and haraz, (2) to determine intake and liveweight changes of non-lactating sheep supplemented with seed pods of the two locally available leguminous trees.

STUDY AREA

This study was conducted at the experimental farm belonging to Kadugli Research Station in south Kordofan. South Kordofan lies within the savanna zone of the sahelian belt, and can be classified as having hot, semi-arid climate. March is the hottest month at Kadugli with a maximum of 41°C and a minimum of 24°C. December and January are the coolest months with 35°C and a minimum of 18°C. Rainfall varies from 700 to 800 mm, which occurs in a single season, primarily from June to September, although there is some rainfall in May and October. A short, hot season occurs after the rains from October to November, followed by cool, dry season from December to February. The main hot season occurs from March to May.

The research farm, which is fenced, encompasses 760.6 ha. The soil is dominated by cracking clays with patches of sandy clays and sandy loams. Acacia seyal dominates the cracking clays and sandy loams; associated with this species are Sorghum spp., Aristida hordaceae, Cymbopogon sp. and Dinebra refraflexa, Balanites aegyptiaca, Ziziphus spina-christi and Acacia polyacantha are widely dispersed in the research farm. Dichrostachys cinera exclusively covers patches of sandy clays and sandy loams.

The research farm is stocked with cattle, sheep and goats at the rate of 9 ha/head-year, 10 ha/head-year and 10 ha/head-year, respectively. Tap water is provided from the station headquarters to the camp site on the research farm year-round.

Cattle, sheep and goats are herded separately in the research farm, the herding usually starts at 8.00 a.m. After a distance of 1.5 km or so the animals are herded back to the camp for watering and shading, herded again in the evening for grazing and corraled at the camp around 5.30 p.m.

MATERIALS AND METHODS

Sixteen non-lactating sheep were selected and divided randomly into 4 groups, 1 group was used for studying diet selection and intake and the other 3 groups were for the feeding trials.

Sheep in the group of diet selection and intake studies were harnessed with bags that were specially designed to fit females. Sheep in this group were trained for accepting the bags while they were being herded as usual before the start of the experiment. After the completion of the training period, sheep were followed by two observers, one for determining herbaceous vegetation cover and the other for determining diet selected and intake. Either observer selected sheep randomly from the group.

The first bite made by the selected sheep was considered the starting point for the sampling of the herbaceous vegetation cover in each grazed area. From this point, 4 line transects each of 1/2 km long were randomly selected and were traversed. Readings for the cover determination were recorded at 50 m intervals along the line transects, using the ten-point frame procedure (Leavy and Madden, 1933). The sampling was continued for a week and was replicated for at least 3 sheep per day.

Diet selection was determined by the bite-count method (Reppert, 1960). About 100 bites were recorded for a single sheep per day and replicated for at least 3 sheep in each grazed area. The sampling continued for a week. The diet selected was composited for each sheep and was pooled for all sheep during the period of sampling.

Intake was estimated by the faecal index method (Maynard and Loosli, 1969) and 24 hr faecal collection according to the following equation.

$$DM = \frac{\text{g faecal DM x \% indicator in faeces}}{\text{\% indicator in forage}}$$

where DMI is dry matter intake. The indicator used was faecal NDF (Waller et al, 1980).

Group feeding was conducted in a randomised complete block design (Steel and Torrie, 1960). In addition to grazing, one group was supplemented with seed pods of kadad, the second group with seed pods of haraz and the third group was control. All groups were corraled at 6.00 p.m. when supplements were offered following the usual practice of herding and grazing. Intake of the supplements was estimated by the following equation:

$$\text{Intake, } g/W^{0.75}kg = 110.4 - 1716(100\text{-}CWC),$$

where CWC is the cell wall constituents and W is the body weight (Goering and van Soest, 1970).

Dry matter and N contents were determined according to AOAC (1984). Neutral-detergent fibre determination followed the procedure of Goering and van Soest (1970). In vitro dry matter digestibility followed the procedure of Tilley and Terry (1963) and IVOMD was determined as a loss in weight after being ashed ir a muffle furnace for 8 hrs at 500°C.

Initial weight was recorded for sheep, which were numbered in each group at the start of the experiment and every week thereafter. Weighing was standardised according to Harris et al. (1970). Sheep in the three groups were gathered in a corral at 7.00 a.m. and were given sufficient time to urinate and defaecate. Weighing was then conducted at random.

Liveweight changes in sheep were calculated as the difference between the starting weekly weight and the ending weekly weight and averaged for sheep in each group. Weight changes were then subjected to an analysis of variance and means were separated by the least significant differences (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Herbaceous vegetation constituted 1.7% of the ground cover, of which 0.6% were grasses and 0.5% were forbs. Litter constituted 17.9%, and the bare ground 81% (Table 1). Cover was not determined for trees and shrubs because in sandy soils where Dichrostachys cinera dominated, it formed inpenetrable thickets that rendered the sampling of this species and the species associated with it impossible. Pratt and Gwynne (1977) reported that D. cinera increased in overgrazed rangelands. After 3 years of grazing it diminished in size to form impenetrable thickets that had to be eradicated (Mckay, 1968).

During the dry season, sheep selected more shrubs and trees than grasses and forbs (Table 2). Although it was not important in the herbaceous cover and composition, Dinebra refraflexa was the grass species selected most. As for shrubs and trees, D. cinera constituted the major proportion of sheep diet; sheep ate its dead, fallen leaves and fallen seed pods. Fallen flowers and leaves of Acacia seyal and Balanites aegyptiaca were eaten by sheep as well as fallen fruits from the latter species. Seed pods of Acacia polyacantha and A. seyal also constituted a considerable proportion of sheep diet during the dry season.

Table 1. Herbaceous vegetation cover and composition in the research farm during the dry season.

Taxon	Cover %	Composition (%)
Grasses		
Hyparrhenia pseudocymbora	0.26	23.4
Brachairia obtusiflora	0.05	4.5
Sehima ischaemoides	0.32	28.8
Forbs		
Chorchorus sp.	0.16	14.4
Justicia sp.	0.32	28.8
Litter	17.89	
Bare ground	81.00	

Table 2. Diet botanical composition of sheep in the research farm during the dry season.

Taxon	Composition (%)
Grasses	
Aristida hordaceae	0.42
Sehima ischaemoides	0.05
Dinebra refraflexa	10.54
Forbs	
Ipomea sp.	0.83
Trees and shrubs	
Dichrostachys cinera (leaves)	29.07
seed pods	9.88
Balanites aegyptiaca (leaves)	10.66
fruits	0.95
Acacia seyal (leaves)	0.74
flowers	33.12
Ziziphus spina-christi (leaves)	0.06
Acacia polyacantha (seed pods)	1.05
Albizia amara (leaves)	0.71
Acacia senegal (seed pods)	1.88
Cadaba farinosa	0.05

In Drongas area of south Kordofan, Schima ischaemoides constituted 71.6% of sheep diet, Balanites aegyptiaca 5.9%, A. seyal 5.7% and Dichrostachys cinera, A. polyacantha and Ziziphus spina-christi less than 1% (Fadlalla, 1985b). Fadlalla also reported that forbs and shrubs constituted over 90% of the transhumant sheep diet in late dry season.

Diet selected by sheep showed high crude protein and NDF constituents (Table 3), and low digestibility. The high NDF concentration and the low digestibility suggested low energy intake by sheep during the dry season. The high crude protein of the diet could be attributed to the high proportion of trees and shrubs (88%) in the diet, particularly fallen seed pods and flowers. During mid-dry season, sheep diet, which comprised 16% trees and shrubs, contained 8% crude protein (Fadlalla, 1985b). Crude protein constituents of the herbaceous vegetation during the same period ranged between 6.6 and 2.9% (Fadlalla, 1982).

Seed pods of *Acacia albida* showed high crude protein and energy contents (Table 3) and low dry matter and organic matter digestibilities compared to seed pods of *Dichrostachys cinera*.

Dry-matter intake was 814.8 g/head/day for sheep supplemented with seed pods of kadad, 855.9 g/head/day with haraz, and 908.6 g/head/day for the control (Table 4). During mid-dry season, dry-matter intake for lactating transhumant sheep was 1252 g/head/day (Fadlalla, 1985b). On Forb Range in Montana, dry-matter intake estimated for sheep during early, mid-and late dry season was 900, 1100 g/head/day, respectively (Buchanan et al., 1972).

Dry-matter intake per 100 kg body weight was 2.9 kg/day. For breeds of sheep, including Merino, Blackhead Persian and Droper, dry-matter intake per 100 kg body weight was 0.93, 1.27, 1.14 kg/day, respectively (Williamson and Payne, 1959). Fadlalla (1985b) reported 3.9 kg/day for pregnant sheep in south Kordofan.

Crude protein intake ranged between 100.2 and 111.7 g/head/day (Table 4), which is comparable with crude protein intake of 100 g/head/day by pregnant transhumant sheep (Fadlalla, 1985b). This could be related to the high crude protein content of the diet selected by sheep in this study.

Supplements of seed pods offered, which were 3.5 kg of kadad and 3.6 kg of haraz, were calculated according to the regression equation of Goering and van Soest (1970). The amount of supplement predicated by this equation was sufficient to feed each group of sheep *ad libitum*, the intake being 3.0 kg for kadad and 3.4 kg for haraz. However, the intake of the supplement predicted by this equation is subject to large errors and hence should be used with caution. The relationship, which was based on cell wall constituents and intake is fairly consistent in some forages but unpredictable in others (Goering and van Soest,

Table 3. Chemical constituents of supplements and the diet selected by non-lactating sheep in south Kordofan, Sudan during the dry season.

Constituent	Diet	Supplement	
		Dichrostachys cinera	*Acacia albida*
Dry matter	9.34	93.1	94.9
Crude protein	12.3	10.9	16.5
NDF	68.1	53.1	59.2
In vitro dry-matter digestibility	31.5	50.5	43.9
In vitro organic digestibility	28.7	48.1	45.8

Table 4. Performance of non-lactating sheep supplemented with seed pods of Kadad (*Dichrostachys cinera*) and Haraz (*Acacia albida*) in south Kordofan, Sudan during the dry season.

Item	Control	Supplemented	
		Kadad	Haraz
Number of animals	4	4	4
Average weight (initial) kg	31.0	27.8	29.2
Voluntary dry-matter intake:			
g/day	908.6	814.8	855.9
$g/W^{0.75}$	69.2	67.3	68.1
kg/100 kg BW	2.9	2.9	2.9
Crude protein intake:			
g/head/day	111.7	100.2	105.2
$g/W^{0.75}$/day	0.5	8.3	8.4
Supplement/every other day:			
amount offered (g/head)	-	875.0	900.0
intake, (g/head)	-	750.0	850.0
crude protein intake:			
g/head	-	81.8	140.3
$g/W^{0.75}$/head	-	27.0	44.7
Average 7-week weight change (kg)	0.17	0.59^{a}	1.12^{ab}

Means with different superscripts are significantly different.

Supplemented sheep gained more liveweight ($P<0.005$) than the control. The two supplements provided additional N intake of 81.8 g/head by kadad and 140.3 g/head by haraz every other day, and additional energy as well. On the other hand, sheep supplemented with haraz gained more liveweight ($P<0.05$) than sheep supplemented with kadad. The control sheep lost liveweight during the experiment.

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THE EFFECT OF SUPPLEMENTS OF OILSEED BY-PRODUCTS ON THE UTILISATION OF LOW-NITROGEN FIBROUS DIETS BY SHEEP

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ABSTRACT

Four experiments in which native pasture hay and sorghum stover supplemented with varying levels of cotton seed and cottonseed cake conducted with sheep are described.

Experiment 1 investigated the effects of supplementing native pasture hay (predominantly *Pennisetum pedicellatum* with two levels of cottonseed cake (0 and 60 g/kg diet DM) and three levels of cotton seed (0,60 and 120 g/ diet DM) arranged in 2 x 3 factorial using 6 Bali Bali sheep in a 6 x 6 Latin square design. There were increases in the apparent digestibilities of DM ($P<0.001$), N ($P<0.001$) and OM ($P<0.001$) due to the inclusion of cottonseed cake. Cotton seed and cottonseed cake interacted in their effects on the digestibilities of OM ($P<0.05$) and N intakes ($P<0.01$). Cottonseed cake increased both total and grass hay DM intakes ($P<0.01$ and $P<0.05$) respectively. Cottonseed resulted in substitution effects as its level was increased ($P<0.05$).

Experiment 2 investigated the effects of supplements of cottonseed cake without or with (60 and 120 g/g diet DM) cotton seed on the liveweight change of Djallonke sheep fed native pasture hay. Twenty-one rams were grouped into three treatments of 7 animals each in a randomized block design. The animals gained 54, 76 and 74 g/day when 0.60 and 120 g/kg diet DM of cotton seed respectively were combined with the cottonseed cake supplement.

Experiment 3 investigated the effects of supplementing sorghum stover with cottonseed cake at three levels (0,60 and 120 g/kg diet DM) in a double 3 x 3 Latin square design using Bali

Bali sheep. The diets containing cottonseed cake increased the apparent digestibilities of DM ($P<0.05$) and N ($P<0.001$), and total DM intake ($P<0.05$). The inclusion of 60 g/kg diet DM resulted in increases in sorghum stover intake ($P<0.05$).

Experiment 4 investigated the response of Bali Bali sheep in liveweight change to the diets in Exp. 3. Three animals were randomly assigned to each treatment and fed individually. There were progressive increases in liveweight gain ($P<0.05$) but with diminishing differences as the level of cottonseed cake was increased. Cottonseed cake at 60 g/kg diet DM increased daily intakes of total and stover DM. At 120 g/kg diet DM total intake was increased but stover intake reduced.

It is concluded that cottonseed cake supplement at 60 g/kg diet DM substantially improved the intake of both fibrous diets, and was as effective as the high level (120 g/kg diet DM) in liveweight gain. This level of inclusion may also be within the economic reach of the farmers.

INTRODUCTION

There is a heavy concentration of ruminant livestock in the heavily cropped (cereals accounting for 80%, Herman 1983) Soudaninan zone of Burkina Faso. This shift in distribution, particularly during the dry season is mainly due to the relatively abundant cereal crop residues. Although on the decline, there still exists substantial amount of native pasture on fallow land left unutilised by the animals during the long dry season because of its low nutritive components.

Despite the severity of feed deficit in the dry season conservation of herbages is seldom a priority at the smallholder farm level. Conservation of the native pasture in late September, when the requirement of labour for crop production is at its lowest ebb, has enabled harvest of up to 4460 kg/DM/ha of fallow land. This was accompanied with increments in the contents of digestible DM, N and P (by 9.2, 74.5 and 66.7%, respectively), and reduction in NDF and ADF (by 22.3 and 19.5%, respectively) when compared to the standing dry and mature pasture herbage (Yilala, 1986). However, the N content of the conserved herbage (9.0 g.kg DM) remained below the critical level of 11.2 g/kg DM, below which voluntary intake of DM could be depressed (Whiteman, 1980), to be followed by loss of liveweight.

Several studies have shown increased intake (Egan, 1965; Kempton and Leng, 1979; Yilala, 1987) and positive responses in liveweight gain (Kempton and Leng, 1979; Olayiwole and Olorunju, 1987) and retention of N (Egan, 1965; Nuwanyakpa and Butterworth, 1987) when such low-N fibrous diets were supplemented with protein.

By replacing part of fallow pasture with forage or dual purpose legumes and conservation as hay it was apparent that the smallholder farmer could at least be partially self-reliant in the source of nitrogen supplement (Yilala, 1986). Cotton being the principal export crop representing 4% of agricultural land use in Burkina Faso (Herman, 1983) its by products, cotton seed and cottonseed cake, appear to be the cheapest amongst the purchaseable sources of N and energy, and could be complementary to forage legumes (Yilala, 1988a).

This paper describes the results of a series of experiments, in which native pasture hay and sorghum stover were supplemented with N and energy source. The experiments were carried out to study the effects upon sheep of varying the levels of cottonseed cake with or without cottons seed on the apparent digestibilities of nutrients, voluntary intake and liveweight change. The experiments were carried out on 2 ha of farmers' fallow land on which forage was produced and conserved, and the animal shed constructed. Resources that could readily available and are within the economic reach of the farmers were given due consideration in the overall approach. All the animals for the feeding trials were contributed by the farmers and returned at the end of the experiments.

MATERIALS AND METHODS

Experimental Designs

Experiment 1

This experiment was conducted to assess the effect of supplementing native pasture hay (predominantly Pennisetum pedicellatum) with two levels of cottonseed cake (0 and 60 g/kg diet DM) and three levels of cottons seed (0, 60 and 120 g/kg diet DM) on the apparent digestibilities of nutrients and voluntary intake. A 6 x 6 Latin square design, using six Bali Bali sheep, with the treatments arranged in 2 x 3 factorial were used. Due to shortage of grass hay only five periods of 19 days each were conducted, and this reduced the number of replications from six to five.

Experiment 2

The effect of supplements of cottonseed cake without or with (60 and 120 g/kg diet DM) cottons seed on liveweight change of Djallonke rams fed native pasture hay was investigated concurrently with Exp. 1. The twenty-one rams contributed by farmers, were grouped into three treatments of 7 animals each in a randomized block design. The trial was conducted for 42 days.

Experiment 3

The effect of supplementing sorghum stover with cottonseed cake at three levels (0,60 and 120 g/kg diet DM) were investigated to assess the apparent digestibilities of nutrients and voluntary intake. A double 3 x 3 Latin square design using six Bali Bali sheep was used.

Experiment 4

A feeding trial was conducted to investigate the response of Bali Bali sheep in liveweight change to the diets in Exp. 3. Three animals were randomly assigned to each treatment. The experiment had two periods: feeding sorghum stover without (21 days), and with cottonseed cake (63 days including the 7 days for adaptation to the supplement).

Feeding and growth period

Djallonke rams of age 10 to 15 months and weighing approximately 12.4 kg (Expt. 2), and Bali Bali rams aged 18 to 21 months and approximately 45.5 kg (Expt. 4) were used for growth trials. All animals were treated against internal and external parasites.

They were fed native pasture hay (Expt. 2) and sorghum stover chopped to 6 cm in length (Expt. 4) ad libitum in groups and individually, respectively. The total amount of diet offered (i.e. in two feeds given at 10.00 and 16.00 h) was 20% above the daily consumption. The animals were given seven days to adapt to the supplements. They had free access to mineral block licks and drinking water.

Sheep were weighed weekly at about the same time on the same day.

Digestibility

Bali Bali sheep were confined in individual pens partitioned with locally made mud bricks. During each experimental period of 19 days the animals were adapted to the diets from day 1 to day 12. The remaining 7 days were used for voluntary intake measurements and collection of faeces. The basal diets, native pasture hay (Expt. 1) and chopped (6 cm) sorghum stover (Expt. 3), were fed ad libitum (20% above the daily consumption) in two feeds given at 10.00 and 16.00 h. Drinking water and mineral blocks were available at all times.

Faeces were collected into canvas bags harnessed to the sheep. The collection was done every 24 h with a one day lag from intake measurements. Faecal samples (10% of daily output) were air and oven-dried for DM determinations and subsequent chemical analysis.

Statistical analysis

The data were subjected to analysis of variance with the variance partitioned into main effects and interactions in Expt. 4 (Cochran and Cox, 1957).

RESULTS

The chemical composition of the ingredients in the diets is give in Table 1.

Table 1. Chemical composition of feed ingredients used in the trials.

	Average		Composition of DM (%)		
Ingredients	N	P	NDF	ADF	Lignin
Basic					
Native pasture hay	1.04	0.15	57.4	34.5	7.0
Sorghum stover	0.97	0.08	68.1	40.9	7.2
Supplements					
Cotton seed	5.00	1.43	-	-	-
Cottonseed cake	7.68	2.85	-	-	-

Apparent digestibility

As shown in Table 2 (Expt. 1) inclusion of cottonseed cake in native pasture hay based diet significantly improved the apparent digestibilities of DM ($P<0.001$), N ($P<0.001$) and OM ($P<0.001$) and DOMD value ($P<0.001$). Cottonseed also improved the interaction with cottonseed cake (Table 3) and significantly influenced the digestibilities of OM and N, and DOMD value ($P<0.05$, $P<0.01$ and $P<0.01$, respectively). That is, the difference between the observed OM digestibility and DOMD value were largest for the diet containing 60 g/kg diet DM of cottons seed and for N digestibility the diet with 120 g/kg diet DM of cottons seed.

Table 2. Effects of supplements of cottonseed cake and cotton seed on the apparent digestibility of nutrients and voluntary intake of native pasture hay by Bali Bali sheep.

	Main effects							Significance of effects[2]	
	Cottonseed cake (g/kg diet DM)			Cotton seed (g/kg diet DM)					
	0	60	s.e.d[1]	0	60		s.e.d	Cake	Seed
Digestibility (%)									
DM	63.7	68.9	1.10	61.9	68.4	68.5	1.30	***	***
OM	64.3	70.6	1.18	64.8	68.8	68.6	1.45	***	*
DOMD	56.3	61.6	1.00	56.2	60.1	60.5	1.20	***	**
N	58.2	74.2	1.15	55.6	66.6	76.6	1.41	***	***
Intake (g/day)									
Total	1329	1551	52.28	1375	14.60	1485	60.03	**	ns
Hay	1147	1274	56.82	1309	1261	1130	69.59	ns	ns

[1] Standard error of difference

[2] ns = not significant, * = P<0.05, ** P<0.01 and *** = P<0.001

Table 3. Effects of interaction of cottonseed cake and cotton seed on the apparent digestibility of organic matter, nitrogen and DOMD (in %).

	Cottonseed (g/kg diet DM)			
Cottonseed cake	0	60	120	s.e.d.
<u>0 g/kg diet DM</u>				
OM	60.4	63.8	68.7	2.10
DOMD	52.3	55.8	60.7	1.67
N	43.8	56.9	74.2	2.00
<u>60 g/kg diet DM</u>				
OM	69.3	73.8	68.5	2.10
DOMD	60.1	64.4	60.3	1.67
N	67.4	76.3	78.3	2.00

Significant effects were also observed in the apparent digestibility of DM ($P<0.05$) and N ($P<0.001$) and DOMD value ($P<0.001$) in animals receiving diets containing both levels of cottonseed cake in the sorghum stover based diets (Table 4, Expt. 3).

Table 4. Effects of supplement of cottonseed cake on apparent digestibilities of nutrients and voluntary intake of sorghum stover fed to Bali Bali sheep.

	Cottonseed cake (g/diet DM)				Significance of effects
	0	60	120	s.e.d	
Digestibility (%)					
DM	59.2	72.5	71.2	1.83	*
DOMD	50.6	61.4	59.1	0.57	***
N	39.6	71.6	75.7	2.44	***
Intake (g/day)					
N	7.2	19.8	28.6	0.82	***
Total DM	964	1410	1265	40.9	*
Stover DM	964	1278	1001	40.9	*

Voluntary intake

Inclusion of cottons seed in Expt. 1 increased total and grass hay DM intakes ($P<0.01$ and $P>0.05$, respectively). Cottonseed showed a slight increase in total DM intake ($P>0.05$) and a progressively decreasing hay intake as its level was increased ($P>0.05$) as shown in Table 2.

Both levels of cottonseed cake in the sorghum stover based diets (Expts. 3 and 4) also led to significant increases in total DM intake ($P<0.05$, Table 5 and $P<0.05$, Table 6, respectively). However, animals receiving the diets containing 60 g/kg diet DM of cottonseed cake showed the greatest intakes in total DM ($P<0.05$ and $P>0.05$) and stover DM ($P<0.05$ and $P>0.05$) in Expts. 3 and 4 respectively.

Liveweight change

The results of liveweight gain (Tables 5 and 6) showed a high coefficient of variation. This might be associated with the problems of competition in group feeding whereas liveweight measurements were made individually (Expt. 2). The inadequate replications might be responsible for the large variation in Expt. 4.

In Expt. 2 the difference in liveweight gain failed to reach significance at $P<0.05$. The liveweight gain within treatments varied between 14 and 100, 55 and 95, and 36 and 110 g/day for treatments A, B and C respectively. The greatest liveweight gain was obtained from the diet containing 60 g/kg DM cottonseed cake + 60 g/kg DM cottons seed.

Table 5. Effects of supplementing native pasture hay with cottonseed cake and cottons seed on average daily intake and liveweight change of Djallonke rams.

	Cottonseed cake (g/kg diet DM)				Statistical significance (P=0.05)
	60				
	0	60	120	s.e.d.	
Intake[1]					
DM (g/kg/day)	497	483	477	-	-
Liveweight change:					
Initial weight (kg)	12.4	11.7	11.7		
Final weight (kg)	14.6	14.9	14.8	0.77	ns
Weight gain (g/day)[2]	54	76	74	14.5	ns
Supplement cost					
USD/hd/day	0.47	0.81	1.19		
USD/100 g LWG[3]	0.88	1.07	1.60		

[1] Calculated from average group daily intake

[2] Coefficient of variation = 37.7%

[3] Liveweight gain

Although not statistically significant (at P=0.05) there were progressive increases in liveweight gain, but with diminishing differences as the level of cottonseed cake was increased in Expt. 4 (Table 6). This rate of liveweight gains during the first 14 days of the supplement were greater (P>0.05) than in the subsequent period.

Table 6. Effects of supplement of cottonseed cake on voluntary intake and liveweight change of Bali Bali sheep fed on sorghum stover.

	Cottonseed cake (g/kg diet DM)				Significance of effects
	30	60	120	s.e.d	
Intake					
Total DM (g/day)	896	1047	1043	382.6	*
(g/kg LW)	18.6	21.8	22.3	1.11	*
Stover DM (g/day)	806	915	773	38.3	ns
Nitrogen	13.7	21.8	28.8	0.28	***
Liveweight change					
Pre-supplementation					
Liveweight gain (g/day)	101	135	108	116	ns
Supplementation					
Initial liveweight (kg)	47.6	46.7	45.3		
Final liveweight(kg)	48.8	49.7	48.7		
Liveweight gain(g/day)					
days 1 to 14[1]	33.3	71.8	109.7	45.30	ns
days 1 to 56[2]	23.8	53.6	60.7	15.30	ns
Food conversion ratio	37.6	19.4	17.2	6.17	*
Supplement cost					
USD/hd/day	0.61	1.23	1.65		
USD/100g LWG	2.7	2.3	3.0		

[1]Coefficient of variation = 36.0%

[2]Coefficient of variation = 44.5%

DISCUSSION

The low and progressive decline in the intake of sorghum stover prior to supplementation during the first 3 weeks, and the increase during supplementation (Expt. 4) confirms the importance of availability of a source of N for effective utilisation of the stover. This effect might be associated with increased rate of fermentation in the rumen (Mehrez and Orskov, 1978) or improved N status of the animal (Egan, 1965) or both.

The aim of supplementation was to create the conditions that will allow increased intake of the low - N fibrous diet and not substitution by the supplement. Based on the DM intake of the Control group (i.e. without supplements) substitution effects of the supplement were calculated according to the ARC (1980). With the inclusion of cottonseed cake at 60 g/kg diet DM (4.8 g N/kg DM) intake of native pasture hay and sorghum stover increased at the rate of 1.80 and 2.8 units, respectively (Appendix Table I). No substitution effect were observed due to cottons seed at 60 g/kg diet DM without or with cottonseed cake. In another study increased sorghum stover intake was achieved with 200 g cowpea hay/kg diet DM, i.e with 5.2 g N/kg DM (Yilala, 1988a). With the doubling of level of cottonseed cake (except in Expt. 3), cottons seed and cowpea hay substitution effects were observed (Appendix Table I).

These was a progressive fall in liveweight during the 3 weeks prior to supplementation (Expt. 4). However, during the first 14 days of cottonseed cake supplementation, animals receiving 60 and 120 g/kg diet DM gained 52 and 230% more, respectively, than those on 30 g/kg diet DM. This possibly indicates the occurrence of compensatory growth in response to the relatively low N status prior to supplementation.

Due to the high coefficient of variation the author is cautious to draw definitive conclusion from the results obtained. However, considering the evidence from other studies (Orskov et al, 1976; Hovell et al, 1983; Yilala and Bryant, 1985) in which changing animals from low to high protein diets resulted in compensatory growth, the finding in this study does not sound atypical.

There are two reasons for emphasizing this point: (1) Since there appears to be a decline in the rate of liveweight gain with time it may not be necessary to include the same amount of protein supplement in the diet during compensatory growth and subsequent periods. (2) Under the observed farm conditions the poor nutritional status of animals during the long dry season is apparent. Therefore, taking advantage of the relationship between the residual effects of previous low N status and possible greater retention of N during the first few weeks of supplementation is of paramount importance. This will have important implication in the efficiency of utilisation of the limited sources of N that are at the disposal of the smallholder farms.

The effects of cottonseed cake and cottons seed were additive (Expt. 2). The highest response in liveweight gain was obtained from the diet containing 60 g/kg diet DM cottons seed, but with no extra advantage when the level was increased to 120 g/kg diet DM. The diminishing increase in the overall pattern of liveweight gain when the level of cottonseed cake was increased (Expt. 4) might suggest that energy was limiting. The acetate type of fermentation that predominates in the stover based diet might have resulted in low production of the glucogenic propionic acid (Leng, 1982). This inadequacy of energy reducing the effectiveness of high level of N for increased retention may be a possible explanation (Yilala and Bryant, 1985).

Considering the cost of supplement/100 g liveweight gain and rate of increase in the intake of fibrous diets, the supplementary value of cottonseed cake at 60 g/kg DM is more preferred than the other levels. The economic benefits realized from the supplementation of crop residues are mostly assessed based on the balance between the biological outputs (in terms of liveweight gain) and the costs of purchased inputs and labour.

Appendix Table 1: Replacement rates of the fibrous diets by supplements of cotton seed, cottonseed cake and cowpea hay fed to Bali Bali sheep.

Source of data	Nitrogen supplement Source	Nitrogen supplement Amount (g/kg/diet DM)	Energy supplement Source	Energy supplement Amount (g/kg diet DM)	Hay/stover intake (g/day)	Replacement rate
Experiment[a]						
1		(0		(0	1191	0
	Cottonseed	(0		(60	1248	+0.43
	cake	(0	Cottonseed	(120	1152	-0.15
		(60		(0	1428	+1.80
		(60		(60	1276	+0.32
Experiment[a]		(60		(120	1118	-0.18
2		(0			964	0
	Cottonseed	(60			1276	+2.78
	cake	(120			1001	+1.14
Yilala (1988)[b]		(0			1169	0
	Cowpea	(200			1190	+0.10
	hay	(400			1149	-0.25

[a] Basal diets in Experiments 1 and 2 were native pasture hay and sorghum stover, respectively.

[b] Basal diet was sorghum stover

Table 8. Estimated quantity of dry matter, organic matter, nitrogen, phosphorous ansd potash in feed refusals and faeces of sheep[1] fed sorghum stover supplemented with cottonseed cake and cowpea hay.

Source of data	Supplement	Feed refusals (kg/hd/yr)			Faecal output (kg/hd/yr)				
		DM	OM	N	DM	OM	N	P	K_2O
Expt. 3	Cottonseed cake (g/kg diet DM)								
	0	62	54	0.5	100	111	1.9	0.19	0.59
	60	91	78	1.9	127	109	2.1	0.90	2.26
	120	82	62	2.4	160	137	2.4	1.49	3.00
Yilala (1986)	Cowpea hay (g/kg diet DM)								
	0	69	62	0.5	153	130	2.1	0.23	1.2
	200	93	74	0.7	152	112	3.0	0.27	1.3
	400	94	75	0.7	140	119	3.0	0.28	1.5

[1] Bali Bali sheep with average liveweight of 45.2 kg during the experimental periods

This may not be adequate for an integrated crop-animal system where inputs are generated within the system. This holds true in most smallholder farm conditions.

Assessement of economic benefits under such conditions may have to consider aspects of recycling of nutrients in which nutrient outputs of the crop component (through crop residues) serve as nutrient inputs to the animal, and vice versa (through manure). To serve as an example, the quantity of DM and nutrients that could be available for composting (for soil fertilisation) were estimated from the daily feed refusals and daily faecal output of sheep fed sorghum stover with supplements of cottonseed cake and cowpea hay (Appendix Table II). The increase in the contents, for example, of phosphorus (P) in the faeces of sheep fed diets containing cottonseed cake is of paramount importance to conditions of poor soil P status in the Soudanian zone of Burkina Faso. It is, of course, assumed that the cottonseed cake might have adequately supplied P and satisfied the needs for the synthesis of microbial nucleic acids in the rumen (Harrison and McAllan, 1980).

For a technology to be accepted it must be able to fit into the objective conditions of the target farms. Farmers do recognise that creating favourable nutritional conditions will improve the performance of animals. However, the conditions that they could create are limited by their economic stand. The purchase of inputs such as protein or energy supplements in most cases is beyond their economic reach, particularly when one considers the need to supplement during the long dry season as in the case of Burkina Faso. Any research work targeted to smallholder farmers should be deliberately biased towards the utilisation of on-farm or locally available resources that could be readily available to and are within the economic reach of the farmers in the overall approach of this and other studies.

The supplements of cottons seed and cottonseed cake in this study are considered as complementary supplements to forage legumes particularly for the latter part of the dry season feeding. Encouraging results were obtained when Djallonke ewe lambs were fed native pasture hay supplemented with on-site produced cowpea hay for five months followed by cottonseed cake for two months during the dry season. The animals gained up to 19 and 40 g/day liveweight on supplements of cowpea hay and cottonseed cake, respectively (Yilala, unpublished data), during this period when loss of liveweight is a common phenomenon.

The feeding in pens for such long period, a break away from the traditional method, was accompanied with increased collection and improved management of manure and feed refusals to make compost. Organic matter is an indispensable resource that is highly valued by the farmers to increase and maintain soil fertility. With the application of compost (made from sheep faeces, feed refusals and some Burkina rock phosphate) at 10 tons/ha it was possible to increase the yield of cowpea forage DM from 2858 to 7751 kg/ha (Yilala, 1989b). Such benefits cannot,
Appendix Table II. Estimated quantity of dry matter, organic matter, nitrogen, phosphorus and potash in feed refusals and faeces of sheep [1] fed sorghum stover supplemented with cottonseed cake and cowpea hay
therefore, be ignored when input-output relationships are examined to assess the economic benefits realized from the supplementation of crop residues. The method of analysis might become more complex when the source of supplement is a forage or dual purpose legume grown on-farm.

CONCLUSION

The following conclusions may be drawn from the study:

1. The low N - fibrous diets, native pasture hay and cereal crop residues, will remain to be the major sources of metabolizable energy (ME) for ruminants in Burkina Faso. The study has undoubtedly confirmed that cottonseed cake, the cheapest among the purchasable sources of N in the country, has improved the utilisation of the above sources of energy through increased digestibility and voluntary intake.

2. The findings suggest that sheep managed in the conventional way prior to supplementation respond positively to protein supplements in liveweight gain consistently. The rapid rate of growth during the first 14 days of supplementation might be

as a result of the residual effects of the previous low N - status of the animals.

3. The further improvement of liveweight gain when cottons seed was added to the cottonseed cake might indicate the importance of increasing the ME intakes of the animals too, although no extra advantage was realized in liveweight gain by doubling the level of cottons seed.

4. For every unit of inclusion of cottonseed cake at 60 g/kg diet DM (4.6 g N.kg DM) the intakes of native pasture hay and sorghum stover were increased by 1.80 and 2.78 units, respectively. The same level of cottonseed cake in the diet was as effective as the high level (120 g/kg diet DM) in terms of liveweight gain. It is possible that the 60 g/kg diet DM of cottonseed cake may also be within the economic reach of the farmers.

5. The high content of P in cottonseed cake might have possibly helped correct the deficiency of P in both native pasture hay and sorghum stover for rumen microbial protein synthesis. It appears that it can also increase the soil P status. Such indirect contributions of protein supplements may need to be considered in the analysis of economic benefits.

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USE OF SORGHUM BRAN AND GROUNDNUT HAULMS IN SORGHUM STOVER BASED DIETS FOR CROSSBRED COWS

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ABSTRACT

Results are reported of a feeding trial in 1986/87 in which a total of 62 half-bred Simmental (SX), three-quarter Simmental (SSX) and half bred Friesian (FX) milking cows were fed sorghum stover supplemented with sorghum bran, groundnut haulms or *Lablab purpureus* hay.

During the wet season animals were grazed under conditions similar to communal areas situation.

Average milk yields per lactation (kg) for SX, SSX and FX were 702.5, 739.0 and 825.5, respectively, and did not differ significantly (P<0.05): neither were there significant differences in duration of lactation between or within breeds fed the different diets. Average dam liveweight at parturition and at 7 and 10 months post-partum were 480, 470, 483 kg for SX; 483, 456 and 466 kg for SSX; and 465, 459 and 452 kg for FX respectively. Differences were not significant (P<0.05). Average birth weights and adjusted 7 and 10-month liveweights of SX calves were 38 kg, 178 kg, 216 kg, of SSX calves 36, 154 and 200 kg and of FX calves 36, 148 and 206 kg. Diet supplementation with sorghum bran did not result in differences in calf liveweight gains within or between breeds.

During the lactation period 7 of the cows and 5 calves died. 40% of calves born suffered from Kerato conjuctivitis, but later recovered after treatment.

INTRODUCTION

In order to reduce large quantities (75%) of fresh milk and milk products imports the government of Botswana livestock research policy continues to place emphasis on the need to increase fresh milk production locally (National Development Plan VI 1985). The variable rainfall pattern in Botswana leading to seasonal milk production hampers commercial dairying. It has been suggested that a dual purpose beef/milk breed of cattle is more appropriate particularly to resource-poor small-scale farmers than specialized milk breeds. Past research has shown that these farmers can produce more milk by keeping Simmental crosses and feeding them crop residues, Lablab (*Lablab purpurues*) hay and sorghum bran (APRU 1986). The Tswana/Tuli breeds of cattle have limited potential for milk production.

Farmers in Botswana produce reasonable amounts of crop residues even during drought years (Appendix I). Most of this crop residue is left in the field and used randomly or indiscriminately by livestock with part of it being trampled by the animals or ploughed under by some farmers resulting in wastage of available feed resources. These residues can have an important impact on animal production if they are conserved as soon as the grain is harvested. At this stage the yield and nutritive value is relatively high (Mosienyane, 1983). In addition to crop residues there are large quantities of Agro-industrial by-products available for livestock in Botswana (Appendix II). Generally, crop residues are low in nutritional value. Even the ruminant livestock are not able to extract energy in sufficient amounts per day to grow or produce milk when fed these plant materials (Anderson, 1978, Said, and Wanyoike, 1987, Dzowela, 1987). Thus there is need to supplement these materials with feedstuffs of higher protein and energy content.

Natural range deteriorates in nutritive quality and quantity during the dry season with protein being the most limiting factor (APRU, 1972). In order to maintain productivity protein supplements must be fed during dry seasons. The relatively more available protein sources are lablab hay, legume crop residues (cowpeas and groundnut) and sorghum bran from sorghum milling.

On-farm and on-station trials have demonstrated that, under drought conditions (Appendix III) lablab can yield up to 3.0 tons/ha dry matter.

Supplements evaluated in these experiments were sorghum bran, groundnut haulms, lablab hay and dairy concentrate. Dairy concentrate consisted of 2 parts sorghum bran and one part sunflower meal.

The objectives of the study were:

- to evaluate the productivity of half-bred Simmental (SX), three quarter-bred Simmental (SSX) and half-bred Friesian (FX) crosses as dual purpose animals under grazing conditions simulating the situations that exist in small-scale communal areas.

- to examine the effect of various protein supplements on Simmental and Friesian crossbreds fed sorghum stover based diets during the dry season.

METHODOLOGY

Sixty two cows consisting of half-bred Simmental (SX), three quarter bred Simmental (SSX) and half-bred Friesian (FX) crosses were used in the feeding experiment.

The base breed was Tswana/Tuli cows. Each breed was divided into 2 groups and fed different supplements. Supplements used were sorghum bran, groundnut haulms, lablab hay and dairy concentrate. All cows were left to graze and fed sorghum stover ad libitum. Animals had free access to a mineral mixture consisting of either bone meal:salt (1:1 ratio) or dicaldium phosphate:salt (1:1 ratio).

Sorghum bran was fed at 1 kg/kg of milk produced while dairy concentrate was fed at 0.5 kg/kg of milk produced. Groundnut haulms and lablab hay were mechanically chopped to facilitate ease of handling and reduce wastage. Both supplements were fed to meet approximately the requirement of a 450 kg cow producing 5 kg of milk/day of 3.5% butterfat in terms of total digestible energy and crude protein (NRC 1978). Cows fed groundnut haulms received 5 kg/day and cows fed lablab hay received 3.5 kg/day.

Cows were milked by hand twice daily (06.00 and 15.30 hours) with calves present to stimulate milk let-down through initial suckling for approximately 1 minute. Calves were left to suckle for 30 to 60 minute after milking.

Calves born to these cows were divided into 2 groups. Calves in group 1 were each supplemented. All calves had access to grazing in a separate calf paddock.

Milking stopped when a cow produced less than 3 kg milk per week. Calves were weaned at the end of lactation.

Routine vaccinations against brucellosis, anthrax, blackquarter, botulism and pasteurella; deworming and spraying against ticks were administered. All calves were vaccinated against calf-paratyphoid within 7 days after birth.

The following were kept:

- daily milk yield
- calf birth weights, 7 months and 10 months liveweights
- cow weight at parturition, 7 months and 10 months postpartum
- breeding

Samples of individual dietary supplements and sorghum stover were taken and analysed in duplicate for dry matter, organic matter, crude protein, crude fibre, ash, according to methods approved by AOAC (1985) and *in vitro* dry matter digestibility (IVDMD) and organic matter digestibility (IVOMD) according to procedures by Tilley and Terry (1963).

Statistical analysis using the t-test (Snedecor and Cochran, 1967) was conducted on the data obtained from lactating cows and calves that completed the trial.

RESULTS

Chemical analysis results showed that crude protein percentages were 9.3, 11.5, 19.9, 16.4 and 6.4 in groundnut haulms, sorghum bran, dairy concentrate, lablab hay, and sorghum stover respectively (Table 1).

Table 1. Chemical composition of the feedstuffs used in the experimental diets.

Item	Composition of dry matter %				*In vitro*	
	Organic matter	Crude protein	Crude fibre	Ash	DMD	OMD
Sorghum bran	97.3	11.5	3.2	2.7	54.4	47.2
Groundnut haulms	90.5	9.3	24.3	9.5	55.0	50.3
Sunflower meal	92.8	36.5	21.4	6.7	55.8	54.0
Lablab hay	90.8	16.4	27.7	9.2	59.9	57.1
Sorghum stover	9.16	6.4	32.5	8.4	59.8	54.8
Dairy Conc.[1]	95.8	19.9	9.2	4.0	54.9	49.4

[1] two parts of sorghum bran to one part of sunflower meal

Table 2 shows the mean milk yield and lactation length of cows used in the study. Amongst different breeds supplemented with sorghum bran the half-bred Friesian crosses (FX) had the highest mean milk yield (827 kg), compared to half-bred Simmentals (SX) (740 kg) and three-quarter bred Simmentals (SSX) (762 kg). Mean lactation length for SX, SSX and FX supplemented with sorghum bran were 36, 30 and 34 weeks respectively. However, there was no significant difference ($P<0.05$) in milk yield and mean lactation length between different breeds supplemented with sorghum bran only. Half-bred Friesians supplemented with groundnut haulms produced 824 kg over a 36 week lactation period.

Overall average milk yields (kg) for SX, SSX and FX (excluding milk left over for calf) were 702.5, 739.0 and 820.5 respectively, but did not differ significantly ($P<0.05$). There were no significant differences in duration of lactation between or within breeds fed the different diets.

Table 2. Mean milk yield and lactation length of half-bred Simmental (SX), three-quarter Simmental (SSX) and half-bred Friesian crosses (FX) fed sorghum bran (S), dairy concentrate (D), lablab hay (L) and groundnut haulms (G) as supplements.

Breed	Supplement	Number of cows	Mean milk yield (Kg)	Lactation length (weeks)
SX	S	9	740±246	36±6
SSX	S	8	762±132	30±6
FX	S	6	827±257	34±5
SX	L	10	665±240	30±8
SSX	D	10	716±328	30±9
FX	G	7	824±208	36±8

Average parturition weight was above 450 kg for all cows used in this study (Table 3), and similar for all breeds. There was also no significant difference ($P<0.05$) in 7 and 10 months post-parturition weights for the three breeds supplemented with sorghum bran although the SX cows tended to gain weight, while the SSX lost weight at 7 months post-partum, but maintained weight thereafter. The FX cows tended to gain weight at 7 months, but lost weight at 10 months post-partum. Amongst the SX groups, those fed sorghum bran were significantly heavier ($P<0.05$) than those fed lablab hay at 10 months post-partum.

Table 3. Mean dam parturition weight, 7 and 10 months post-partum liveweights (Kg) of half-bred Simmental (SX), three-quarter Simmental (SSX), and half-bred Friesian crosses (FX) fed sorghum bran (S), dairy concentrate (D), Lablab hay (L) and Groundnut haulms (G) as supplements.

Breed (Kg)	Supplement	Number of cows	Parturition weight (kg)	7 month weight (Kg)	10 Month weight (Kg)
SX	S	10	486±46	490±73	512±50
SSX	S	10	490±52	465±50	469±35
FX	S	6	458±38	470±50	458±53
SX	L	11	473±46	449±27	454±29
SSX	D	13	476±46	446±40	462±65
FX	G	9	472±52	448±36	446±26

($P<0.05$)

Overall the liveweights of the crossbreds fed the different supplements tended to decrease during the lactation period.

Table 4 shows the mean calf liveweights at birth, 7 and 10 months according to calf diets and dam. Calf birth weights were similar across breeds. There were no significant differences ($P<0.05$) in liveweight gains between calves supplemented with sorghum bran and those not supplemented. This may be due to adequate suckling and a light stocking rate for all calves in the calf paddock. Therefore supplementation did not result in increased liveweight gains. Average calf liveweights at 7 and 10 months indicate that calf growth was satisfactory.

Table 4. Mean birth weights 7 and 10 months liveweights (Kg) of calves according to dam breed and supplement.

Month Breed (Kg)	Number of calves	Supplement	Calf birth weight (kg)	7 month weight (Kg)	10 Month weight (Kg)
SX	9	S	36±4	174±42	210±50
SX	10	nil	40±6	183±33	223±33
SSX	8	S	37±5	149±23	211±29
SSX	14	nil	35±8	160±33	190±26
FX	8	S	36±5	146±33	217±36
FX	5	nil	36±3	151±41	194±46
All	27	S	36±4	155±35	212±41
All	29	nil	37±7	167±30	204±34

There were several cases of kerato conjunctivitis, cancer eye and sweating sickness. Kerato conjunctivitis and cancer eye were more likely to occur in calves with unpigmented eye surroundings. Provision of shade and reduction of dust reduced the occurrence of eye diseases.

Seven cows died in the trial period. The causes of mortality by breed and diet were:

Three SX cows supplemented with lablab; one due to abscess in the jaws, and two due to undiagnosed diseases.

Three SSX fed dairy concentrate; one due to calving difficulty, and two due to wire ingestion, resulting in penetration to the heart via the rumen cud.

One SSX cow supplemented with sorghum bran was killed by thieves.

Seven cases of stillbirths were recorded
Two from SX cows fed lablab
Two cases from SSX cows fed sorghum bran
Two cases from SSX fed dairy concentrate

Six of these stillbirths occurred between September 1987 and November 1987. Although specimen samples were submitted, veterinary diagnostic reports did not show any disease causing stillbirths.

Five calves died.

Three from SX cows; one due to a broken leg, one due to sweating sickness, and one due to diarrhoea.

SSX cows lost two calves; one killed by thieves and one due to weakness which resulted from lack of colostrum milk and death of the dam.

Kerato conjuctivitis infected 40% of all calves born. The disease occurred mostly between December 1987 and April 1988, which coincided with the longest day length and relatively higher seasonal rainfall.

DISCUSSION

The nutrient content of sorghum stover is low, hence this feed fed alone is not sufficient to maintain an animal let alone production of milk unless it is supplemented with feed sources of higher nutrient quality and quantity.

Large quantities of sorghum bran and other agro-industrial by-products are available in Botswana, and are less costly compared to dairy concentrates imported from neighbouring countries. More interest is developing in the agricultural sector to try to use these by-products to supplement crop stover or grass hay-based diets. Most of the agro-industries are situated in and around urban areas, where most of the fresh milk consumers are situated. This makes it convenient for some small-scale dairy farmers around urban areas to buy and utilise these by-products by feeding them to dairy animals.

The variation in milk yield within breeds and across breeds could be due to the fact that the base breed, Tswana or Tuli, has not historically been selected for milk production. There were also not sufficient numbers of cows per treatment.

The mean milk yield for the Friesian crosses was higher than that of other breeds, reflecting the high milk potential of the pure Friesian cows if kept under good management conditions.

With daily milk production of about 3.0 kg/cow/day (excluding milk taken by the calf), and at the current producer price of P 0.70/kg (US $ 0.36), a farmer would make about P 2.10/cow/day (US $ 1.07) less costs. On-farm feeding trials showed that the average daily milk production values obtained from half-bred Simmental crosses fed lablab hay and sorghum bran under similar management conditions were 3.1 kg and 3.4 kg respectively (APRU 1987), while the Tswana cows on similar diets produced 1.4 kg and 1.6 kg respectively. The average lactation length for SX (285 days) was longer than that for Tswana cows (202 days). On average SX cows produced 12.8 times more milk per lactation than Tswana cows. Therefore the rationale for using dual-purpose animals such as Simmental crossbreds in this type of production system is justified.

The fact that, on average, cows fed the supplements maintained weight during the lactation period is essential for dual-purpose beef/dairy cows such as the crosses used in this study. The crossbred steers could be sold to the already well established Botswana Meat Commission (BMC) at premium prices. This would compensate for the relatively low milk yield in crossbreds compared to that of pure-bred cows. If locally available protein and energy rich materials such as lablab hay and sorghum bran could be incorporated in a dairy diet, milk production could be increased. Lablab hay and crop residue could be produced on-farm with low inputs; the major cost being the cost of labour for harvesting and storage. Sorghum bran which is also produced on-farm and from Commercial Sorghum Mills appears to be an adequate alternative to imported expensive concentrates in this production system (APRU 1986).

It was not easy to quantify the amount of milk suckled by the calf during milk let-down and after milking. Non significant differences ($P>0.05$) in calf weights of the non supplemented and supplemented groups could be due to enough grazing in the calf paddock, light stocking rate and reasonable amount of milk consumed by the calf. Most of these calves were calved after the drought. With green lush pastures and reasonable amount of milk consumed by the calf one would expect the sorghum bran supplement would have little effect in improving liveweight gains.

By using locally available materials as feedstuffs for their livestock, farmers would not only be helping our developing industries but they would be fulfilling the national objective of self-sufficiency in food production. More farmers are expected to engage in arable crop and dairy production knowing they have industries and consumers where they can sell and have their produce to be processed. This will not only reduce the enormous importation but also reduce the unemployment problem.

Farmers are encouraged to form co-operative societies. These help dairy farmers to work together as a group, have milk collection points and thus reduce the cost of each individual farmer transporting his milk daily to the milk packaging and processing centres. Through Financial Assistance Policy (FAP) and other government programmes both the individual and co-operative farmers can get financial help from the government to improve their farming enterprises and thus their welfare.

Although research/extension linkages are not as strong as they ought to be, linkages are established through meetings held periodically. At these meetings extension staff brief researchers on problems in the field and researchers brief extension staff on what research programmes are currently conducted on-station as well as on-farm.

Research results and recommendations are published and distributed to extension staff and farmers through Agrifacts - a paper printed by Agricultural Information, of the Ministry of Agriculture.

Although the government tries to protect local farmers from outside market influx by issuing import permits, this has not been easy for the planners. One of the reasons is that farmers do not inform the planners of the amount of milk produced on a regular basis.

In addition to on-station research, a Small-Scale Dairy Project was initiated in 1985/86 to encourage milk production in peri-urban areas. At the moment the project is working with about 46 dairy farmers around Gaborone (DPR, 1987). The project has been collecting and interpreting data on the technical and economic viability of introduced Simmental crossbreds fed crop by-products based diet and supplemented with legumes fodders (Lablab hay) and/or sorghum bran. The milk yield data obtained from on-farm trials with 40 dairy participating farmers (1986/87) have been similar to those obtained from on-station trials. The on-station trails reported in this paper will therefore complement trials currently conducted in on-farm situations. The success of on-station trials will depend on the adoption of the technologies by farmers. The pilot dairy project will be the basis for establishing dairy herds throughout Botswana.

CONCLUSIONS

Dry season feeding based on available farm crop stovers, supplemented with high crude protein lablab hay, groundnut haulms and milling by-products such as sorghum bran, is a practical approach for feeding lactating and in-calf cows in small-scale farm situations. These by-products are widely available on small-scale farms in Botswana.

Dual purpose Simmental x Tswana crossbreds require less management, health care and feed than pure bred dairy animals. In addition to increased milk yield, these animals can be sold at premium prices for beef as well as for use as draught animals.

There were no differences (P<0.05) in milk yield per lactation between half-bred Simmental (702.5 kg), three quarter Simmental (739.0 kg), and half-bred Friesian (825.5 kg), fed stover-based diets supplemented with either sorghum bran or lablab hay, groundnut haulms or dairy concentrate (sorghum bran:sunflower meal, 2:1 ratio). There were, however, variations within SX and SSX breeds supplemented with different diets.

Management of lactating cows, in-calf cows and calves, milking, animal health and record keeping procedures were appropriate to small-scale dairy farm conditions. The management system was adopted by participating dairy farmers.

Forty percent of all Simmental calves born were infected with Kerato conjuctivitis but later recovered after treatment with Terramycin.

Calf growth in half-bred Simmental, three quarter Simmental, half-bred Friesian were similar. During the trial, calves did not respond to sorghum bran supplementation, indicating that the quantity of milk suckled, and grazing conditions were adequate.

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Appendix I. Average production of different crop residues obtained during favourable rainfall and drought years in Botswana.

	Favourable rainfall (1980-1981)		Drought years (1982-1986)	
Crop residues (MT)	Area harvested (Ha)	Prodn (MT)	Area harvested (Ha)	Prodn (MT)
Sorghum stover	127.0	57.0	60.0	18.4
Maize stover	53.0	34.0	13.0	11.0
Millet stover	14.0	5.0	8.0	1.9
Pulses (beans)	14.0	5.0	4.0	0.9
Groundnuts	4.0	3.4	1.0	1.1

Source; Agricultural Statistics Unit (1986).

Appendix II. Total production per year of different agro-industrial by-products in Botswana.

By-products		Production (MT.DM)
Sorghum bran		14,800
Brewers' grain[1]	(Barley-spent grain)	780
Brewers' grain[2]	(Sorghum/maize-spent grain)	2,128
Wheat bran		5,544
Hominy chop		10,000
Meat meal		2,949
Blood meal		318
Bone meal		1,031

[1] spent grain from beer malt brewing

[2] spent grain from "chibuku" malt brewing

Sources: Sorghum Milling Co. Kgalahari Breweries, Botswana Breweries, Bolux Milling Co., Botswana Meat Commission, Personal communication.

Appendix III. Average rainfall in Botswana during normal and drought years.

Year	Average rainfall (mm)
1979	399
1980	412
1981	555
1982	373
1983	332
1984	302
1985	321
1986	442
1987	389

Source: Rainfall Unit, Department of Meteorological Services, Ministry of Works, Transport and Communications, personal communication.

PARTIAL REPLACEMENT OF MAIZE WITH GRADED LEVELS OF CORN COBS IN PIG WEANER/GROWER DIETS

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ABSTRACT

A study was carried out to investigate the effect of graded levels of corncobs as partial replacement of maize on the performance and carcass quality of weaner-grower Landrace pigs. Thirty two Landrace weaner pigs averaging 16.02 kg, initial liveweight were randomly assigned to four treatments with two replicates (2 females and 2 castrates/replicate) in a completely randomized design. Corn cobs were included at the levels of 0%, 10%, 20 and 30% in isoproteinous diets. The pigs were given feed on concrete floored pens and watered <u>ad libitum</u> through automatic nipple drinkers during a 12-week experimental period. Two pigs from each treatment (1 female and 1 castrate) were slaughtered for grading at the end of the experiment. Results showed significant differences ($P<0.05$) between treatments in average daily feed intake, daily weight gains and feed/gain ratios. When used up to 20%, corncobs offer the most efficient and cost-effective diet for pigs. When properly publicized, this ration can cut down feed cost to farmers.

INTRODUCTION

Increasing feed costs due to competition between man and animals for cereal grains has stimulated interest in ways of making use of agricultural by-products in the diets of monogastrics and ruminants. The North West and Western Provinces of Cameroon produce 3,080 metric tons of farm residues (corn stover, corncobs, rice straw, rice bran etc) annually (Fomunyan, 1984).

Corncobs a widely available crop residue that when treated and used in pig feeding, it could reduce the cost of production and improve the quality of their carcasses.

Studies on ways of improving the digestibility of the high fibre content in corncobs abound in the literature. Beckman (1921) and Burrow (1980) (cited by Sundstol, 1981) have used several treatment methods (physical, alkali and microbiological to improve the digestibility of corncobs. These three main bonding methods are aimed to break the ligno - cellulose bonding thus increasing the digestibility of the roughage. Babatunde *et al* (1975) has recommended a level of up to 15% of corncobs in pig grower finisher diets. It was the aim of this study to see to what extent corncobs can efficiently replace corn in pig weaner/grower diets.

MATERIALS AND METHODS

Dried corncobs used in this study were collected from the Institute of Agronomic Research (IRA), at Bambui Station. The corncobs were ground into a meal and included at the levels of 0% (control group), 10%, 20% and 30% in isoproteinous diets (Table 1).

Thirty-two weaner landrace pigs averaging 16.02 kg liveweight were randomly assigned to 4 treatments with 2 replicates (2 females and 2 castrates/replicate). The pigs were treated for endoparasites, using "Exhelm" and for ectoparasites with "Tigal" and allowed one week adaptation period. They were group-fed *ad libitum* in concrete floored pens and water was given through automatic nipple drinkers during the 12-week experimental period.

Table 1. Composition of the experimental diets fed to weaner/grower pigs.

Ingredients	Levels of corncobs			
	0%	10%	20%	30%
Corn	60	50	40	30
Corncobs	0	10	20	30
Fish meal	4	4	4	4
Cottonseed cake	14	16	16	16
Groundnut cake	12.5	12.5	14.5	16.5
Rice bran	7	5	3	1
Bone meal	1.5	1.5	1.5	1.5
Vitamin premix*	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
	100	100	100	100
<u>Calculated analysis</u>				
Digestible energy (Kcal/kg)	3308.62	3209.48	2989.44	2834.52
Crude protein(%)	20.08	20.06	20.91	20.21
Crude fibre (%)	2.91	6.28	9.40	13.19
Calcium (%)	0.67	0.67	0.66	0.66
Phosphorus (%)	0.77	0.77	0.75	0.69
Lysine (%)	0.72	0.73	0.75	0.76
Methionine (%)	0.43	0.41	0.39	0.35

* A vitamin/mineral premix manufactured by BEAUTS Co. Inc. Man, U.S.A., to contain; Calcium 27%, Phosphorus 10%, Iron 0.6%, Zinc 0.35%, manganese 0.25%, Copper 0.06%; Iodine 0.002%, Cobalt 26 ppm, Selenium 4pp and per kg; Vitamin A 220,000, Vitamin D 66,000, Vitamin E 44,014; Vitamin K 88 mg; Vitamin B 12; 0.76 mg; Niacin 1122 mg.

Pigs were weighed weekly and data on feed intake recorded. For carcass appraisal, two pigs (one female and one castrate) from each treatment were fasted for 18 hours during which they were given only water and were slaughtered the following morning. After chilling, the following carcass measurements were taken on the right side: length from the anterior edge of the first rib to the anterior edge of the aitch bone of the pelvis; back fat thickness opposite the first and last rib and last lumber vertebra; loin eye area, calculated from the tracing of the longissimus dorsi muscle sectioned at the tenth rib.

The percent lean cuts taken on the left side included percent ham, percent picnic shoulder, percent loin and percent Boston butt.

The economic approach of this study was assessed assuming all other cost rather than making feed constant throughout the experimental period of all treatments. Cost analysis of the feed used was carried out using current market prices of different ingredients. Statistical analyses were done according to methods of Steel and Torrie (1960).

RESULTS

Data on growth performance of pigs is summarized in Table 2. Average daily feed intake decreased with an increase in the level of corncobs in diets although average daily gains declined with additional levels of corncobs. Pigs fed 0% and 10% levels of corncobs consumed significantly ($P<0.05$) more feed (1605 g and 1545 g) compared to intake (1354 g and 1343.5 g) of pigs with 20% and 30% levels of corncobs respectively. Weight gains for pigs with 0% and 10% levels were significantly higher (473 g/day and 451 g/day) than for pigs with 20% and 30% (340 g/day and 331 g/day) respectively. In terms of feed conversion, pigs fed 0% and 10% levels of corncobs were better converters compared to pigs fed 20% and 30% levels.

Table 2. Mean value of performance of pigs fed graded levels of corncobs.

Parameters	Levels of corncobs				S.E.M.
	0%	10%	20%	30%	
Number of animals	8	8	8	8	
Initial weight (kg)	16.06	16.06	16.06	15.96	1.85
Final weight (kg)	59.18[a]	56.93[a]	47.06[b]	47.81[b]	7.63
Daily feed intake (g)	1605[a]	1545[ab]	1355[bc]	1344[c]	116.0
Daily weight gains (g)	473[a]	451[a]	339.5[b]	330.8[b]	36.40
Feed/gain ratios	3.39[a]	3.53[ab]	3.99[b]	4.04[b]	0.22
Mortalities (number of pigs)	-	-	-	2	-

a, b, c = Means within each row not having common superscript are significantly different at (<0.05).

Table 3. Some carcass measurement of pigs fed diets containing graded levels of corncobs.

Parameters (%)	Levels of corncobs				S.E.M
	0%	10%	20%	30%	
Carcass yield*(%)	67.9	69.3	67.8	65.2	1.84
Length (cm)	71.7	68.2	68.5	66.5	2.34
Back fat thickness(cm)	2.0[a]	2.0[a]	1.8[a]	1.2[a]	1.04
Loin eye area(cm)	16.9	18.3	16.4	16.0	2.03
Ham** (%)	30.5	28.2	29.6	30.4	1.84
Loin**(%)	33.4	31.0	31.4	30.8	1.84
Boston butt.**(%)	14.9	15.2	16.3	15.1	3.24
Picnic shoulder** (%)	17.9	16.0	18.9	16.6	0.32
Lean meat**(%)	58.6	58.6	60.2	61.9	0.81
Bones**(%)	14.7	14.7	14.8	14.2	0.81
Fats**(%)	20.1[a]	19.9[a]	14.3[b]	13.1[b]	1.40

* = expressed as percentage of liveweight

** = expressed as percentage of carcass weight

a,b,c = means within row not having common superscript are significantly different at (P<0.05).

Table 4. Cost and returns in feeding graded levels of corncobs to weaner/grower pigs

Parameter	0%	10%	20%	30%
Mean daily weight gain (kg)	0.473	0.451	0.340	0.330
Mean daily feed consumption (kg)	1.605	1.545	1.354	1.343
Feed converstion ratio	3.39	3.43	3.98	4.07
Feed cost (FCFA/kg)	113	107	102	97
Income (kg live weight FCFA)	382	367	407	391
Revenue/cost ratio	3.38	3.51	3.99	4.03
Net income over feed cost (FCFA/kg)	269	260	305	294

1 U.S. dollar = 295 FCFA.

Data on the effect of graded levels of corncobs on carcass yield are shown in Table 3. Pigs fed graded levels of corncobs had leaner carcasses than the pigs fed the control diet. The percentages of lean meat increased with the increase of the level of corncobs in the diets while the percentage of fat decreased. On the whole no significant differences were observed in the carcass yield obtained from each diet except for backfat thickness and percentage fat.

The estimated price of corncobs was 25 FCFA/kg and was based on transportation and processing costs. The cost of production of 1 kg of feed decreased as the level of corncobs in the diets increased. Economic data on feeding graded levels of corncobs to pigs is summarized in Table 4. Total feed cost (corncobs) including other ingredients was lowest (97 FCFA) for the diet with 30% corncobs but highest (113 FCFA) for the diet with no corncobs. Income was lowest 376 (FCFA/kg) liveweight in the diet with 10% and highest 407 (FCFA/kg) liveweight in the diet with 20% levels of corncobs.

DISCUSSION

Data on the growth performance of pigs reveal that average daily feed intake decreased with increase in levels of corncobs in the diets compared to the control group. This decrease in feed intake is probably due to high levels of fibre content in the diets which made it unpalatable when compared to the control diet. These results agree with the findings of Kornegay (1978), and Cole et al (1967) which show that the pig can tolerate a wide range of crude fibre in the diet provided energy density is adequate. This shows that unless prevented by bulk or perhpas palatability the pig tends to eat until its energy requirement is fulfilled (Kornegay, 1978).

Average daily gains declined with additions of levels of corncobs. This declined in growth rate agrees with previous reports by Axelsson and Erickson (1953) when low nutritive value feed is fed to pigs.

Pigs fed 0% and 10% corncobs had feed intake, weight gains and efficiency of feed conversion significantly (<0.05) higher than pigs fed 20% and 30% levels of corncobs. Two mortalities were recorded in the group with 30% corncobs in their diet due to pronounced effect of vaginal prolapse. Female pigs fed tested diets showed vaginal prolapse. Picard, (Personal communication) attributed this effect to the level of fibre in the diet. This were probably so because the corn from which the corncobs were obtained was not treated with any chemical as the control group did not show the same sign.

Pigs fed graded levels of corncobs had leaner carcasses than the pigs fed the control diet. The percentage lean meat increased with an increase in the level of corncobs in the diets while the percentage of fats decreased. These findings are in agreement with the works of Hoefer et al (1963); Merkel et al (1958) and Salmela et al (1960) who reported that the production of lean pork carcasses can be achieved by replacing high energy feeds with bulky low energy feeds that are high in crude fibre or by the addition of inert materials such as corncob cellulose, sand and polyethylene in pig diets. Contrary to these studies are the works of Babatunde et al (1975) who reported marginal effects on carcass quality due to the fact that pigs had not sufficiently eaten high levels of fibre.

In terms of gains from production, the diet with 20% corncobs was the most profitable with a net income of 305 FCFA/kg liveweight while the diet with 10% corncobs was the least profitable test diet with a net income over feed cost of 266 FCFA. Although mean daily weight gain, feed consumption and feed cost decreased successively with increased levels of corncobs, diets with higher levels of corncobs did not necessarily yield a high income per kilogram liveweight. This was probably due to the similarity in the carcass that increased levels of corncobs significantly increased the percentage of lean meat which has a higher cash value.

The findings of this study indicate that corncobs can be fed to pigs at the level of 20% to get leaner carcasses. Corncobs are easily available in villages and can be ground in corn mills for incorporation in pig diets. Increased use of corncobs by peasant farmers could be enhanced by widespread dissemination of this technology by extension workers.

Although the extension service in Cameroon is not well-developed, formal and informal linkages can be made between large-scale corn producers and pig farmers to increase the supply of corncobs. Rural development organisations such as MIDENO (North West Development Authority), WADA (Wum Area Development Authority), PAFSAT (Promotion of Adaptive Farming Systems with use of Animal Traction) and UNVDA (Upper Nun Valley Development Authority) can incorporate these results into farm packages for distribution to farmers. The economic benefits of these results to farmers are substantial in terms of price and quality of meat produced. Whereas the price of corn fluctuates between 50 and 85 FCFA/kg as a result of supply and demand, the price of corncobs will almost invariably remain constant at 25 FCFA/kg under the same conditions. Apart from the price incentive for users of corncobs, maize producers will find a market for corncobs which would otherwise be wasted.

The other technologies used in this study which constitute concrete floors for pens, stone walls, automatic nipple drinkers are appropriate for a research station but this could easily be adapted to farmers' needs. They could have concrete floors containing drinking and feeding troughs and hard wood walls. Used motor vehicle tyres could be buried in pig fences as drinking troughs. This would be inexpensive to farmers.

Farmers in Cameroon generally own the land they cultivate. Since the construction of pens and the necessary infrastructure constitute long term investiment on the part of the farmers, land does not constitute a problem. In addition due to the fact that all the required inputs increase the chances of the adoption of the technology under discussion (i.e. improved feed for pigs), they will be able to gain more.

The efficient utilisation of the results of this study depends to a great extent on the education of the farmers. And since farmers will generally be willing to accept new technologies which they are convinced would serve their best interests, the impact of improved feed for pigs would greatly improve their production.

CONCLUSION

From the results obtained in this study corncobs can be used in weaner/grower pig diets to obtain more lean meat. When treated and fed, corncobs can enhance the growth performance of weaner/grower pigs. The diet is relatively easy to prepare and when used up to 20%, it offers the most efficient and cost effective diet for pigs. When properly disseminated, this ration can cut down on feed cost to farmers.

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ON-SITE RESEARCH FOR THE ESTIMATION OF THE NUTRITIONAL STATUS OF SHEEP AND GOATS GRAZING AT EL-OMAYED PASTURE AREA

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Summary

A governmental resolution which allowed the Bedouins of the Matrouh Governorate to export sheep and goats resulted in significant movement of flocks from the Nile delta to the Marsa Matrouh area. The number of heads of small ruminants moving to the new area was almost double that of the normal and led to overgrazing and a deterioration of many parts of pasture land.

Research was initiated to determine the present nutritional status of sheep and goats at El-Omayed, 90 km west of Alexandria. Two university of Alexandria employees introduced the research team to Bedouins at the site. Experiments to determine forage preference, feed intake, grazing periods, the nutritive value of consumed material the present and the proper carrying capacity were all conducted using flocks of one influential Bedouin. His flocks were managed by his five sons.

The grazing period and DM intake of goats in summer were between 1/3 to 1/2 their corresponding values in winter. Sheep did not show such degree of difference between summer and winter. The studied pasture area was capable of supplying the existing sheep with 77 and 85% of their TDN requirements in summer and winter. The corresponding values for goats were 37 and 100%, respectively. The proper carrying capacity of the studied area was about 5 feddan/head in summer and 2.5 feddan/head in winter.

Treatments for improving the nutritional status of animals were suggested. A mineral mixture was formulated to compensate

[1] One feddan = 0.42 ha

for the recognised local mineral deficiencies. It was manufactured in the form of licking blocks. This supplement improved the performance of animals during summer by 22%. The first co-operating Bedouin helped in extending the distribution of these blocks to neighbours. Two years later, the number of clients using the blocks reached 14.

INTRODUCTION

The pasture area at the northern coastal zone of the western desert of Egypt (administratively known as Governorate of Matrouh) was lately overgrazed due to the doubling of sheep and goats there, during the last 10-12 years. This was a result of the Government's action allowing the Governorate of Matrouh to export sheep and goats. Export price was higher than the local market price. However, during this period, feeds became scarce and the Bedouins of Matrouh had to import feeds from the Nile delta where feeds were also in short supply.

The present study aimed at studying the nutritional status of the animals in El-Omayed (90 km west Alexandria) as a sample area of the Matrouh Governorate. Means of improving the present situation were also investigated. The implications of such a study in a desert environment are described with emphasis on the social and economical value of the results.

MATERIALS AND METHODS

El-Omayed has a temperature range of between 10 - 20^{o}C during the winter and 30 - 40^{o}C in summer. Rainfall averages 150 mm annually, two thirds of which falls between November and February. Rainfall is more intensive along the coastal region, diminishing rapidly inland. Sandstorms occur during the spring, frequently lasting three days over a 50-day period, called El-Khamasin. Relative humidity during the summer may reach 72% decreasing to 16% in the winter.

The soil at the experimental site is calcareous alluvium with a high content of limestone (30-35% $CaCo_3$). The soil texture is fine and it is moderately affected by salts. However, it is very poor in contents of organic matter, phosphorus, nitrogen and most microelements.

The animals at the experimental site were mainly sheep and goats (dark coloured) with very few donkeys. Animals under the site conditions have one breeding season per year. Sheep at the site were of the Barki breed. They were white coloured with black head. Flock size ranged between 40 and 200 heads per person. In 1965 sheep exceeded goats by 2.7:1. This number now is moving towards a lower sheep/goat ratio. Veterinary service was almost negligible in the area. Mortality rate, especially around the age of weaning, was quite high (25-50%) with a peak in summer.

The recognised (prevailing) plants on site were Cutandia dichotoma, Asphodelus microcarpus, Thymelaea hirsuta, Plantago albicans, Helianthemum lippii, Canducellus spp, Convolvulus lanatus and Rumex spp.

Identification of co-operating Bedouins

The research group was introduced to the inhabitants of the experimental area through two University workers who are from this area and are well-known by the Bedouins there. Both individuals had maintained close contact over the years with their friends and relatives at the research site. They also observed the social traditions of the district and were therefore viewed as solid personalities. They did not exhibit the paternalistic behaviour characteristic of many non-Bedouins. These University employees also knew and understood the research staff and the purposes of research in question. They were pleased to demonstrate to their employers their influence in the district. Through them, the Sheikh, his five sons and thereafter, 12 other Bedouins at the site were convinced to co-operate with the research team. This approach was required since it is obligatory in Bedouin society to move under the umbrella of the most influential person on site.

The Bedouin participation consisted of providing the animals for the research team to carry out its observations and tests. Their involvement was obtained under the following conditions:

a) A basal payment of 100 EGP*/month to the head of the family. In addition, frequent gifts (mainly of sugar, tea, flour and clothes) were made, depending on the occasion.
b) A rental fee of one EGP/head/month for each animal studied.
c) A salary (30 EGP/month) for the person (one of the Sheikh's sons) who shepherded the experimental flock.
d) At the beginning of each experiment, the head of the family received between 15 and 30 EGP depending on the type of experiment.
e) Salaries were provided for assistants as needed. These assistants were always women or girls since the boys did not agree to work. Each young girl employed for collecting range plants was paid 0.35 EGP per 25 kg bag filled with a certain plant species. The 12 to 16-year-old girls who assisted in the experiments such as digestibility trials received 20 EGP/week.
f) Any veterinary care was preceeded by some payment to the head of the family in addition to those who actually assist in adminishing the treatments.

Experimental design; The oesophagally-fistulated sheep and goats (as described by Schutte et al. 1971) were hired from the Sheikh. Three sheep and two goats were selected. Surgery was made at the experimental station of the Faculty of Agriculture, University of Alexandria. After recovery, the animals were returned to the site to be used in determining grazing preference and feed intake.

The actual grazing period was determined by observation using four research assistants who followed grazing animals (one observer per animal) measuring the grazing time with a stop watch. Sixteen sheep and sixteen goats were observed on four consecutive days each month over the whole year.

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* EGP = 1 Egyptian pound = 0.45 US$

Digestibility and mineral balance trials were conducted on three sheep and three goats during both the winter and summer seasons. These experiments were conducted according to conventional methodologies.

The forage production of each feddan of rangeland was estimated by using randomly - selected quadrat measurements from 10 locations per feddan. For each quadrat, the consumable plant parts were collected manually, weighed, and the dry matter content was estimated. These measurements were made monthly over a complete year.

The number of feddans required to feed an animal was then calculated by using standard feed requirement data and measuring feed availability at the experimental site.

Studies on the effect of feed supplements were conducted on two separate flocks of the Sheikh, each of 48 heads of sheep and goats. The supplements were combined in a block manufactured at the University laboratory. The carrier material was ground maize stalks bound by molasses. The additives (minerals and vitamin A) were dissolved in the molasses. Performance of the treatment was measured indirectly by the willingness of the Bedouin to continue using the blocks in subsequent years.

Logistics of field research: The experimental programme in El-Omayed lasted for two consecutive years (two winter and two summer seasons). A research assistant (Ph.D. student) with four technicians visited the site twice weekly. They used a Jeep for transport from the faculty location to the experimental site, a distance of about 180 km round-trip. Transport costs were about 0.10 EGP per km. Two weighing balances were left on site, one for the animals and the other for preparation of rations for the digestibility trials. Bags, rubber funnels and tubing with harnesses were required for the digestibility and balance trials to collect the faeces and urine. A specific building for housing the fistulated and experimental animals was constructed on-site.

The costs of such facilities were as follows:

	USD
1. Vehicle	9,000
2. Bags, funnels and harnesses	800
3. Oesophagal fistula (3 pieces)	300
4. On-site building	200
5. Chemicals and glassware	1,000
6. Weighing balances	700

RESULTS

Consumed feed by eosophagally-fistulated animals would either drop through the fistula into the fitted bag, or it passed directly to the rumen. The amount of consumed dry matter (DM) which dropped into the fistula was found to be higher in goats than sheep as indicated in Table 1. The actual DM consumption of feed during a 30-minute period can then calculated as follows:

$$\frac{\text{DM collected in the fistula during 30 min.}}{\text{\% of consumed feed dropped in the fistula}} \times 100$$

Botanical analysis of the material collected from the fistula (Table 2) indicated that species preference was similar for sheep and goats in summer. During the winter, sheep grazed more Asphodelus microcarpus and less Thymelaea hirsuta, than goats.

Table 1. Distribution of consumed DM (g/33 min.) between the fistula and the rumen.

Type of animal	Season	Consumed		Dropped in the fistula		Passed to the rumen	
		g	%	g	%	g	%
Sheep	Summer	160	100	60	38	100	62
	Winter	66	100	16	24	50	76
Goats	Summer	55	100	26	48	29	52
	Winter	56	100	21	37	35	63

Table 2. The percentage distribution of consumed pasture plants by sheep and goats during the summer and winter seasons.

	Sheep		Goats	
Plant species	Summer	Winter	Summer	Winter
Asphodelus microcarpus	85	85	85	70
Thymelaea hirsuta	6	10	6	25
Rumex spp.	-	1	-	1
Canducellus spp	-	1	-	1
Helianthemum lippii	4	1	4	1
Plantago albicans	4	1	4	1
Cutandia dichotoma	-	1	-	1
Convolvulus lanatus	1	-	1	-

Table 3 indicates that the daily DM consumption by sheep and goats was almost similar in the winter while during the summer, goats had a much smaller intake of DM. On an energy intake basis

(Table 4) goats suffered more than sheep in the summer season, obtaining only 36.7% of their required total digestible nutrient (TDN). This suggests the importance of giving goats priority in the use of government-distributed concentrates. In addition, providing goats with some overhead shelter during the summer season would be desirable.

The results in Table 4 indicated that the pasture conditions in winter would enable a carrying capacity of one small ruminant per 2.5 feddans (Table 5). It may be assumed that the yield of feed per feddan during the summer was actually the residual of the pasture, that was not consumed during the winter season. In summer season the carrying capacity must be at least 5 feddans per animal if they were to obtain all their requirements from the pasture alone.

Table 3. DM consumption, digestible protein and TDN content of summer and winter pasture diets grazed by sheep and goats.

Season	Sheep				Goats			
	Grazing period	Consumed DM period			Grazing	Consumed		
	(h/day)	(g/hd/day) DM	% DP	% TDN	(h/day)	(g/hd/day) DM	% DP	% TDN
Summer	3.25	1264	4.6	59	2.5	550	4.5	63
Winter	4.25	1338	2.3	73	5.0	1529	2.1	66

Table 4. Ability of local pastures to meet TDN requirements of grazing sheep and goats at the El-Omayed site during the summer and winter seasons.

Season	TDN % in consumed DM		Consumed TDN (kg/head/day)		Required TDN (kg/head/day)		TDN intake as percentage of requirements	
	Sheep	Goats	Sheet	Goats	Sheep	Goats	Sheep	Goats
Winter	70	68	0.936	1.040	1.1	1.0	85.1	100
Summer	61	60	0.771	0.330	1.0	0.9	77.1	36.7

* sheep body weight of 45 kg and goats of 40 kg.

Table 5. The carrying capacity (fed/animal) of grazing land at the El-Omayed site for sheep and goats.

Season	Available feed		TDN requirement		Carrying capacity	
	kg DM/feddan	kg TDN/feddan	Sheep	Goats	Sheep	Goats
Summer (6 months)	70	42	201	191	4.8	4.7
Winter (6 months)	118	82	201	191	2.5	2.4

The patterns of mineral balances indicated (Table 6) positive balances in sheep and goats during the winter season. Some problems (specially in sheep) of mineral deficiencies were identified in the summer season (if the animals were not supplemented with concentrates). Calcium balance was unusually high especially with sheep. When a mineral mixture was composed (Table 7) and given to the animals to compensate for the level of deficiency, the TDN content of the same amount of consumed DM was increased by 22% (Table 8). Feed intake increased by an average of 18%. These results indicated that providing grazing animals during the summer season with some licking blocks containing the deficient minerals could raise the adequacy of their TDN intake (given the present levels of DM intake) to 98 and 50% instead of 77% and 37% of their requirement (see Table 4) for sheep and goats, respectively.

Table 6. Mineral balance patterns (g/head/day) of sheep and goats grazing the El-Omayed site in the summer and winter seasons.

	Sheep		Goats	
Mineral	Summer	Winter	Summer	Winter
N	1.55	4.60	1.05	0.70
Cu	0.01	0.03	-0.05	0.00
Fe	-0.08	0.44	0.47	0.65
Zn	0.08	0.03	0.08	0.03
Mn	-0.01	0.04	0.03	0.01
Ca	7.01	28.56	6.18	0.74
Mg	1.52	0.40	1.73	0.08
S	-2.91	0.20	1.42	1.90
P	-0.02	0.80	-0.48	0.13
Na	10.76	1.07	13.19	1.73
K	0.69	1.15	12.07	1.91

Table 7. Composition of the supplemental mineral mixture for grazing sheep and goats in the summer season.

Mineral salt	G/Head/day
Sulfur	3.368
Ammonium phosphate	1.104
Zinc sulphate	0.092
Ferric sulphate	0.340
Manganese oxide	0.032
Total	4.936

Table 8. Effect of the mineral supplement on the digestibility of nutrients for sheep fed summer pasture plants

	Coefficient of digestibility (%)	
Item	Without supplement	With supplement
DM	66	80
CP	44	52
EE	65	73
CF	85	89
N-Fext	70	86
TDN	62	73
DP	2.86	2.63

DISCUSSION

The preference of Asphodelus microcarpus and Thymelaea hirsuta, although both contain colchicine and caumarine (Tockholm et al, 1956), is not explainable within the limits of the present work. However, it may be speculated from the chemical composition of the individual plant species that these two selected plants had less content and relatively more balanced calcium/phosphorus ratios. The ash content of these two plants averaged 10% while it was 15 - 22% in other plants.

The animals were selecting the more digestible fractions of the plant. This would explain the high TDN content of consumed DM (see Table 3) in both winter and summer.

The failure of goats to manage enough feed intake during summer (Table 4) as compared to sheep may be explained on the basis of body colour. Goats were either black or dark brown which may have resulted in higher heat stress. Sheep were of a white body colour.

The yield in kilogram of consumable feed per feddan is mainly dependent on rainfall rate as claimed by Field (1980). The same author indicated that soil fertility and rate of water evaporation from the plants are also contributing factors to pasture yield. Field (1980) found that DM yield at pasture increases threefold by rainfall increase of 60%. Accordingly, the carrying capacity presently found (Table 5) should not be taken as a fixed estimate. Every year such a parameter should be revised and adjusted. The mineral mixture supplement (Table 7) should be also formulated according to the deficiencies found in each location. Results of Yassen (1958) and Van Eys (personal communication) emphasise the significant role minerals play on feed intake and animal performance. Naga (1984) indicated that a combination of vitamin A, urea and minerals significantly improved the performance of adult and growing animals. The excessive Ca retention (Table 6) could be adjusted to normal by feeding a calculated amount of wheat bran (Naga, 1987). Phytic acid in the bran would chellate the extra Ca in the diet and then prevent its absorption.

The above information was used for manufacturing licking blocks in the Faculty's laboratory. The licking blocks contained mineral mixture, urea, Vitamin A, wheat bran, sodium chloride, molasses and cement. The blocks were used for the Sheikh's flocks only. The shepherds observed the crowding of animals around the blocks in summer, the fast drop of placenta after the dam's delivery (2hrs instead of 2-3 days), and the significant reduction in offspring mortality. The research team was asked to provide some licking blocks without mentioning that the blocks would be passed onto neighbours. The licking blocks were given free at the beginning, and later at a cost when neighbours expressed more interest. The number of clients which started with four, gradually reached 14 in 1.5 years. The positive side in this activity is the continuity of purchasing the blocks although the research team left the site when the clients were 11.

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CAN AGRO-INDUSTRIAL BY-PRODUCTS AND CROP RESIDUES SAVE THE NIGERIAN LIVESTOCK INDUSTRY

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INTRODUCTION

Nigeria is one of the countries where animal protein consumption per caput is still very low being about 9.36 kg/caput/year (Egbunike, 1988) without taking account of fish and game meat consumed. Yet every sector of the livestock industry is having serious setbacks mostly due to the escalating prices of feeds which normally constitute 60-80% of production costs depending on species.

Hitherto, Nigeria had depended almost exclusively on imported feed ingredients for the production of compound feeds and with the overvalued "naira" appeared to making some headway in livestock production especially in the poultry sector which utilised about 90% of compound feeds produced in the country. With the economic recession and the noncomitant ban imposed on the importation of the major constituents of livestock feeds, especially grains, many entrepreneurs in the livestock industry that are unable to withstand the tough competition have fallen by the wayside. Under this condition wide variations exist in feed supply and hence prices which have resulted in the present low level of productivity of the animals regardless of the system of management.

The capacities of livestock feed mills and average prices of poultry feeds are summarised in Tables 1 and 2 respectively considering that poultry feeds form about 90% of feed mill products. It can be observed that at 50 or 65% maize inclusion the amount of maize required cannot be met internally especially when viewed against the background that this commodity is in very high demand in other sectors of the economy viz for human foods and for industries like the breweries. Thus, Nigeria must look inwards for her feed resources. Fortunately, the pioneering work of Oyenuga (1966) paved the way for the understanding that agro-industrial by-products and crop residues could be economically used to supplement the erratic feed supply.

This paper assesses the potential of agro-industrial by-products and crop residues to meet the nutrient requirements and hence, support the growth and productivity of livestock in Nigeria.

Table 1. Capacities of livestock feedmills in Nigeria for 1987 ('000 metric tonnes).

Item	Quantity
1. Total installed capacity	2,015.00
2. Utilised capacity	735.89
3. Percent utilised	36.52
4. Maize equivalent	
(a) at 50%	1,007.50
(b) at 65%	1,309.75

Source: Anonymous (1988)

Table 2. 1987 average prices of poultry feed in Nigeria (Naira per ton*).

Feed type	Range	Mean
Broiler starter	868.67 - 1160.00	1050.90
Broiler finisher	863.00 - 1168.40	1017.30
Chick mash	867.78 - 1066.50	960.12
Grower's mash	721.00 - 1259.00	838.77
Layers mash	796.00 - 974.62	906.77

*US$ 1.00 = 4 naira (1987)
Source: Akinwumi (1988)

SUPPLY OF AGRO-INDUSTRIAL BY-PRODUCTS AND CROP RESIDUES

Agro-industrial By-products

As shown in Table 3 the supply of agro-industrial by-products is considerable being at least 738,271.6 tonnes per annum. Although their rate of utilisation is dependent on their chemical composition and the species of livestock in question, it is evident that wheat bran/offals were the most common followed by fresh or wet brewers' grains while maize bran and cassava chaff were the least.

It is worthy to note that some of these data may represent underestimations since they were collected from registered industry only. For example in the cases of rice and cassava by-products (especially the latter), the aggregate of rural producers could account for a very substantial amount of production. However, mention must be made of the chemical composition and physical form of these by-products which tend to limit their usefulness. For example a bulky product containing a high level of sugar would, due to high moisture content, deteriorate rapidly during storage due to fermentation and contamination by moulds (to produce mycotoxins) while oily products become easily rancid. These by-products can be classified as energy, protein and combined energy/protein sources.

Energy sources are rich in fermentable carbohydrates and low in protein. The best example is molasses traditionally used as a carrier for urea in ruminant feeding. Molasses is produced in the two sugar industries in Nigeria: Numan, in Gongola State, and Bacita and Jebba in Kwara State.

Protein sources are mostly the oilseed cakes. Palm oilseed cakes are produced in the southern part of Nigeria (Bendel, Cross River, Imo and Rivers States) and form the most abundant and least expensive oilseed cake available. It is however notorious for being gritty and unpalatable. Cottonseed and groundnut cakes are also important although the latter had declined drastically about three decades ago and is only coming up again with this spirit of looking inwards.

Combined energy and protein sources by-products considered under this category are cereal and brewers' grains. Until the ban on wheat importation, wheat bran was the most important cereal bran in the country. However brans from traditional grains (sorghum, millet, rice and maize) are growing rapidly in quantity. As regards brewers' grains, most of the 32 breweries originally produced wet grains that were available for the asking. As the usefulness of the grains in livestock feeding became increasingly clear, some of these breweries started to dry some of their grains for sale. These dried grains constitute only 5% of the total produced (Table 3).

Crop residues

With the advent of the oil boom in the mid sixties in Nigeria came an unfortunate neglect of agricultural production which hitherto yielded about 80% of Nigeria's export earnings. This had an unparalleled drop in crop production and a concomitant increase in imports to meet the needs of the fast growing human population. All these led to a drastic reduction in the quantity of available crop residues. However with economic recession there is now an upward turn in the production of crops and hence in the availability of residues.

It is known that most of the ruminants in Nigeria are found in the Guinea savanna and Sahel zones where they are managed by pastoralists. These zones are the major cereal (sorghum, millet and maize) growing areas of Nigeria. The amount of straws and leaves left in the cereal plants after harvesting can be estimated. For example in the case of sorghum which is the most abundant of the cereals in these areas, the ratio of grains to straw is 1:4 at the time of harvest. Thus with a production of about 6 million tonnes of sorghum in Nigeria 24 million tonnes of straw would be available for use in livestock production annually. Also with a ratio of 1.3:1 for leaves and grains 5.2 million tonnes of leaves would be left behind. With the recent

FAO figures it must follow that this tremendous tonnage will be more than equalled by total amount of maize, millet and rice straws, giving a modest annual estimate of more than 52 million tonnes of crop residues in this zone alone. In addition to this, there is an estimated amount of over 400,000 tonnes of maize cobs available for livestock feeding after the necessary treatment.

Table 3. Supply of major agro-industrial by-products by registered companies in Nigeria (1985).

Type		Production (tonnes/yr)	Price (₦/ton)
Wheat bran/offals		382,666	139-180.00
Cottonseed cake		6,707	315.00
Groundnut cake/pellets		6,970	550.00
Palm kernel)	meal	50,000	60.00
	) cake/pellets	33,000	65.00
Molasses		24,000	51.00
	)fresh	190,000	n.a**
Brewers grains	) dried	10,182	30-100
	) bran	23,800	150.00
Rice	) husks	6,530	n.a
	) chaff	59.60	
Cassava	) peeling	2,943	
Maize bran		450	n.a.
Total		738,271.60	

* US$ 1.00 = 2 naira (1985)

** n.a. = not available.

Source: Reddish and Scarr (1987)

LIVESTOCK TO BENEFITS FROM AGRO-INDUSTRIAL BY-PRODUCTS AND CROP RESIDUES

Because of the poor quality of these materials, it is normally thought that only ruminants can benefit from them. However, it is now known that they can be beneficial to non-ruminants as well after having been properly processed as shown later. For example, we have consistently used the items on Table 4 with the exception of molasses, sorghum and maize stovers. The only difference in the utilisation of these materials for ruminants and non-ruminants would be the levels of inclusion in the diets. In cattle production, these materials have been used for a long time for fattening as was developed by the Livestock Project Unit for smallholder farmers over a 120-day period. In this scheme cattle of 200-340 kg liveweight are introduced to rations made up of a combination of these materials as shown in Table 5. It is obvious that the dried brewers' grains and molasses combination is the cheapest. Average daily gains (ADG) of 0.38 - 0.85 kg have been reported with fattening periods of not more than 160 days recording higher values. This makes it possible for two complete fattening cycles per annum. If, for example, 30,000 additional tonnes of dried brewers' gains were made available from the breweries and used for fattening cattle, 100,000 cattle would, fed at 3 kg/head/day for 100 days, gain 5 million kg in liveweight. At 60% dressing weight, this would give an additional 3,000 tonnes of saleable meat.

Table 4. Chemical composition of some agricultural by-products and crop residues.

Product	DM (%)	Crude protein (% or DM)	Metabolisable energy (MJ/kg.DM)
Wheat bran	90	17.20	10.10
Cottonseed cake	90	26.90	11.00
Groundnut cake	90	48.60	12.00
Palm kernel cake	90	18.60	12.60
Molasses	75	4.10	12.70
Dried brewers' grain	90	20.40	10.30
Rice bran	89	10.60	10.80
Sorghum stover	93	4.75	6.28
Maize stover	94	5.60	-

Table 5. Typical rations formulated from agro-industrial by-products and crop residues for cattle fattening.

Ingredient	Rations		
	1	2	3
A. Quantities (kg)			
Wheat offals	3.00	3.00	-
Groundnut cake	0.25	-	-
Molasses	1.00	1.00	1.00
Crop residue/grazing	2-3	2-3	3.00
Cottonseed cake	-	0.50	-
Dried brewers' grains	-	-	3.00
B. Chemical composition			
Metabolisable energy (MJ)	57.19	57.88	58.98
Crude protein (g)	615.00	623.00	657.00
C. Cost/head/100 days (₦)	68.50	74.00	46.00

These materials have been used, when available, to avoid the annual weight loss of cattle during the 5-6 months dry season in the northern parts of Nigeria. This prevents the drop in fertility while reducing both calf and herd mortalities. In addition, heavier weaning weights would be achieved. It could thus be construed that the benefits of dry season supplementation far outweigh those of fattening.

As for small ruminants, agricultural by-products and crop residues are also used for fattening and dry season feeding. For example, Adebowale (1985) and Ademosun et al (1987) have shown that inclusion of dried brewers' grain at 25 and 50% levels gave weight gains in goats of 38.4 and 29.2 g per day respectively. As regards poultry and pigs, which are more abundant in the south and which have to be intensively fed throughout the year, by-products and crop residues with or without cassava peels (Tewe and Egbunike, 1988) have virtually kept the industries going without much loss in the level of production even at lower costs.

CONSTRAINTS ON THE COUNTRY-WIDE UTILISATION OF RESEARCH RESULTS ON AGRO-INDUSTRIAL BY-PRODUCTS AND CROP RESIDUES

Constraints on the use of by-products and crop residues include, according to El Hag and Kurdi (1986), bulkiness, location in areas with lower animal population density, poor nutritive value and unsuitability for direct animal use. In Nigeria today, the issue of the bulkiness and location in areas far from those where the materials are needed has been partially solved by the development of a good network of roads and the opening up of the rural areas for development since the establishment of a directorate charged with this function two years ago. As regards the poor nutritive value and non-suitability for immediate animal use, research results have shown that supplementation with molasses, non-protein nitrogen (urea and poultry excreta) and chemical (NaOH) and physical (grinding and pelleting) treatments improve the nutritive value and intake and hence the response of animals to some of these by-products. El Hag and Kurdi (1986) concluded that physical treatment was more useful in improving the nutritive value of these products and was also economically more feasible than the chemical treatment. On the other hand constraints on the use of research results on the by-products and crop residues include the following:

Lack of appropriate terms.

As pointed out by Kayongo-Male et al (1986) the use of different local names in different localities and by researchers constitutes a problem calling for the adoption of a standard system for describing crop residues and by-products. An example is the use of "cassava peels" to describe a mixture of the peel, flesh and some discarded tubers most of the time.

lack of biological screening

It is known that some of these products contain some abnoxious materials that may be harmful to animals when used for a long time. Because most of the experiments have been on short-term basis, it has not been easy to adopt some of the recommendations arising from research results blindly. Theobromine and hydrocyanic acid contents in cocoa husks and cassava peels/leaves, respectively, tacitly caution against long-term utilisation of these products especially for breeders. For example, Osuagwuh (personal communication) has shown that the long-term feeding of cassava peels to breeding nanny goats causes abnormal embryogenesis resulting in the birth of stunted neonates that have very little chance of surviving.

Contrasting responses of animals of different species, physiological states and ages.

Recommendations drawn from some results tend to ignore the fact that different species or classes of animals e.g. ruminants and non-ruminants) respond differently to agricultural by-products and crop residues. Also animals of different physiological status (pregnant or not) and ages would obviously respond differently to these materials. Often the ages and liveweight of experimental animals are not indicated while sometimes pregnant or sick animals are used thus making adoption of results therefrom difficult.

Composition differences of crops

It is continuously becoming clearer that varietal differences exist in the morphological and chemical compositions of plants. Except in experiments where the varieties of crops involved are clearly stated, adoption of results may be jeopardised.

Conflict between the goals of the researcher and the farmer

In many instances the researchers work in complete isolation of the end users of their results, the farmers. Under such circumstances these results are a clear wastage of time and funds as they are not normally adopted by the farmers. In a few cases their adoption has been a failure. This may partially explain the almost regular non-repetition of research results at the farm level and calls for a proper exchange of ideas between the researcher and the farmer and the development of proper packages for the transfer of research findings from the researcher to the farmer by extension experts.

SUMMARY AND RECOMMENDATIONS

The tremendous potential of agro-industrial by-products and crop residues in upholding the aims of livestock production has been indicated in this report. There is a supply of at least 738,271.6 tonnes of agro-industrial by-products nationally and 52 million tonnes of crop residues in the cereal belt of Nigeria. Judicious use of these in conjuction with the grass/pasture carryover from the rainy season in the form of hay or silage will minimise the dry-season weight loss in our animals, especially ruminants, and encourage acceptable weight gains while reducing calf and herd mortalities. In the case of non-ruminants, the ban placed on the importation of feed resources has been partially contained by the use of these non-conventional feed resources.

However, there is need for more research to arrive at the optional utilisation of agro-industrial by-products and crop residues for livestock production in Nigeria. Emphasis should be continuously placed on farming systems research so as to achieve optimum production of both crops and livestock. The investigation and development of alternative legumes and browse species for supplementation of agro-industrial by-products and crop residues should also be emphasised.

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POTENTIAL OF RUBBER SEED AS PROTEIN CONCENTRATE SUPPLEMENT FOR DWARF SHEEP OF CAMEROON

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ABSTRACT

The performance of West African Dwarf sheep fed concentrates containing graded levels of unextracted rubber seed flour was evaluated in two experiments. In the first experiment carried out in 1984, 15 local sheep were fed concentrates containing 0, 10, 20, 30, 40 and 50 percent unextracted rubber for a period of three months. Results indicated that sheep fed concentrates containing 10 and 20% rubber seed had similar dry matter and crude protein intake as those on the control (0% rubber seed), while those maintained on 30 and 50% rubber seed concentrates consumed significantly ($P<0.05$) lower levels of dry matter and crude protein. The digestibility of dry matter, organic matter and crude protein was significantly lower in sheep fed 30 and 50% rubber seed concentrates compared to those on the 10 and 20% concentrates. Animals fed concentrates containing 0, 10 and 20% rubber seed gained 9, 10 and 17 g/day whereas those on concentrates containing 30 and 50% rubber seed lost weight at the rate of 26 and 51 g/day respectively. It was concluded that the limit of 20% rubber seed in concentrate rations for sheep should not be exceeded.

In the second experiment, 12 uncastrated male dwarf sheep ranging in age from 8 to 14 months and weighing between 11 and 15 kg were used to investigate performance when fed fresh Elephant grass and concentrate supplements containing 0, 10, 15 and 20% unextracted rubber seed meal as a substitute for cottonseed cake during a period of 56 days.

Dry-matter intake decreased as the level of rubber seed in concentrate supplement was raised. There were no significant differences in dry matter, organic matter and crude protein

digestibility between the control and all other treatments containing rubber seed meal. Daily weight gain of sheep fed concentrates containing 0, 10, 15 and 20% rubber seed were 36, 50, 41 and 38 g/day respectively. Twenty percent level of incorporation of rubber seed meal or flour in concentrate rations for sheep is recommended. Application of results on the industrial and smallholder scale is discussed particularly as regards collection, shelling, detoxification and extraction of oil to obtain the cake which is a valuable protein source for livestock.

INTRODUCTION

There are large resources of conventional and non-conventional feeds in Cameroon that can be profitably used in stimulating animal production in general and small ruminants in particular. Prominent among the non-conventional agro-industrial feed resources is rubber seed. At the moment the country has the potential of producing 26,000 tons of rubber seed and the quantity will increase considerably when young plantations begin to produce fruits and with the creation of new plantations.

Rubberseed meal and the cake are higher in total digestible nutrients than soya-bean meal and is highly promising as a protein supplement. Rubberseed meal has a high level of lysine and tryptophan, making it a good companion for maize in poultry and pig rations, but poor in lysine (Ensminger and Olentine, 1978). Rubber seeds can be processed into oil and cake by pressing or ether extraction. The seed yields about 44 % oil, 50 % cake and 6 % other wastes. The cake may contain 8 - 15 % oil. The oil is comparable to soya-bean oil. The oil can be used for making paint and varnish (IRCA, 1982). Also, seeds when boiled and drained are eaten by Indians in the Amazon Valley of South America (Seibere, 1948).

Despite its potential as a protein feed for animals, fresh rubber seeds contain a toxic factor, cyanogenetic glucocide. The content in fresh seeds is about 200 mg/100 g of seeds (Gick _et al_, 1967). In the presence of the enzyme limarinase or in a slightly acid medium the cyanogenetic glucocide is converted to hydrocyanic acid which is poisonous. Symptoms of poison include increased pulse rate, no response to stimuli and spasmodic muscular movements (Maner, 1972). The hydrocyanic acid combines with hemoglobin to form a cyanohemoglobin complex which cannot carry oxygen. Small quantities of hydrocyanic acid do not result in death but may adversely affect the health of the animal (Stosic and KayKay, 1981). Detoxification of fresh rubberseed can be carried out by the following methods: Storage of fresh seed for 5-6 months before oil extraction; heat treatment by roasting fresh seeds in a kitchen oven or boiling in hot water, and soaking seeds in ash solution for 12 hours after which they are washed.

Although the cake or rubberseed meal can be used as animal feed (IRCA, 1983; Stosic and KayKay, 1981) little attention has been devoted to exploiting it in Cameroon as feed for livestock.

The first experiment was therefore designed to assess the value of rubberseed flour as the major protein source in concentrate supplements for West African Dwarf sheep. The second study was designed to limit the level of rubberseed flour in concentrates to below 20 % such that it substituted cottonseed cake in the diet of Dwarf sheep. The 20 % or less level of rubberseed in sheep concentrate supplements was based on the results of the first experiment.

MATERIAL AND METHODS

Experiment 1

Fifteen adult West African Dwarf sheep from the University farm, weighing between 15 to 20 kg were used for the study. Prior to the experiment they were dewormed and sprayed against ticks. The animals were randomly assigned to five treatments in a completely randomized design. The basal ration was fresh Guatemala grass (*Tripsacum laxum*) cut on a daily basis while the treatments were five concentrate supplements containing 0, 10, 20, 30 and 50 % rubberseed flour on weight basis.

Rubberseed flour was obtained from seed that had been stored for 6 months and boiled to detoxify them. The proportions of feedstuff's in each concentrate are shown in Table 1 while the proximate composition is shown in Table 2. Animals were maintained in individual metabolism cages during the entire experimental period of three months (January-April 1984). Concentrate (200 g/day) was served to each animal at 09.00 hours every morning while chopped forage (1.0 kg) was served at 10.00 hours and 16.00 hours. Water was provided to each animal *ad libitum*. Residues were weighed the following morning in order to estimate intake. The sheep were weighed weekly. During the last week of the experiment faeces were collected for evaluation of digestibility of diets.

Table 1. Experimental rations for local sheep.

Ingredients (%)	Concentrates				
	A	B	C	D	E
Maize	100	90	80	70	50
Milled rubber seed	-	10	20	30	50
Bicalcium Phosphate	1	1	1	1	1
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

Table 2. Proximate composition of Guatemala grass and concentrates fed to local sheep (%).

	DM	OM	ASH	CP	CF	ME	NFE
Forage I	28.84	93.60	6.40	15.95	32.58	1.57	43.50
II	26.16	93.28	6.72	15.67	29.25	2.89	45.47
Concentrate							
A	86.65	97.67	2.33	9.08	2.18	2.23	84.18
B	85.26	96.63	3.37	11.28	2.50	2.63	80.22
C	86.58	97.72	2.37	13.13	2.13	3.18	77.22
D	84.14	97.11	2.89	15.59	3.48	3.73	74.31
E	84.84	96.70	3.30	23.20	7.00	5.47	61.03

I, II represent experimental periods
A = control (no rubberseed in concentrates)
B = 10% rubberseed by weight in concentrate
C = 20% rubberseed by weight in concentrate
D = 30% rubberseed by weight in concentrate
E = 50% rubberseed by weight in concentrate

Experiment II

Twelve uncastrated West African Dwarf rams ranging in age from 8 to 14 months and weighing between 11 and 15 kg from the University farm at Dschang, Cameroon were used for the investigation. The animals were dewormed and sprayed against ectoparasites before the study began. The animals were randomly assigned to four treatments in a completely randomised block design. The basal diet was chopped fresh elephant grass (*Pennisetum purpureum*), cut on a daily basis while the treatments were for concentrate supplements containing 0, 10, 15 and 20 % rubberseed flour on weight basis. Rubberseed had been stored for 6 months and boiled to detoxify them. The proportions of various feedstuffs in each concentrate are shown in Table 3 while their proximate composition is shown in Table 4.

Animals in each treatment were group-fed for 7 weeks (March-May 1986) and thereafter they were transferred into individual metabolism cages for a period of 2 weeks for evaluation of feed digestibility. The daily ration, 600 g/day of concentrate supplement per group of animals was served at 08.00 hours and 10.00 hours while 6 kg of fresh elephant grass was also served twice a day. Residues of concentrate and forage were weighed after every 24 hours to estimate feed intake. Salt licks and fresh water were provided *ad libitum* while polyvitamin was provided in drinking water every fortnight. Animals were weighed weekly.

In both experiments proximate analysis of forage, concentrate and faecal samples was carried out according to the methods of A.O.A.C. (1970). Data from the experiments were analysed according to the procedures of Steel and Torrie (1980) for analysis of variance and the Duncan's multiple range test was used to test for significant differences between treatment means.

RESULTS

Experiment 1

Dry matter intake, digestibility and liveweight gain by sheep on various treatments are presented in Table 5. Dry matter intake ranged from 30.58 to 54.29 g/day/$W^{0.75}$kg. There were no significant differences in dry matter intake between sheep fed concentrate supplements containing 0, 10 and 20 % rubberseed flour with consumption of 53.84, 52.89 and 54.22 g/day/$W^{0.75}$ kg respectively. When the percentage of rubberseed flour in concentrate was increased to 30 and 50 % there was a significant ($P<0.05$) decrease in dry matter intake. The trend was similar for crude protein intake. Crude protein intake decreased from 7.20 to 5.61 g/day/$W^{0.75}$ kg as rubberseed flour in concentrate was raised from 0 to 50 %.

Table 3. Composition of rations fed to local sheep.

Ingredients (Percentage)	A	B	C	D
Maize	76.1	69.9	66.8	63.7
Rubberseed cake	0	10.0	15.0	20.0
Cottonseed cake	22.4	18.6	16.7	14.8
Salt	0.5	0.5	0.5	0.5
Bicalcium phosphate	1.0	1.0	1.0	1.0
Total	100	100	100	100

Table 4. Proximate composition of concentrate rubberseed and forage.

Components (percentage)	A	B	C	D	Rubber seed	Forage
Dry matter	89.8	90.4	90.3	90.3	92.7	15.35
Ash	3.5	5.1	3.2	3.8	2.6	13.90
Crude protein	20.5	19.3	19.3	19.6	21.0	8.48
Crude fibre	3.1	3.7	3.6	6.3	4.0	16.96
Ether extracts	5.7	8.1	10.9	12.3	39.7	3.78
Nitrogen free	67.2	64.2	53.0	58.0	32.7	56.88

A = Control (only cottonseed cake)
B = 10% rubberseed
C = 15% rubberseed
D = 20% rubberseed

Dry matter digestibility decreased as the level of rubberseed flour in rations was raised. Whereas for the control treatment dry matter digestibility was 77.91% for rations containing rubberseed it declined from 73.22% (10% rubberseed flour) to 57.42% (50% rubberseed flour). The same trend was observed for organic matter digestibility. Crude protein digestibility was quite high with values ranging from 74.96% to 79.99% for treatments with rubberseed flour in the concentrate. There were no significant differences between treatments.

While animals on the control treatment and those containing 10 and 20% rubberseed flour registered increase in weight or maintained their weight, those on concentrate containing 30 and 50 percent rubberseed flour lost weight continuously up to the 7th week after which they began to register gains but the initial weight was not attained when the experiment ended. Sheep on diets containing 30 and 50 percent rubberseed flour had an average daily weight loss of 21 and 51 g respectively, while those having 10% and 20% rubberseed flour registered daily weight gains of 17 and 10 g respectively. The average daily gain for the control ration was 9 g.

Experiment II

Feed intake, digestibility and live weight gain by dwarf sheep maintained on fresh elephant grass and concentrate supplements containing various levels of rubberseed flour as substitute for cottonseed cake are presented in Table 6.

There were no significant differences in dry-matter intake between treatments. Values ranged from 59.82 to 63.18 g/day/$W^{0.75}$ kg. Crude protein intake decreased as the level of rubberseed flour substituted for cottonseed cake in the concentrate was raised. Differences between treatments were not significant. For the control treatment, crude protein was 9.25 g/day/$W^{0.75}$ kg while for sheep on concentrates with 10, 15 and 20 % rubberseed daily crude protein intake was 9.25, 8.66 and 7.68

g/day/$W^{0.75}$ kg respectively. Dry-matter digestibility ranged from 67.22 to 70.66 % for sheep having concentrates with rubberseed flour while for those on concentrates containing only cottons seed as protein supplement it was 69.62 %. There were no significant differences between treatments. Organic matter and crude protein digestibilities were high with ranges of 69.29 to 72.36 and 73.21 to 76.45 % respectively. There were no significant differences between treatments. There were significant differences between treatments in daily weight gain. Whereas sheep on the control ration gained 36 g/day those on concentrates containing 10, 15 and 20 % rubberseed flour had weight gains of 50, 41 and 38 g/day respectively. Sheep on concentrate with 10% rubberseed flour had significantly ($P<0.05$) higher weight gain than other treatments.

Table 5: Feed intake digestibility and live weight gain by West African dwarf sheep fed fresh Guatemala grass and concentrate supplements containing various levels of rubberseed flour.

	TREATMENTS				
	A	B	C	D	E
<u>Feed intake</u>					
Dry matter g/day	448.08	370.67	369.61	326.11	298.17
g/day/$W^{0.75}$kg	53.84a	52.59a	54.22a	37.56b	30.58b
Crude protein g/day	66.63	50.69	54.08	51.43	48.99
g/day/$W^{0.75}$kg	7.20	7.19	7.94	5.92	5.61
Dry matter	77.91	73.22ab	72.50b	60.95c	57.42d
Organic matter	79.28a	74.15b	73.52b	69.90c	60.52c
Crude protein	80.22a	79.10a	78.37a	74.96a	79.99a
<u>Live weight changes</u>					
Mean initial weight (kg)	18.86	12.36	12.53	20.30	22.36
Mean final weight (kg)	19.80	13.76	13.40	18.10	18.06
Average live weight gain (g/day)	9	17	10	26	56

<u>NB</u>: Figures in the same row with the same letter script are not significantly different (P>0.05)

Table 6. Feed intake, digestibility and live weight gain by castrated dwarf sheep fed elephant grass and concentrate supplements containing graded levels of rubberseed flour as substitute of cottonseed cake.

	Treatments			
	A	B	C	D
<u>Feed intake</u>				
Dry matter g/day	464.24	430.53	535.81	365.83
g/day/$W^{0.75}$kg	63.14	63.88	59.82	55.22
Crude Protein g/day	67.62	67.22	61.95	51.29
g/day/$W^{0.75}$kg	9.25	9.25	8.66	7.68
<u>Digestibility (%)</u>				
Dry matter g/day	69.62	67.22	67.22	70.66
Organic matter	71.77	69.44	69.29	72.36
Crude protein	75.18	76.21	73.21	76.45
<u>Weight changes</u>				
Mean initial weight kg	13.58	11.33	13.33	12.00
Mean final weight kg	15.60	14.13	15.60	14.13
Average live weight gain (g/day)	36	50	41	38

A = 0% rubberseed
B = 10% rubberseed
C = 15% rubberseed
D = 20% rubberseed

DISCUSSION

In both experiments, there is generally the tendency for dry matter intake to decrease as the level of rubberseed flour in rations is raised, but this decrease is not significant until the 20% level of incorporation is exceeded. Bo Gohl (1982) pointed out that rubberseed cake can constitute upto 25% of rations for poulets so long as it is supplemented with sulphur containing amino acids. Buvanendran and Siriwardene (1970) reported that rubberseed meal could be used upto the level of 20% for broiler rations while Maffeja (1984) found 20% level of incorporation appropriate for pig rations. Rubber seed may be incorporated in rations at higher levels after detoxification and defattening (Stosic and KayKay, 1981). The seed used for the experiments being reported here were not defatted. Riviere (1978) recommended 0.5 - 1.0 kg/day of rubberseed cake for young cattle while Bo Gohl (1982) suggested 2 - 3 kg per day for adult cattle, but indicated that the product was not quite appetising to sheep.

A decrease in crude protein intake with increase in the level of rubberseed flour in concentrate supplements for sheep was also evident in both experiments. This may be associated with diminishing amounts of concentrate that are consumed as rubberseed proportion in the concentrate is increased which is particularly significant when the proportion exceeds 20 %.

Dry matter digestibility was generally high in both studies, indicating that the rumen microbial population was adequately supplied with dietary nitrogen. The high digestibility of crude protein was also an indication of efficient use of dietary protein.

Meanwhile weight gains were poor in Experiment I when compared to the same levels of incorporation of rubberseed flour in Experiment II (i.e. 10 and 20%). This may be attributed partially to the use of adult sheep in Experiment I whereas growing sheep were used in Experiment II. Also, rubberseed was the major source of dietary protein in Experiment I whereas cottonseed cake and rubberseed were used in experiment II. This could have introduced differences in efficiency of feed intake and utilisation between the two groups of animals. However, the consistent loss in weight by sheep fed concentrate rations with 30 and 50 % level of rubberseed flour in experiment I may be attributed to the possibility of accumulation of hydrocyanic acid in the product which may not have been adequately detoxified before the seeds were milled into flour. Weight loss could also result from the low dry-matter intake that was observed.

At the moment, rubberseed is not used as animal feed despite abundant production in various rubber plantations in the rainy forest region of Cameroon. The cost of production involves collection from the plantations, shelling of fruits to obtain the seeds, detoxification either by treatment with ash solution or heat or long storage for at least 6 months, milling of seed into flour, and separation of oil to obtain the cake using a press or ether extraction.

Utilisation of rubberseed meal or cake has a lot of applications at the level of the smallholders in the southern parts of Cameroon where rubber plantations employing a large labour force are common. Associated with these plantations are smallholder schemes which also sell latex to the large agricultural corporations.

The abundant family labour available in rubber plantations can supplement family income considerably from collection of seed which can be marketed and subsequently processed into the oil and cake on an industrial basis. The oil can be transformed into soap, paint and varnish.

The smallholders can provide better quality feed for poultry, pigs, sheep and goats just by collecting and processing rubber seeds that are presently allowed to rot in plantations. Locally undefatted meal or cake can be used as animal feed. The only constraints against the exploitation of the product are the cost of collection; the bulky nature of the fruits containing the seeds and the tendency for the seed to become mouldy as they are not stored under proper conditions. Also, rubberseed production is seasonal. A large crop is obtained between August and September while a minor one occurs in December and January. Interrupted supply will therefore demand adequate storage to cover other seasons of the year. These constraints can be surmountable at the smallholder level. Any press used for palm, soybean or groundnut oil extraction can also be used for rubberseed oil extraction. Since there is competition for consumption or export of palm, soybean or groundnut oil, rubberseed oil at the smallholder scale may form a basis for small-scale soap production at the family and village level.

Small-scale farmers in the south of Cameroon are not aware of the potential of using rubberseed as animal feed and production of soap from its oil. There is a need to develop a cheap press for extraction of rubberseed meal and a fruit cracker to reduce the time factor associated with these operations so that the processing of rubberseed is more appealing to small-scale farmers. Pilot studies in a rural setting to demonstrate the processing of rubberseed and possibilities for utilisation are needed for smallholders in order to captivate their interest.

CONCLUSION

Utilisation of undefatted rubberseed meal in rations of sheep should not exceed the 20% level of incorporation. Higher levels may be used if extraction of oil is carried out to obtain the cake. A mixture with other protein sources like cottonseed cake is an advantage. Detoxification is a prerequisite for utilisation of rubberseed. Processing and use of rubberseed meal or cake as animal feed especially for small ruminants has a lot of potential at the smallholder scale. Soap production is a small-scale industry that can develop from the processing of rubberseed.

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THE UNEXPLOITED POTENTIAL OF IMPROVED FORAGES IN THE MID-ALTITUDE AND LOWLAND AREAS OF ETHIOPIA

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ABSTRACT

Livestock production is an important integral part of the farming systems in all parts of Ethiopia. This sector of agriculture plays a vital role in the livelihood of the majority of people in the country. In spite of this, the productivity of livestock is low mainly due to malnutrition and undernutrition.

This paper gives a brief summary of the major factors contributing to low productivity of Ethiopian livestock in the mid-altitude and lowland areas of the country and describes the potential role of improved forages in overcoming these problems.

INTRODUCTION

Ethiopia is an agricultural country whose large majority of people are engaged in farming. Production of food crops and livestock are simultaneously done in the cultivated highland and mid-altitude areas. Food crops are produced for subsistence and livestock are raised to provide mainly draft power for crop cultivation and other secondary outputs like milk, meat, hide/skin, dung, manure etc.

LIVESTOCK POPULATION

Ethiopia with its 36.7 million heads of cattle, 24 million sheep and 17.7 million goats, owns the largest livestock population in Africa and is among the top ten in the world (FAO, 1973). The majority of the cattle population of Ethiopia (78%) are found in the mixed farming highland and mid-altitude zones and the rest (22%) are found in the lowland pastoralist areas (Beyene Kebede, 1985)

The highland and mid-altitude zones of the country support 75% of the sheep population and 27% of the goats. The lowlands are inhabited by 25% of the national sheep flock and 72% of the goats (Galal, 1980).

CATTLE PRODUCTION SYSTEMS

In the mixed farming mid-altitude areas cattle are kept primarily for traction purpose and provide milk and meat as by-products. Cattle number per family in these areas is usually small. Cattle obtain their feed requirement by grazing on natural pastures, fallow lands, marginal lands that are not suitable for arable farming and to some extent from crop residues. Due to allocation of more land for crop production, grazing lands are limited. Because of the seasonality of rainfall distribution, grazing conditions are not favourable for more than half the year. Thus animal weight gains obtained during the wet season are lost during the dry season when the feed supply declines both in quality and quantity.

In the lowland pastoralist areas where no or little farming is practised cattle are kept to provide mainly milk. The climate in these areas is harsh with low, unreliable and unevenly distributed rainfall and with year round high temperatures. Animal production usually concentrates around water points and herd size per family is usually large. Range lands in these areas are heavily overgrazed due to high livestock population density. The zone provides the largest proportion of meat production in the country (Alemu Tadesse, 1987).

LIVESTOCK PRODUCTIVITY

Livestock productivity in Ethiopia in high and mid-altitude and lowland areas, in particular is generally, low due to several factors such as poor genetic make up, poor nutrition and poor veterinary care. But poor nutrition is the major limiting factor. Animals in these zones and other parts of the country depend mainly on natural pastures for their feed requirements.

NATURAL PASTURES

Natural pastures which provide more than 90% of the livestock feed are very poorly managed in both ecological zones. In the mixed farming mid-altitude areas better soils are used for cropping and the main permanent natural pasture lands are found on the upper slopes of hills and seasonally waterlogged areas. In the lowlands where extensive pastoralism is practised most of the land except for rivers, swamps, lakes and deserts contains natural pasture which may be associated with woodland in the wetter areas.

Considering the country as a whole, grazing lands contribute 53% (FAO, 1981) of the total land area. Even though the amount of grazing areas seems to be large, the yield and quality of the pasture is very low. Due to poor management and overstocking, natural pastures in both ecological zones are highly overgrazed resulting in serious land degradation, loss of valuable species and dominance by unpalatable species.

In the subhumid mid-altitude areas natural pastures are dominated mainly by Hyparrhenia species which tend to grow fast and become stemmy and fibrous within short period of time thus losing their palatability and feed value. In these areas the overgrazed pastures are dominated by unpalatable Sporobolus and Pennisetum species. Herbage growth is luxuriant during the wet season and this gives large bulk of herbage during the dry season which is be burnt to encourage regrowth in subsequent rains. In semi-arid mid-altitude zones, rainfall is the major factor influencing primary productivity. In some areas feed reserves are so low that a single season of lower than average rainfall can result in the loss of lives of many animals.

Because of diversity of climate, a number of forage species, mainly grasses, are found in both ecological zones. As opposed to natural grasslands of the highland areas which are rich in legume species, grasslands of the mid-altitude and lowland zones have low proportion of legume. The proportion tends to decrease with decrease in altitude. The less abundant native legumes of the lower altitude have sprawling growth.

ECONOMIC IMPORTANCE OF CATTLE

In spite of their poor productivity cattle play a very important role in the livelihood of the majority of people in the rural areas of the mid-altitude and lowland zones of the country. In mid-altitude areas where crop production is the primary occupation of the farming community, they are used as a source of mechanical power to cultivate farm lands. They also provide the main source of animal protein in the form of meat and milk. This protein has higher dietary value than protein of crop origin. In this zone cattle are a form of saving or investment readily converted into cash when the need arises. So, they contribute an important share of farm income (Legesse Dadi et al, 1987).

In the lowlands the livelihood of the pastoralists wholly depend on the milk obtained from cattle. Here also they are used as source of income.

TESTED CULTIVATED PASTURE AND FODDER CROPS

Over the past two decades quite a large number of annual perennial forage and fodder species have been tested in the mid-altitude and lowland zones of the country under rainfed and irrigated conditions respectively. As a result many useful improved herbage species have been identified for both ecological zones.

Chloris gayana, *Panicum coloratum*, *Panicum maximum*, *Melinis minutiflora*, *Pennisetum purpureum*, *Zea mais*, *Sorghum vulgare*, *Sorghum almum*, *Desmodium uncinatum*, *Stylosanthes guianensis*, *Leucaena leucocephala*, *Dolichos lablab*, (*Lablab purpureus*, *Macroptilium atropurpuruem* and *Vicia atropurpurea* are the most promising pasture and fodder species among the tested species so far and are recommended for mid-altitude areas ranging in altitude from 1000 to 1800 m (Lulseged Gebre-Hiwot and Alemu, 1985).

The recommended perennial forages are highly productive (Tables 1 and 2) and in the sub-humid mid-altitude areas under rainfed conditions can give two harvests during the time of normal rains and three to four cuts during years of more than average rainfall.

In research centres and some dairy state farms, the first cut which is usually taken in mid-July is used for making silage the regrowth which is cut in October is used for making hay. Following hay-making, the pasture fields provide considerable grazing for about two months sometime during the early months of the dry season (November and December).

Chloris gayana, *Cenchrus ciliaris*, *Pennisetum purpureum*, *Panicum* spp, *Medicago sativa* and *Leucaena leucocephala* are promising species for semi-arid and arid lowland areas below 1000 m usually under irrigation.

Table 1. DM yield of improved forages in the sub-humid mid-altitude areas of Ethiopia.

	DM Yield (t/ha)				
Varieties/species	1982	1983	1984	1985	Mean
Annuals					
Oat-8237	8.37	8.57	8.04	n.a.	8.33
Sorghum sudanense	5.43	15.96	14.08	n.a.	11.84
Sorghum almum	13.53	17.34	12.74	n.a.	14.33
Dolichos lablab	5.16	14.04	11.74	n.a.	10.31
Perennials					
Chloris gayana	-	9.21	15.55	20.57	18.34
Panicum coloratum	-	9.93	18.00	13.64	13.86
Pennisetum purpureum	16.25	14.41	26.60	14.78	18.01
Desmodium uncinatum	-	1.40	14.70	8.72	10.28

Source: IAR (1986)
n.a. Not available
- not recorded

Table 2. DM yields of two varieties of Leucaena leucocephala at sub-humid mid-altitude areas of Ethiopia.

Varieties	Dry matter yield (t/ha)			
	1981	1982	1983	Mean
Peru	7.69	12.82	15.22	11.91
Cunnigham	6.93	12.64	17.01	12.19

Source: IAR (1986)

In irrigated areas of the lowlands alfalfa and Rhodes grass are very important and can give 8-10 harvests with herbage yield of 45-55 t/ha DM each year. (Lulseged Gebre-Hiwot, 1985).

In general, as research results show (Table 3), the introduced improved species are more productive than naturally occurring swards and have higher nutritive value. The length of green feed period/growing season is longer for cultivated pastures than for native pastures.

Table 3. DM yield of Chloris gayan aand natural pasture harvested at monthly intervals in the subhumid mid-altitude areas of Ethiopia.

Months	Dry matter (%)		Dry matter (t/ha)	
	Chloris gayana	Native pasture	chloris gayana	Native pasture
August	30.0	27.0	6.46	3.46
September	33.0	33.0	8.77	4.64
October	40.0	35.0	10.32	5.64
November	47.0	50.0	10.41	5.94
December	64.0	52.0	12.55	4.03
January	58.0	68.0	10.38	4.53
February	61.0	76.0	8.98	5.17
March	66.0	78.0	11.50	4.42
April	59.0	69.0	6.92	2.89
May	52.0	56.0	8.32	5.86
June	44.0	39.0	9.86	9.96
Mean	50.4	53.0	9.44	5.13

Source: IAR (1986)

ESTABLISHMENT OF IMPROVED FORAGES IN NATURAL PASTURES

As indicated in the previous section, most of the natural grazing lands in the mid-altitude and lowland zones are highly overgrazed due to mismanagement and over stocking. Their productivity and feed value are also low due to low proportion of legumes. Improved forages, mainly legumes, can improve the productivity of these pastures by improving the fertility status of the soil. They can also improve the feed value of native pastures since they have more protein content than naturally occurring grass swards.

To improve the productivity, vegetation compostion and feed value of degraded natural pastures, oversowing of improved legumes and grasses has been tried in the mid-altitude areas. Results (Table 4) indicate that *Stylosanthes guianensis* showed superior establishment on burnt natural pasture while *Desmodium uncinatum* is potential species for this purpose. Rhodes grass failed to establish with minimum soil disturbance.

Table 4: DM yield and percent composition of improved legumes oversown in hyparrhenia-dominated natural pasture in the subhumid mid-altitude areas of Ethiopia.

Treatments	Oversown legumes	DM yield (t/ha)		Percent composition	
		Legumes	Native	legumes pasture	Native pasture
1	+ Stylosanthes guianensis (cv. Endeavour)	0.05	2.69	2.0	98.0
	+ S. guianensis (cv. Cook)	0.02	2.67	0.7	99.3
	+ S. humilis	-	2.97	-	100.0
	+ Desmodium uncinatum	-	3.26	-	100.0
	S. guianensis (cv. Schofield)	0.07	2.54	3.0	97.0
II	+ S. guianensis (cv. Endeavour)	0.17	3.12	6.0	94.0
	+ S. guianensis (cv. Cook)	0.28	3.86	7.0	93.0
	S. humilis	0.18	2.99	6.0	94.0
	D. uncinatum	0.41	3.68	10.0	90.0
	S. guianensis (cv. Schofield)	0.38	2.88	12.0	88.0
III	S. guianensis (cv. Endeavour)	0.19	2.70	7.0	93.0
	S. guianensis (cv. Cook)	0.09	2.53	3.0	97.0
	S. humilis	0.08	2.74	3.0	97.0
	Desmodium uncinatum	0.54	2.90	16.0	84.0
	S. guianensis (cv. Schofield)	0.42	3.07	12.0	88.0
IV	S. guianensis (cv. Endeavour)	0.09	3.28	3.0	97.0
	S. guianensis (cv. Cook)	0.53	3.05	15.0	85.0
	S. humilis	0.06	3.99	2.0	98.0
	D. uncinatum	0.27	3.56	7.0	93.0
	S. guianensis (cv. Schofield)	0.55	2.82	16.0	84.0

Note: + Treatments

I = Undisturbed natural pasture

II = Disc-harrowed natural pasture

III = Oxen-ploughed natural pasture

IV = Burned natural pasture

Source: IAR (1986)

Conventional methods of pasture establishment demand high capital cost and labour. Low cost establishment methods such as intercropping forages with food crops are economically feasible for resource poor farmers. Research results (Table 5 and 6) indicate that some improved forages such as Chloris gayana and Desmodium uncinatum can successfully establish when undersown to maize after final weeding of the crop without affecting maize grain yield. The forages persisted well for three to four years after establishment.

It is a tradition among the majority of farmers in the mid-altitude areas to abandon their crop lands to naturally regenerated fallows after some years of continuous cultivation. This is done for soil fertility restoration purposes. Fallowing is good since it allows accumulation and storage of nutrients in the above ground vegetation for later release to the surface soil. It also helps to add organic matter to the surface soil thereby increasing total nutrient and cation exchange capacity.

It also has the additional value in reducing crop-associated weeds, pests and diseases (Mohammed Saleem, 1984). If improved forages are planted on fallow lands they have double advantage of rapidly restoring the fertility of soil and providing nutritious herbage to livestock. The forage which successfully establishes using the indicated method can be effectively used for this purpose.

Table 5. Grain yield of maize intercropped with different forage crops at two mid-altitude areas of Ethiopia.

No	Intercropped forages	Maize grain yield (q/ha)	
		Bako	Awassa
1	Control (no intercropped forage)	73.3	58.9
2	*Chloris gayana* (cv. Pokot)	67.5	59.2
3	*Chloris gayana* (cv. Masaba)	77.9	n.a
4	*Chloris gayana* (cv. Rongai)	74.9	n.a
5	*Panicum maximum*	74.2	58.5
6	*Brachiaria ruziziensis*	81.7	n.a
7	*Cenchrus ciliaris*	n.a	58.4
8	*Desmodium uncinatum*	66.0	62.7
9	*Medicago sativa*	n.a	56.4
10	*Phaseolus lathyroides*	n.a	58.7
	Mean	73.4	59.0
	cv	19%	13.9
	SE	±7.0q/ha	±5.8q/ha
	n.a	not available	

Source: IAR (1982)

Table 6. Dry matter yield of different forages undersown to maize in the subhumid mid-altitude area of Ethiopia.

Intercropped forages	Dry matter yield (t/ha)		
	1983	1984	Mean
Chloris gayana (cv. pokot)	8.26	14.42	11.38
Chloris gayana (cv. massaba)	11.78	12.47	12.12
Chloris gayana (cv. Rongai)	10.65	15.14	12.89
Desmodium uncinatum	5.68	7.53	6.60

Source: IAR (1986)

SEED PRODUCTION POTENTIAL OF IMPROVED FORAGES

Except few, most of the improved tropical forages adapted to the environmental conditions of the mid altitude and lowland areas of Ethiopia have no problem of flowering and seed setting. Small quantities of seeds are often collected from experimental plots and bulking seed production mini plots. Observations made at Bako which is one of the subhumid mid-altitude areas of the country, show that Rhodes grass at optimum seed rate and row spacing on experimental plots can give up to 700 kg of seeds/ha. *Panicum coloratum*, *Desmodium uncinatum* and *Stylosanthes guianensis* gave seed yields of 500 kg/ha, 400 kg/ha and 350 kg/ha respectively. *Lablab purpureus* gave about 1700 kg of seeds/ha (unpublished data).

Work done at the same location also indicated that seed yields of vetch (*Vicia atropurpurea*) could be increased by upto 600% (Table 7) when grown and supported by fences. This allows multiple harvests.

Table 7. Effect of support system on seed yield of *Vicia atropurpurea*

	Seed yield (q/ha)			
Treatments	1983	1984	1985	Mean
Without support	7.71	6.39	5.96	6.69
With support	48.71	51.99	49.59	50.10

Source: IAR (1986)

PRESENT STATUS OF IMPROVED FORAGES IN THE FARMING SYSTEMS OF THE MID-ALTITUDE AND LOWLAND AREAS OF ETHIOPIA

As in many other parts of the country, diffusion of research results has been slow in the mid-altitude and lowland areas mainly due to non-availability of a well-organised extension system, particularly before the establishment of Research and Extension Linkage Coordination Division (RELC). This Division was established two years ago based on the agreement made between the Institute of Agricultural Research (IAR) and the Ministry of Agriculture (MOA) in order to bridge the gap between research and extension which is the major bottleneck to the development of Ethiopian agriculture.

Although many useful and suitable improved forages have been identified for the two ecological zones, they have not effectively reached the farming community. Only two species, *Chloris gayana* and *Medicago sativa* are used in research centres. Some dairy producer co-operatives which are emerging in some mid-altitude areas own crossbred cattle which require better feeding. These co-operatives are growing pastures and fodder crops such as oats, vetch and Rhodes grass. The improved pastures are used for hay or green feeding.

FACTORS LIMITING THE UTILISATION OF IMPROVED FORAGES IN THE SMALL-HOLDER SECTORS

1. Farmers give more priority to the production of food crops. They are reluctant to devote their extra land and labour for production of forages. This is mainly due to economic factors and due to lack of knowledge.

2. Poor co-ordination among research institutions and development organisations.

Due to lack of co-ordination there is very loose link between research and extension. Researchers do not get enough feedback information to enable them to plan their research activities based on the need of farmers. So, most of the time, projects are proposed based on locally perceived problems.

3. Shortage of seeds of required species.

There is no forage seed producing organisation in the country at present. The Ethiopia seed enterprise is the only seed-producing organisation which is engaged in the production of seeds of selected food crops only. So there is acute shortage of pasture seeds in the country.

4. Lack of low cost packages is another limiting factor.

CONCLUSION

The livestock sector plays a very important role in the overall development of Ethiopia's agriculture. The country has a large cattle population, vast areas of grazing lands and suitable environment for raising livestock. The people also have the traditional background and knowledge of raising livestock for different purposes. All these are potential resources awaiting exploitation for improving the country's livestock productivity.

Experience indicates that with the application of some improved management practices, such as using improved feeding systems, the productivity of livestock can be raised. The promising improved forages identified so far can also contribute much towards improving the productivity of livestock in both ecological zones.

In order to facilitate the immediate diffusion of improved forages into the farming systems of the two ecological zones, the farmers need to learn the importance of these species in improving the productivity of livestock. A well-organised extension system is required for this purpose.

The Research and Extension Linkage Co-ordination Division can play a great role in this aspect. Thhere was recently established in IAR inorder to bridge the gap between research and extension. The main task of the division is to demonstrate research results on farmers' fields and train development agents on how to utilise research results. The division is also mandated to feed back information on farmers problems to researchers.

The problem of seed shortage also needs to be solved in order to efficiently utilise these species. The effort being made by the Fourth Livestock Development Project of the Ministry of Agriculture to make forage seeds available to farmers is one possible solution for the problem. But still more effort is needed from other organisations like the Seed Enterprise of Ethiopia in producing seeds of the recommended forages in larger quantities for both ecological zones.

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THE POTENTIAL OF SWEET POTATO (<u>IPOMEA</u> <u>BATATAS</u> (L.)LAMB) AS A DUAL PURPOSE CROP IN SEMI-ARID CROP/LIVESTOCK SYSTEMS IN KENYA

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ABSTRACT

The potential of sweet potatoes (<u>Ipomea</u> <u>batatas</u>(L.)Lamb) for use as a dual purpose crop in crop/livestock systems of semi-arid Kenya was studied on twelve accessions. Root initiation (fibrous and fresh roots), vine growth and nutritional quality and effects of supplementing vines and cottonseed cake (CSC) on growth of Boran weaner male calves were investigated.

Time to fibrous root initiation was not significantly different ($P<0.05$) but significant differences ($P<0.05$) were observed in mean root numbers and lengths after 10 days of growth. Accessions differed significantly ($P<0.05$) in time to freshy tuber initiation, enlarged tuber numbers and tuber weight. Trends in vine components (stem and leaves) yields showed a decline after 120 or 150 days from transplanting. A significant ($P<0.05$) time x vine dry matter (DM) accumulation rate interaction was obtained. Percent protein (CP), cell contents (CC), cell wall constituents (CWC) and acid detergent lignin (ADL) differed significantly ($P<0.05$) among the accessions while acid detergent fiber (ADF) and ash were not significantly different ($P>0.05$).

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Supplemental vines and cottonseed cake significantly improved ($P<0.01$) intake of Rhodes grass hay, calf growth rates and feed conversion efficiencies.

The data suggests that sweet potato vines could replace CSC as a livestock feed supplement.

Implications on the use of vines as livestock feed supplements are discussed. The variation exhibited in the attributes measured indicate that selections that optimise tuber and vine yields are possible.

INTRODUCTION

Crops and livestock form integral components in providing for the human population in semi-arid Kenya. This has necessitated re-orientation in developing technical packages that integrate the two production systems. Several studies have reported on dry matter production and distribution in sweet potato (Ipomea batatas(L.)Lamb) during growth and development (Austin, 1973; Huett and O'Neill, 1976; Karachi, 1982a and Bourke, 1984). Attempts were further made (Karachi, 1982b) to broadly classify Kenyan materials into dual purpose tuber and vine producing types based on tops: tuber yield ratios.

The dual purpose types have a potential role in the development of production technologies that aim at integrating crops and livestock commodity factors into an integral production system. The following investigations were initiated to study production characteristics, forage quality and animal production potential of some selected Kenyan sweet potato accessions for inclusion into crop/livestock production systems.

MATERIALS AND METHODS

Twelve accessions, Mania, Namala, Mkizumu, 3011, Kiganda, Munyoka (R), Calorine Lee, Musinya, Widowi, Mulenjet, Opiemo and Lunyulule were used in each experiment.

Experiment 1: Fibrous root development

The experiment was conducted in an open grasshouse at National Dryland Farming Research Centre, Katumani. The aim was to determine whether there were differences in fibrous root initiation and growth between the accessions under adequate moisture conditions.

Five 30 cm long apical vines from each accession were cut at a node, tied loosely together with cotton thread and put in 10 cm diameter, 20 cm long polythene bags. The cut vine tips were bedded into 3 cm depth of water. The experiment was a randomised complete block design with three replications. Indications of root initiation were recorded on each vine daily as swellings at the nodes. Mean root lengths and numbers were recorded 10 days from root initiation for each accession. Water in polythene bags was not changed during the experimental period.

Experiment 2: Tuber development and vine quality

Two experiments involving yearly replanting were conducted under rainfed conditions at Beef Research Station, Nakuru. Each experiment was established after 30 mm establishment rainfall was received; a total of 610 mm (year 1) and 590 mm (year 2) was received during the growth periods.

Plot sizes were 6 m x 3.6 m. The design was a split-plot with accessions as main plots and sampling dates as sub-plots. There were three replicates. Vine cuttings, 30 cm long, were planted on flats at 60 cm within row spacing and 30 cm between row spacing. Fertilizers at the rates of 20 kg P/ha, 15 kg K/ha and 10 kg N/ha as single superphosphate, muriate of potash and calcium ammonium nitrate, respectively, were placed in small furrows about 3 cm depth and width adjacent to vine rows and immediately covered. The plots were clean weeded throughout the experiment.

Trends in tuberisation and dry-matter accumulation were monitored over four harvest dates ranging from 120, 150, 180 and 210 days after planting. Six randomly selected adjacent plants were harvested by hand digging leaving the border plants. On each harvest date, total number and fresh weight of enlarged tubers, >3 cm diameter, clean of soil and total fresh weight of vines were recorded. Subsamples, on replicate basis, of enlarged tubers (sliced) and vines were dried in a forced draft oven (105^{0}C for 24 h) for dry matter (DM) determination. Another set of subsamples was dried at 60^{0}C for 24 h, ground to pass through 2 mm sieve and stored in airtight plastic bottles for chemical analysis. Crude protein (CP) was determined by microkjedahl method and ash content as described by AOAC (1970). The fibre fractions were determined according to Goering and Van Soest (1970).

Bulking plots of the same accessions were established at the same time for a feeding trial.

Experiment 3: Effect of supplement sweet potato vines and cottonseed cake (SCS) on growth of weaned Boran calves.

The experiments were conducted aimed at comparing growth rates of penned Boran calves fed on chopped (approximately 3 cm length) Rhodes grass hay as basal roughage supplemented with either sweet potato vines (mean CP, 13% on DM basis) or cottonseed cake (mean CP, 33% on DM basis). Sweet potato vines were 210 days old from transplanting. The vines were harvested, air dried and chopped (approximately 3 cm length) before commencement of the trials. All weaners were dewormed before the start of the experiment using Ranzole (Merk, Sharp and Dohme B.V. Netherlands Commercial) mineral supplement 'stock lick', from Unga Feeds Ltd, Nairobi and water were provided *ad libitum*

Calves, 131±5, 134±7 and 140±4 kg (experiment 3a) and 132±6, 129±3 and 126± kg (experiment 3b) initial mean fasted liveweights (16h without water or feed) were either fed hay (*ad lib*), hay + 500 g vines DM and hay + 200 g DM cottonseed cake head/day. The supplements provided additional 65 and 66 g crude protein/head/day respectively. In experiment 3b the weaners were supplemented with additional 100 g urea/molasses, (4% CP) head/day to improve forage intake. Each experiment consisted o a preliminary period of 14 days to allow adjustment of weaners diets and facilities. Calves were randomly allocated to treatments in groups of nine per pen. Half of the estimated ha intake (established during the adjustment period) was mixed witl the supplements and offered at 09.00 h. The remaining forage component was offered at 14.00 h allowing 15% more forage than that consumed the previous day. The experimental design was a randomised complete block with two replications.

Records were kept of feed offered, less refusals, to obtair intake data. The dry matter intake was calculated on a basis ol 7 day totals of dietary components offered, less refusals. At the start of each experiment and after every 15 days during the feeding period, starved weaner liveweights were taken.

Chemical composition of feeds on offer was determined as described in experiment 2. _In vitro_ dry matter digestibility wa estimated by Tilley and Terry (1963) procedures. Statistical analyses of all data was done according to Steel and Torrie (1980). Means were subjected to Duncan's multiple range test fo determination of significant differences.

RESULTS AND DISCUSSION

Fibrous Roots

Time to fibrous root initiation was not significantly different ($P<0.05$) between the cultivars but significant differences ($P<0.05$) were observed with fibrous root numbers and root length (Table 1). However, relationships between these rooting characters are not apparent. This experiment should be conducte under field situation to examine whether the accessions exhibit similar growth trends under limited moisture conditions.

Freshy roots

Time to production of thickened tubers as measured by roots >3 cm diameter (Table 2) differed significantly ($P<0.05$) among accessions. Generally, accessions Mania, 3011 and Muyoka (R) could be classified as early tuber initiators ($<$than 150 days from transplanting) while the others (except Namala, Mulenjeti and Lunyulule) which did not produce tubers are late tuber initiators. The late tuber initiators also tended to have significantly higher ($P<0.05$) root tuber numbers. Root tuber numbers and tuber weight varied among accessions confirming the results of Karachi (1982b) and Randle (1987). Accession 3011 had the highest and significant ($P<0.01$) mean tuber weight (21.4 ± 2.2g) while Muyoka (R) had the lowest and significant ($P<0.01$, 3.3 ± 0.4g). Accession Opiemo had the highest and significant ($P<0.01$) mean tuber numbers (13.3 ± 1.5g) and Muyoka (R) the lowest and significant (1.7 ± 0.1g). No apparent relationship between root tuber numbers, tuber weight or time to tuber initiation was evident.

Tops dry weight

Changes in dry weights of tops components are shown in Figure 1. A significant ($P<0.05$) harvest time x species interraction was detected. Accessions showed declined trends in leaf and stem DM accumulation after day 120 from transplanting but at different rates. The leaf component declined at a higher rate than that of the stem fraction leading to a reduction in leaf contribution to total DM with maturity which conforms with Randle (1987). This could eventually result in reduction of the nutritive value of the vines (Karachi 1982a). The declining trends were most marked when enlarged root tubers were recorded suggesting most assimilates were directed to tuber development (Austin, 1973 and Bhagsari and Harmon, 1982).

Table 1. Fibrous root initiation, number of roots (mean ± S.E) and root lengths (cm, mean ± S.E)

Accession	Days to root initiation	Number of roots	Root lengths (cm) (10 days from initiation)
Mania	4	8.9 ± 1.2	11.5 ± 0.5
Namala	3	15.3 ± 2.9	15.5 ± 1.3
Mkizumu	5	6.5 ± 0.8	5.0 ± 0.6
3011	4	7.8 ± 1.2	5.0 ± 0.2
Kiganda	4	3.3 ± 0.2	8.0 ± 1.2
Muyoka (R)	3	9.4 ± 1.1	6.0 ± 0.3
Calorine Lee	3	6.6 ± 0.5	10.5 ± 1.1
Musinya	3	6.4 ± 0.3	12.5 ± 1.7
Widowi	3	4.7 ± 0.2	10.0 ± 0.7
Mulenjeti	4	9.2 ± 0.7	8.2 ± 0.3
Opiemo	3	7.3 ± 0.4	10.1 ± 0.9
Lunjulule	6	8.8 ± 0.4	4.0 ± 0.1
LSD (P<.05)	NS	4.3	3.5

Table 2. Number of tubers (Mean ± S.E) and tuber weight[a] (g, mean ± S.E) per vine[a]

Accession	DAYS FROM PLANTING 120		150		180		210	
	Number of tubers	Tuber weight	Number of tubers	Tuber weight	Number of tubers	Tuber weight	Number of tubers	Tuber weight
Mania			5.5 ±1.3	6.5 ±1.4				
Namala[b]								
Mkizumu					4.1 ±1.2	12.1 ±1.2		
3011	3.6 ±0.2	21.4 ±2.2						
Kiganda							2.2 ±0.1	8.2 ±2.0
Muyoka (R)	1.7± 0.1	3.3 ±0.4						
Calorie Lee							2.4 ±0.3	6.6 ±1.3
Musinya							7.4 ±0.8	14.4 ±1.6
Widowi					3.1 ±0.8	8.8 ±0.7		
Mulenjeti[b]								
Opiemo					13.3 ±1.5	17.7 ±0.9		
Lunyulule[b]								

[a] Tubers with middle portion >3 cm diameter

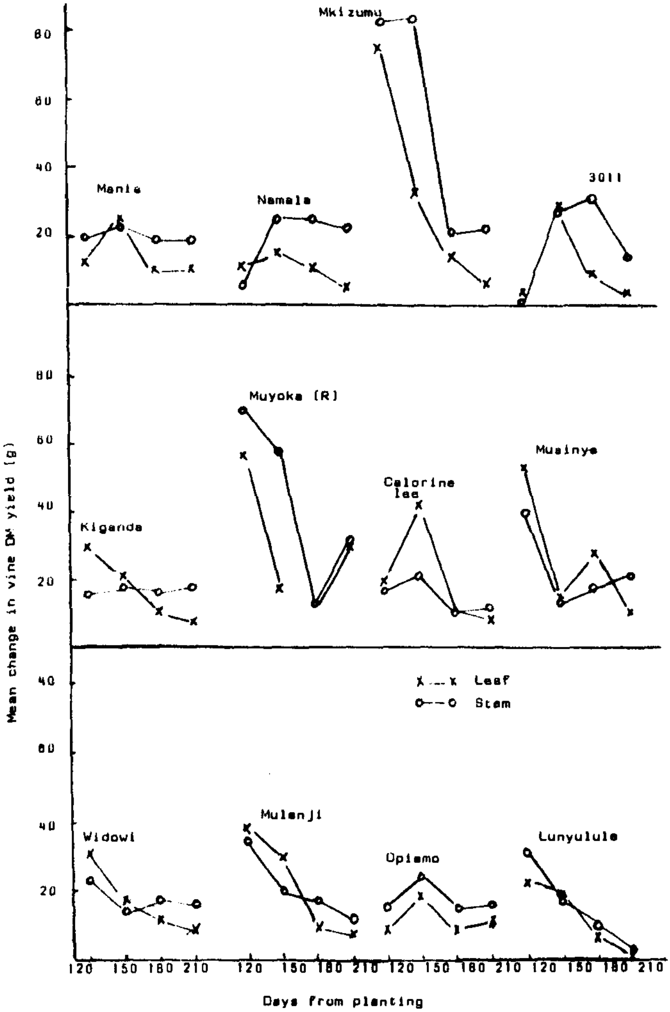
b Accessions did not tuber within the experiment period

LSD (P<.05)

Tuber numbers 3.2

Tuber weight 4.6

Figure 1: Trends in vine components dry matter production



Chemical composition of tops

Chemical composition of tops (Table 3) showed significant ($P<0.05$) differences in protein content (CP%), cell contents (CC%), cell wall constituents (CWC%) and acid detergent lignin (ADL%). Acid detergent fibre (ADF%) and ash contents were not significantly different ($P>0.05$). The content of these attributes ranged by approximately 5, 13, 11, 4, 6 and 2 percentage units respectively between the accessions indicating that selections could be made that optimises vine nutritional qualities. Overall, the materials show protein levels are adequate to meet animal requirements for beef production (Church, 1980). However, the lignin levels are high which is characteristic of forbs (Van Soest, 1982). A.N. Said (unpublished data) recorded low water intake and high urination rates by sheep fed sweet potato vines. Fractionating the mineral content in the ash and the DM content in the forage may assist in explaining this observation.

Calf responses

Chemical composition of rations offered (Table 4) indicate protein content was slightly above levels that intake is depreseed (6-8% CP, Van Soest 1982). *In vitro* dry matter digestibility (IVDMD%) show that the feeds were of medium quality and generally improved with supplementation.

Table 3. Chemical composition (Mean ± S.E) of vines after 210 days from planting.

Accession	CP%	CC%	CWC%	ADF%	ADL%	ASH%
Mania	11.1 ± 1.2	46.5 ± 3.4	53.6 ± 1.6	46.2 ± 0.2	14.2 ± 0.2	10.6 ± 0.6
Namala	13.9 ± 1.9	47.0 ± 5.8	53.7 ± 0.7	42.0 ± 0.2	13.2 ± 1.2	12.2 ± 1.1
Mkizumu	12.1 ± 1.3	45.5 ± 1.3	54.5 ± 2.4	39.0 ± 2.2	14.4 ± 0.4	11.3 ± 0.3
3011	14.0 ± 0.5	44.6 ± 5.9	55.1 ± 0.3	37.6 ± 1.3	13.1 ± 0.7	11.6 ± 0.3
Kiganda (K)	10.6 ± 0.6	45.4 ± 2.6	52.2 ± 4.2	43.6 ± 1.2	14.6 ± 0.9	11.2 ± 1.6
Muyoka (R)	12.8 ± 0.6	54.4 ± 1.8	52.0 ± 0.1	42.8 ± 3.4	14.0 ± 0.5	10.0 ± 0.5
Calorine Lee	12.6 ± 0.1	49.2 ± 1.3	51.0 ± 2.3	40.4 ± 1.8	13.5 ± 1.3	10.0 ± 0.8
Musinya	12.2 ± 0.2	47.8 ± 4.1	47.9 ± 1.7	38.2 ± 2.1	12.1 ± 0.3	11.5 ± 0.4
Widowi	9.6 ± 0.8	43.8 ± 3.9	56.2 ± 1.9	41.8 ± 1.7	14.4 ± 0.6	9.9 ± 1.3
Mulenjeti	13.8 ± 1.1	45.3 ± 2.8	53.6 ± 3.3	41.1 ± 0.5	15.8 ± 1.1	11.5 ± 1.9
Opiemo	12.8 ± 0.3	41.4 ± 3.5	58.6 ± 1.8	42.4 ± 1.9	16.2 ± 1.3	11.5 ± 1.0
Lunyulule	15.1 ± 0.9	50.1 ± 1.4	48.6 ± 1.7	37.8 ± 1.8	12.8 ± 0.8	10.0 ± 1.2
LSD (P<.05)	2.8	6.3	6.5	NS	3.4	NS

Table 4: Chemical composition and *in vitro* dry matter digestibility of rations.

Ration	CP%	ADF%	ADL%	ASH%	IVDMD%
		Experiment 1			
hay alone	6.1	53.9	5.6	10.4	40.1
hay + vines	6.8	51.3	6.1	12.3	47.3
hay + CSC	7.2	51.7	6.4	11.8	48.8
		Experiment 2			
hay alone	6.5	52.6	5.2	10.6	43.6
hay + vines	7.1	47.8	5.6	13.6	50.7
hay + CSC	7.4	50.2	6.2	12.6	46.2

Table 5: Effect of vines and cottonseed cake (CSC) supplementation on DM intake and calf growth rates

		Treatments		
		Experiments		
Total DM intake	hay	hay + vines	Hay + CSC	S.E.
(kg/day)	2.7^a	3.5^b	4.1^c	.25
Growth rate (kg/day)	$.11^a$	$.28^b$	$.37^c$	.03
Feed conversion ratio (feed/gain)	24.5^b	12.5^a	11.1^a	1.37
		Experiment 2		
Total DM intake kg/day	3.4^a	4.2^b	4.6^b	.21
Growth rate (kg/day	$.18^a$	.34b	$.39^b$	.05
Feed conversion ratio (few/gain)	18.9^b	11.8^a	11.8^a	1.12

S.E. - Standard error

abc - means within a row followed by different superscripts differ (P<.01)

Weaners supplemented with vines and cottonseed cake consumed 30 and 50% more (P<0.01) total DM respectively than those fed on grass alone (Table 5 experiment 3a). The improved feed intake was associated with 2.5 to 3.4 times (P<0.01) gain in calf liveweights and 49 to 55% improved (P<0.01) efficiencies in utilising the feed above that of calves fed on grass alone. Inclusion of urea/molasses (experiment 3b) increased (P<0.01) total DM intake, liveweight gains and feed utilisation efficiencies. The magnitude of gain was 1.9 and 2.2 times (P<0.01) and feed efficiency, 38% (P<0.01) above that of control calves. Molasses was probably associated with overcoming dietary energy deficits since liveweight gains were similar among the supplemented groups. Cottonseed cake contains substantial levels of energy.

Practical implications

Inherent climatic constraints in semi-arid bimodal rainfall zones with <120 growing days, entail that the cultivars/accessions should initiate fibrous and fresh root growth and the partitioning of assimilates between tops and root tubers within relatively short growth periods. Although no differences were exhibited on time to fibrous root initiation, data on root numbers and lengths suggest that differences may exist in the ability of the accessions to exploit the available moisture. This could be a critical determinant of successful establishment under unreliable and limited moisture conditions typical in semi-arid environments. Freshy root initiation by accessions 3011 and Muyoka (R) indicate their ability to produce tubers within the period effective moisture is expected (in Machakos). The other accessions appear suitable for semi-arid unimodal rainfall high altitude areas, 150-180 growing days (in Nakuru) while accessions Namala, Mulenjeti and Opiemo are essentially vine producing types under these growth conditions.

Sweet potato tubers are used as dry season human food security. Prolonged storage of tubers in the soil leads to leaf shed and increased synthesis of fibre fractions in the stem which are antiquality characteristics. Vine DM accumulation rates declined within 120-150 days from transplanting but showed minimal change at 210 days suggesting this would be the optimal feeding period. Therefore the use of sweet potato vines as feed supplement in the dry season may require selection of materials with capacity to retain leaves. Another possibility would be to cut vines before leaf-shed for storage. However information on effects of cutting vines on tuber storability is lacking.

Supplementing weaners with 500 g/head/day of vines effected growth equivalent to that of calves fed 200 g cottonseed cake head/day. At the current price of KShs.7.00 (USD 0.35)/kg high grade cottonseed cake it is apparent that compounding feeds based on vines rather than cottonseed cake would be an attractive venture. Greater value would further be obtained from supplementing vines to dairy stock or replacement heifers than beef-animals. Nevertheless, the DM content of fresh vines is usually <30%, necessitating feeding substantial amounts.

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SESSION IV
TECHNOLOGY TESTING, EVALUATION AND ADOPTION

INTERCROPPING *TRIFOLIUM* SPP. IN WHEAT AND ITS SUITABILITY FOR SMALLHOLDER FARMER CONDITIONS OF THE ETHIOPIA HIGHLANDS

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ABSTRACT

In May/June 1987 two annual Ethiopian clovers, *Trifolium decorum* and *T. quartinianum* were intercropped in wheat, *Triticum aestivum* on a vertisol at Shola, Addis Ababa (2380 m, 9° 02'N), and on a Nitosol at Holetta 40 km West of Addis Ababa in single or double alternate rows or by broadcast. The intercropped wheat received 30 kg N/ha and the clovers 0, 20, 40, Or 80 kg P/ha. Control wheat plots received split-applications of 0, 30, 60, 90 kg N/ha. There were no significant grain yield reduction by intercropping from which 1075-1992 kg grain/ha were obtained. Broadcasting significantly gave less yield than row planting. P had a linear effect on legume yield which varied from 471-5766 kg/ha. Holleta had higher yields due to better drainage and sufficient rains during the growing season. Shola had lower yields mainly due to some water logging in wheat and low rainfall for the clovers as there were insufficient rains in many parts of Ethiopia.

INTRODUCTION

Previous evaluation of annual native *Trifolium* spp. showed that they can produce up to 6 t DM/ha thus indicating potential for livestock feed under highland conditions (Kahurananga and Tsehay, 1984). This potential can be realised if these legumes are used under mixed crop/livestock farmer conditions. Usually smallholder farmers do not readily adopt the cultivation of forages as they devote both land and labour to crop production. The forages can only be adopted if they are introduced into cropping systems. One way of achieving this is through intercropping. This provides nutritious feed for livestock while at the same time improving soils fertility through biological N fixation which in turn sustains crop production. Therefore, the purpose of this study carried out in 1987 was to develop methodologies for intercropping annual Trifolium spp. into wheat, suitable for smallholder farmer conditions.

MATERIALS AND METHODS

The trial was conducted at two sites. The first one was at ILCA Headquarters, Shola, Addis Ababa ($9^{o}02'N$, $38^{o}4'E$) at an elevation of 2380 m on gently sloping ground with seasonally water-logged black clay, Vertisol. The soil was slightly acidic (pH 5.8) and very deficient in both total N (0.19%) and available P (8.68 ppm). Total annual rainfall in 1987 was 1090 mm with 723 mm falling during the growing season from May to October (Shoamare, 1988). Average maximum and minimum temperatures during the growing season were $22^{o}C$ and $11^{o}C$ respectively. See Table 1 for details.

The second site was at the Institute of Agricultural Research (IAR) station at Holleta, 40km West of Addis ($9^{o}03N$, $38^{o}30E$) at an elevation of 2400 m on gently sloping ground with well drained red brown clay loam soil, Nitosol. The soil was acidic (pH 5.5) and deficient in total available N (0.12%) and available P(9.00 ppm). Total annual rainfall was 1102 mm with 797 mm falling during the rainy season from May to October. Average maximum and minimum temperatures during the growing season were $21^{o}C$ and $8^{o}C$ respectively. (Gebre Hiwot et al 1987). See Table 1 for details.

The experiment was a randomized split-plot design with three replicates. Two clovers, Trifolium decorum and T. quartinianum were intercropped in wheat, variety Enkoy at 3 spatial designs plus wheat alone and 4 sub-plot fertilizer treatments of 0, 20, 40, 80 kg P/ha. Urea was applied at a rate of 30 kg N/ha in all wheat rows. There was an extra sole wheat control with 4 split-plot treatments of 0, 30, 60, 90 kg N/ha. In all there were 8 main plots and 32 sub-plots in three replicates.

The main plots were 5 m x 2.4 m with 1 m paths and the sub-plots were 15 kg of clover/ha. The first spatial design consisted of alternate rows of wheat and clover at 20 cm rows and the clover also 20 cm apart. The third consisted of wheat in 20 cm rows and the clover broadcast. A row woker was used to make shallow rows (1 cm) for clover and deeper ones (5 cm) for wheat into which fertilizer was applied and mixed with soil before the seeds were planted. Clover seeds were scarified with sand-paper prior to planting. The planting dates were 25 May at Holetta and 2 June at Shola.

Observations taken included emergence date, percentage germination, first and full flowering dates for clovers and tillering and heading dates for wheat. The clovers were harvested at 50% flowering and the wheat at full maturity. The legumes were harvested at Holetta on 23 October and the wheat on 6th November. The harvesting dates for wheat and legumes at Shola were 22 October and 7 November respectively. Two 50 cm x 50 cm random quadrats were cut at 2 cm stubble height from each sub-plot using sheep shears. Material from each sub-plot was bulked, weighed and a 250 gm sample taken and dried in the oven at 65^{o} for 24 hrs for estimation of dry matter. In the case of wheat, the seed heads were removed before the straw was oven-dried. The wheat heads were dried in the sun and then threshed and the seed weighted. After samples were taken all the wheat was harvested and the remaining stubble and clover left for cattle which ate it to the ground level.

Table 1. Rainfall and temperature data for Holetta and Shola, Ethiopia, 1987.

	Rainfall (mm)		Number of Rainy days		Air temperature (?C) at 1.5 m			
							Minimum	Maximum
	Holetta	Shola	Holetta	Shola	Holetta	Shola	Holetta	Shola
January	2.4	6.2	3	2	2.5	6.6	22.9	23.9
February	112.1	32.8	10	10	10.1	10.0	22.5	24.4
March	77.3	249.1	21	24	6.8	11.7	23.6	22.8
April	82.4	78.0	12	13	8.2	11.4	22.6	23.4
May	137.0	196.3	16	17	8.8	11.4	22.6	23.0
June	86.5	51.4	23	23	7.8	10.4	22.0	22.5
July	182.1	192.6	27	31	8.8	11.0	20.9	21.4
August	261.8	179.2	29	30	9.7	11.3	20.0	21.2
September	112.9	73.9	16	17	7.8	11.4	21.5	22.7
October	19.0	29.6	6	9	5.6	9.1	22.6	23.3
November	11.4	0.4	2	1	2.2	7.1	23.3	23.5
December	27.4	0.4	3	1	3.0	7.5	23.5	24.0
Total	1102.3	1689.9	168	178				

Sources: Adapted from Gebre Hiwot et al; (1987); Shoamare; (1988).

RESULTS

The data were subjected to analysis of variance and the results are given in Table 2. Data from the sole wheat with N fertilizer only were analysed separately (Table 4).

Grain yields varied from 906 kg/DM/ha in broadcast plots to 2280 kg/DM/ha in row plots at Holetta. There were no significant yield differences between single or double rows but there were significant differences between rows and broadcast plots (P<0.01). Broadcast plots gave lower yields. Straw yield varied from 2140 kg DM/ha to 5240 kg/DM/ha. Once again the broadcast plots gave lower yields. Average legume yields varied from 471 to 5766 kg DM/ha. Legume yields followed similar trends with _T. quartinianum_ significantly out yielding _T. decorum_ without much detrimental effect on wheat yield P<0.01). Fertilizer P had a linear effect on legume yield. There was no significant P effect on wheat yield which also had received 30 kg N/ha like all intercropped wheat. Fertilizer N did not significantly affect yield on sole wheat which did not significantly differ with that of intercropped wheat (P<0.05). In the intercropped plots total DM production significantly exceeded wheat alone (P<0.01).

The results at Shola followed a similar pattern with some exceptions. Wheat yields were slightly, though not significantly lower than at Holetta. However, the clover yields were very significantly lower (P<0.001). Also, single row plots significantly exceeded double row plots but still broadcast plots had the lowest yields (P<0.01). Fertilizer N had a significant effect on wheat yield (P<0.05). In all, the yields at Shola were lower than at Holetta.

DISCUSSION

Intercropped methodology

The most significant outcome of this trial was the successful intercropping of the annual Ethiopia _Trifolium_ spp. in wheat without any significant reduction in wheat yield. This confirms other research in the highlands in 1987 whereby Trifolium spp. were interplanted in wheat on Vertisol sites without reducing wheat yield (Tedla et al, 1988). The clovers can therefore be integrated into smallholder farming systems for producing high quality feed within the cropping enterprise.

The developed methodology consists of planting wheat at the normal seeding rate of 150 kg/ha and one and half times the normal seeding rate of clover or 15 kg ha in single alternate rows 20 cm apart. The usual P fertilizer rate of 40 kg/ha used for clover is suitable. However, since the clover yields obtained were about half those obtained when grown alone it is important to test production at 20 kg P/ha. A rate of 30 kg/ha seems to be suitable for wheat. The usual recommended fertilizer is 100 kg/DAP ha with 18 kg N/ha and 21 kg P/ha (Wolde Mariam, 1971.

The wheat and clover were planted at the same time and the clovers were planted at the same time as the wheat at Holetta and later at Shola. The ideal situation is for the clover to mature after wheat. It is therefore still necessary to look at different planting dates or relay intercropping of the clovers. Also several accessions of all the potential clover species need to be tested in order to select late flowering ones as only 2 species were used in this trial. Previous trials showed significant interspecific and intraspecific variations among the Ethiopian clovers (Akundabweni, 1984; Kahurananga and Tsehay, 1984).

Effect of soil and climatic factors

There were significant differences in production between the two sites. One contributing factor was drainage. Holetta which was well drained had better wheat yields than Shola which was waterlogged. Wheat prefers reasonable drainage (Purseglove, 1972). Another factor affecting the trial was rainfall distribution during the growing season. There was heavy above average rainfall in May (206% at Shola) which necessitated the rather early planting in May. Wheat is usually planted in the

Ethiopian highlands in June/July (Wesphal, 1975). Unfortunately the rainfall in June at Shola was only 51 mm which was 18% of the average for that month (Shoamare, 1988). This severely retarded the growth of clovers which were at the seedling stage although the wheat fared better. Similar observations were reported from Degollo, one of the vertisol project sites (Abate et al, 1988). Similarly the subsequent months had below average rainfall. This reflected the pattern in most of Ethiopia as there were insufficient rains in June and July in most places (National Meteorological Services Agency, 1987).

The rainfall distribution at Holetta was much better and both the wheat and clovers grew well. This means that intercropping is suitable in areas with long growing seasons. In the United States, intercropping of small grains including wheat and soybeans has been successful in areas which have sufficiently long and moist growing seasons (Kaplan and Brinkman, 1984).

Factors affecting adoption

The most important aim in crop production is crop yield. No smallholder would adopt a technology which reduces yield. Intercropping clovers in wheat did not reduce grain yield. There was the added bonus of high quality feed which could be harvested as hay or grazed with stubble. Another factor which affects adoption is labour requirements at harvesting. This favours late maturity species such as _T_. _decorum_ which would mature after the wheat is harvested. The alternative is to use early flowering species such as _T_. _steudneri_ for providing green-feed to livestock. Short maturing wheat varieties ready for harvest immediately after the end of the rains would also be at a later date after the wheat is established. There is therefore need for fine-tuning of the intercropping package for on-farm testing. A crucial pre-requisite will be production of large amounts of seeds sufficient for such testing.

Table 2: The effect of P and method of planting on DM yield of intercropped wheat and *Trifolium* spp at Holetta and Shola, Ethiopia, in 1987.

Mean DM (kg/kg)

Level of Treatment	Level of (P) (kg ha^{-1})	Wheat grain Holetta	Wheat grain Shola	Wheat grain Holetta	Wheat grain Shola	Total wheat Holetta	Total wheat Shola	Legume Holetta	Legume Shola	Wheat & legume Holetta	Wheat & legume Shola
Td 1 row	0	1820	1556	3580	3193	5400	4760	2428	1200	7828	5060
"	20	1600	1893	3320	3080	4920	4973	2304	1552	7224	6526
"	40	1780	1993	4280	2673	6060	4666	4387	1924	10477	6950
"	80	1893	2400	4540	3993	6433	6393	1745	2009	8179	8403
Td 2 rows	0	1700	1486	4073	2213	5773	3700	1753	2252	7526	5952
"	20	1910	1086	4033	2893	5943	3980	2945	1080	8886	5060
"	40	2080	1040	4480	1906	6560	2946	2528	1720	9088	4666
"	80	2280	1413	3866	3066	6146	4480	1983	2203	8129	6683
Td broadcast	0	866	1246	2046	1966	2913	3213	2552	606	5466	3820
"	20	940	913	2246	2903	3186	3006	2645	860	5832	3866
"	40	1520	1193	3513	1793	5033	2986	2251	813	7284	3800
"	80	1380	1540	3260	2466	4640	4006	2584	920	7224	4926
Tq 1 row	0	1533	1573	3406	2186	4940	3760	4146	706	9086	4466
	20	1000	2080	2346	2873	3346	4953	5625	960	8972	5913
"	40	1606	2480	3373	3440	5380	5920	5969	1326	11349	7246
"	80	1906	1666	4346	2546	6253	4213	7324	1520	13577	5733
Tq 2 rows	0	1486	1293	3246	2460	4733	3753	2891	1046	7624	4800
	20	1893	1086	3893	2000	5786	3086	3571	526	9358	3613
"	40	1486	373	3013	1346	4500	3720	5557	1133	10051	4853
"	80	1833	880	4193	2020	6026	2900	5750	1495	11777	4395

Table 2: The effect of P and method of planting on DM yield of intercropped wheat and Trifolium spp at Holetta and Shola, Ethiopia, in 1987.

Mean DM (kg/kg)

Level of Treatment	Level of (P) ($kg\ ha^{-1}$)	Wheat grain Holetta	Wheat grain Shola	Wheat grain Holetta	Wheat grain Shola	Total wheat Holetta	Total wheat Shola	Legume Holetta	Legume Shola	Wheat & legume Holetta	Wheat & legume Shola
Tq broadcast	0	1100	1180	2140	1480	3240	2660	3150	172	6392	2832
"	20	940	1220	2573	1873	3513	3093	2827	473	6340	3566
"	40	1353	1166	3566	1820	4920	2986	2586	553	7506	3540
"	80	906	1666	2266	2646	3173	4313	3855	686	7030	5000
Sole wheat	0	1807	1100	4300	1740	6107	2840	-	-	-	-
"	20	1753	1067	3330	2113	5083	3180	-	-	-	-
"	40	1953	1687	5240	3026	7193	4713	-	-	-	-
"	80	1320	1300	3093	2587	4413	3887	-	-	-	-
S. E.	246	273	501	400	697	610	772	453	885	805	

Td = <u>Trifolium decorum</u>; Tq = <u>T. quartinianum</u>; S.E. = Standard error.

Table 3: Levels of significance of treatment effects on DM yields of intercropped wheat and *Trifolium* spp. at Holetta and Shola, Ethiopia, 1987.

Treatment	Wheat grain		Wheat straw		Total wheat		Legume		Wheat legume	
	Holetta	Shola	Holetta	Shola	Holetta	Shola	Holetta	Shola	Holetta	Shola
Planting method	0.02765NS	0.0236*	0.2887NS	0.049*	0.2764NS	0.0202*	0.0019**	0.700NS	0.524NS	0.0039**
P linear	0.0209*	0.1359NS	0.0088**	0.0395*	0.0073**	0.0395*	0.0213*	0.0352*	0.0001***	0.0072**
Trifolium spp.	0.3605NS	0.953NS	0.3605NS	0.1880NS	0.3694NS	0.3456NS	0.0004***	0.0496*	0.1036NS	0.0392*
1 row vs 2 rows	0.5245NS	0.0020**	0.7697NS	0.0366*	0.6709NS	0.0050**	0.859NS	0.9160NS	0.5751NS	0.0122*
1,2 rows vs broadcast	0.350*	0.0706NS	0.0327*	0.0156*	0.0320*	0.0152*	0.0298*	0.0130*	0.0067**	0.0010***

NS = not significant P<0.05

* Significant P<0.05.

** Highly significant P<0.01.

*** Very highly significant P<0.001.

Table 4: Effect of N on DM yields (kg/ha) of wheat at Holetta and Shola, Ethiopia, 1987.

	kg N/ha									
	0		30		60		90		LSD (P<0.05)	
	Holetta	Shola	Holetta	Shola	Holetta	Shola	Holetta	shola	Holetta	Shola
Wheat grain	1300	1073	1693	1400	1567	1653	1327	1987	388	788
Wheat straw	3667	1620	3686	2273	3873	2340	3673	3173	202	1256
Total	4967	2693	5379	3673	5440	3993	5000	5160	503	2073

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STRATEGY OF SADCC/ICRISAT REGIONAL PROGRAMME ON THE IMPROVEMENT OF SORGHUM AND MILLETS AS FORAGES

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INTRODUCTION

Sorghum and millets are the major crops grown in the marginal rainfall areas of SADCC countries. As a proportion of the total area under cereal production, these crops account for 77% of the area under cereal crops in Botswana, 35.6% Tanzania, 27.9% Lesotho, 26.0% Mozambique, 25.1% Zimbabwe, 11.0% Angola, 10.2% Malawi, 8.4% Zambia and 3% Swaziland (FAO 1986). Livestock production is a very important component of the agriculture in the semi-arid regions, because apart from providing milk and meat for food, they also provide traction power, transportation, manure, hides and skins and other industrial products. Sorghum and millets being the most important crops in these regions are thus likely to play a very important role in the nutrition of livestock. Currently only commercial farmers who account for a very small proportion of the farmers in the region grow these crops wholly for livestock feed. However most of the communal farmers who are the majority graze the stover after the grain is harvested. Most studies have revealed that the nutritional quality of the stover is not very good (Martin and Wedin, 1974; Rose et al, 1980; Ross et al, 1983). However, its continued use for grazing is imperative, therefore there is a need to improve the nutritional value of the crop residue without sacrificing grain yield.

Pasture improvement in the SADCC region is concentrated mainly on the improvement of natural grasslands which form the main source of nutrients for Africa's livestock. It is known that in the absence of major animal diseases, nutritional stress is the major constraint to increased livestock production (Chigaru, 1985). Nutritional stress can only be alleviated through an integrated research involving enhanced nutrient productivity from the land. Successful forage legumes, cereal crop intercrops have been reported in which livestock gets nutrients from both the crop residue and the legume during the dry season (Saleem, 1985), through undersowing of Stylosanthes guianensis three weeks after the grain sorghum. In Botswana, Chandler (1985) obtained high yields with lablab (Lablab purpureus) and velvet beans (Stizolobium spp.) when these were undersown in maize fields. When Siratro (Macroptilium atropurpureum) was established under sorghum and maize it made a very useful contribution to quality by increasing the crude protein content of fodder hay by 2.2%. Several reports have been published on the use of elephant grass (Pennisetum purpureum). The cultivars Gold Coast and Cameroons have been recommended for cultivation in Malawi (Anonymous, 1975). Elephant grass is the most commonly grown grass used a fresh fodder for silage in Mozambique (Timberlake and Dionisio, 1985). Hay (1978) observed that during the wet season, elephant grass, greatly outyielded Rhodes grass (Chloris gayana), coloured guinea grass (Panicum coloratum), stylo (Stylosanthes guianensis), desmodium (Desmodium spp.) and siratro. During the dry season, elephant grass still maintained higher yields than the other species.

Interspecific hybrids between pearl millet and elephant grass were first reported by Burton (1984). The importance of this interspecific cross stems from the fact that the cross, a sterile triploid yields more fodder than either of the parents, its forage quality is better than that of elephant grass and it can be produced commercially (Powell and Burton, 1966). Other useful aspects of this cross are the possibilities of transferring useful traits (e.g. disease resistance) from elephant grass to pearl millet.

The productive potential of the panic grass (Panicum maximum) c.v. Ntchisi for cut-and-carry was found to be about three fourths of that achievable by interspecific crosses between pearl millet and elephant grass (Dzowela, 1985).

The interspecific hybrids between pearl millet and elephant grass have been released in different parts of the world. Some examples are banagrass in South Africa and NB21, MB67 and PBN-83 in India.

Hanna and Monson (1980) observed a range of variability in dry matter yield distribution and forage quality attributes in different elephant grass by pearl millet interspecific hybrids. The variability thus observed suggests that these factors could be improved by selecting the right elephant grass clones as pollinators.

Increasing the digestibility and intake of forages by using relatively simple inherited genetic characters is one of the most exciting areas for forage improvement. A case in point is the simply inherited dwarf (d2) gene in pearl millet found to reduce the height of plants by one-half, increase the amount of leaf by 50% and still manage to realize 78% as much dry matter per hectare as its near isogenic tall counterpart (Hanna, 1975). The d2 gene in pearl millet produced only 85% as many steer days of grazing as the tall but animals on the dwarf millet made 20% better daily gains while steer gains per hectare were equal for both millets (Burton et al, 1969).

In a study to evaluate the yield and nutritive value of sorghum, (Sorghum bicolor (l.) Moench) maize and pearl millet residues, Mosienyane (1983) observed that the dry matter digestibility of pearl millet was poorer than that of sorghum and maize stover. This is due to high concentration of lignin (Cherney et al, 1988). Efforts are underway to improve the stover quality of pearl millet by reducing the lignin content through modification of the lignification process like the one observed in brown-midrib (bmr) maize plants (Grand et al, 1985). Recently a bmr gene has been found in pearl millet that reduced permanganate lignin concentration in the stems of bmr millet by one half that of normal millet and improved its in vitro dry matter digestibility to a level better than that of sorghum and maize (Cherney et al, 1988). This gene improved the quality of pearl millet similar to that of bmr mutants of sorghum and maize. Thus the bmr trait in pearl millet has an excellent potential of improving the quality of forage pearl millet and even make possible the utilisation of pearl millet stover which otherwise is left in the field in most countries in Africa. The quality of pearl millet stover is poor in Africa because most of the varieties/landraces grown are very tall (poor leaf:stem ratio) and stems are very thick. In India pearl millet stover is fed to animals but the plants are medium tall, have thin stems coupled with high tillering. It will be worth comparing different types of pearl millet possessing different morphological traits such as leafiness, plant height, stem thickness, brown-midrib, tillering and forage quality traits to establish the association between morphological traits and forage quality.

To get a good picture of the potential role sorghum can play in the livestock industry of the SADCC region, one has to look at the achievements of forage sorghum research work elsewhere. *Sorghum bicolor* var. sudanense (Sudangrass) was introduced in USA by C.V. Piper and the first variety (Wheeler) was released by Carl Wheeler in 1911. California 23 was distributed to farmers in 1938 (Peterson and Miller, 1950). Tift was another forage sorghum variety selected from a cross between Leoti red sorghum and other sudangrass selections (Burton, 1943). Since then several varieties of sudangrass have been released in USA. Few examples are sweet sudangrass (Karper, 1949), Piper sudangrass (Smith and Ahlgren, 1952), Lahoma (Anonymous, 1954), Greenleaf (Pickett, 1954) and Georgia 337 (Burton, 1964).

During the last twenty years, several forage sorghum varieties have been released in India. These are: JS 73/53, Meethi sudan, HC 136, HC 171, HC 260, UP Chari 2, RC 2, PC 6, PC 9 and PC 23.

STRATEGY

The SADCC/ICRISAT regional programme organised a Cereal Forage Research Monitoring Tour from 10 to 23 February 1988 in which 15 scientists from the region including the PANESA coordinator participated. The group visited five countries: Zimbabwe, Botswana, Lesotho, Swaziland and Mozambique and the future strategy on improvement of sorghum and millets for forages was discussed.

The strategy was discussed with the regional programme's technical advisory panel in March, 1988 at Maseru, Lesotho and with the Donors' Review Panel in June, 1988 at Matopos, Zimbabwe. Their contribution helped in improving our strategy. An outline of our strategy is presented below:

Research strategy

The strategy will aim to specifically:

- To improve sorghum and millets for dual purpose particularly by improving the quality of crop residue in high yielding entries. Brown midrib genes will be utilised in sorghum and pearl millet to improve their dry matter intake and digestibility attributes.

- To develop better varieties of banagrass i.e. to generate interspecific hybrids between selected pearl millet and elephant grass accessions and to evaluate them for fodder yield and quality under moisture stress situations.

- To improve forage sorghum for forage yield and quality. This will be done by generating crosses between sorghum and sudangrass and selecting in segregating generations bmr genes which will be utilised to improve the intake and digestibility.

- Intercropping studies involving sorghum and millets with fodder legumes and grasses will be carried out to maximize the grain, crop residue and legume fodder yield. Useful fodder trees and browses will be included in such studies.

- Collection and maintenance of all the forage species relevant to the region and to use them in crop association studies where ever appropriate.

- Improvement of pearl millet and finger millet for hay and/or silage will be a low priority.

- Determination of usefulness of small millets as forage crops in the SADCC countries. The improvement of small millets for forage in the near future is of low priority.

Support strategy

As there are not many breeders and/or agronomists in SADCC working on this aspect, one of our strategy will therefore be to strengthen the national programmes by providing them with short training courses or training towards a degree.

- Efforts will be made to improve the research facilities such as forage laboratories in different SADCC countries.

- We shall involve ourselves to a limited extent through collaboration with the national programme on feeding trials where large quantities of grains are required.
- Forage breeders, agronomists and animal nutritionists from the region are working hand in hand and the regional programme will act as a co-ordinating unit for improving the utilisation of sorghum and millets as forages.

ACHIEVEMENTS

Introduction and Evaluation

The improvement of sorghum and millets for forages was started late in 1987 and since then the major activity has been introduction, maintenance and evaluation of the materials. A total of 152 sorghums and 106 sudangrass accessions have been introduced from USA, India, Argentina, Australia, Lesotho, Swaziland, Zimbabwe and Tanzania. These include male-sterile lines on A1 cytoplasm as well as lines with bmr genes. 146 accession of pearl millet, 36 of *Pennisetum glaucum* spp *Monodii*, 20 Napier grass, 5 pearl millet x Napier grass hybrids and 65 minor millets (5 species) have been introduced from USA, Ethiopia, Indian, West Africa, Botswana, Tanzania, Mozambique, Zimbabwe, Swaziland and Australia. Recently 2 accessions of *P. pedicellatum*, 5 of *P. polystachion* and 2 *Panicum maximum* were introduced from Tifton, USA. In addition to this 85 forage species were introduced from the International Livestock Centre for Africa, (ILCA), Ethiopia.

Cereal forage yield trial

A trial of 25 pearl millet entries was conducted in all SADCC countries except Angola and Zambia during the 1987/88 season. None of the introductions was superior to Babala millet which was developed in South Africa. However 11 entries: PS 126, PS 135, PS 192, ICMS 7704, PS 472, 84-52, PS 200, 52-9 x 51-13, 86-10242, PS 195 and 435 x 51-5 were selected for high tillering, resistance to diseases, and fodder yields.

Forage Sorghum Introduction Nursery

A nursery of 105 forage sorghum accessions including sudangrass was grown at Aisleby, Zimbabwe and Maseru, Lesotho in single row plots. Based on visual scores, eight entries were selected. During 1988-89 all the entries together with new introductions will be re-evaluated.

Breeding Programme

During the 1988 off-season, the following crosses were generated:

Sorghum x sudangrass: 256
Sorghum A lines x sorghum/sudangrass: 102
Pearl millet x Napier grass: 15
Pearl millet x Monodii: 119
Monodii x Napier grass: 16

All these crosses will be evaluated and advanced during the 1988/89 rainy season.

A forage pearl millet composite is being constituted by recombining 38 forage pearl millet lines.

1988-89 Trials

Eight trials have been organised for the 1988/89 season. The list of trials together with the number of entries and number of locations in each country is given below:

- Cereal Forage Yield Trial: 20 entries, 23 locations in 8 countries.

- Regional Forage Sorghum Introduction Trial: 81 entries, 11 locations in 5 countries.

- Regional Sudangrass Introduction Trial: 90 entries, 11 locations in 4 countries.

- Regional Forage sorghum B-line Evaluation Trial: 49 entries, 8 locations in 4 countries.

- Regional Forage Millet Introduction Trial: 64 entries, 11 locations in 6 countries.

- Minor Millets Evaluation Trial: 64 entries, 5 locations in 3 countries.

- Cereal Forage Preliminary Variety Trial: 10 entries, 2 locations in Zimbabwe.

- Monodii Evaluation Trial: 15 entries only at Matopos.

The above list shows the interest and the commitment among the forage scientists to collaborate on the improvement of sorghum and millets for forages. This also provides an opportunity to provide a large number of accessions to the scientists in the region, with the hope that these accessions can be incorporated in crop-livestock production systems.

COLLABORATORS

The main collaborators on a country wise basis are:

Botswana	Arabia Moyo	Agronomist
Lesotho	Victor R. Ramakhula	Agronomist
Malawi	C.F.B. Chigwe	Breeder
Mozambique	Celia Jordao	Nutritionist
	Inacio Maposse	Agronomist
Swaziland	Paul D. Mkhatshwa	Agronomist
	Brenton B. Xaba	Nutritionist
Zambia	Bhola Nath	Breeder
Zimbabwe	Peter Hatendi	Nutritionist
	T. Smith	Nutritionist
Tanzania	G.M. Mitawa	Agronomist

A multi-disciplinary approach is being followed where breeders, agronomists and animal nutritionists are working together. As the project grows, assistance from pathologists and entomologists may be required.

SUMMARY

The improvement of sorghum and millets for forage was started late in 1987. The strategy was developed in February 1988, during the Cereal Forage Research Monitoring Tour in which 15 scientists from the region including the co-ordinator for ILCA/PANESA participated. The strategy was further refined during the Technical Review in March 1988, and the Donor's Review in June 1988. The major research activities have been collection, seed increase and the evaluation of germplasm accessions of sorghum and millets and related species from many sources. Regional trials are being organised and a breeding programme has begun. Crosses have been generated among sorghum, sudangrass and sorghum male-sterile lines as well as among pearl millet, Napier grass and P. glaucum sp. monodii accessions to produce better varieties of forage sorghum and banagrass (pearl millet x napier grass). Research on the improvement of the nutritive value of crop residue will (dual purpose) be initiated in 1989 once the forage laboratory facilities are established.

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RHODES GRASS BREEDING IN ZIMBABWE: AIMS, ACHIEVEMENTS, PROSPECTS AND ROUTE TO AGRICULTURAL APPLICATION

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INTRODUCTION

Sir George Stapledon (1940; 1942) founder of the Welsh Plant Breeding Station and William Davies (1952) advanced the concept of grass as a crop. The acceptance of grass as a crop with concommitant improved management are fundamental prerequisites to the development of grass through breeding effort. Put simply, improved seed has to be sown whether as long or short term leys or as permanent pasture to be of benefit.

The PANESA region has seen sporadic grass selection work in Zambia and Tanzania (Van Rensburg, 1969) and Kenyan breeding input (Bogdan, 1969) and more recently great improvement in Kenyan cultivars (Boonman, 1978). In developed countries pasture breeding has benefited from longer term involvement. The highly competitive nature of grass breeding in EEC countries for example is witness to the grass crop precept.

Grassland utilisation in Zimbabwe ranges from the grazing of unimproved veld through to intensive irrigated pastures based on Kikuyu grass. The most extensively sown pasture grass is Katambora Rhodes grass (*Chloris gayana* Kunth). The Rhodes grass breeding project in Zimbabwe arose as a response to the identification of important regional pasture research topics in an IDRC-Pasture workshop in Harare in 1984 (Clatworthy, 1985).

Katambora is grown in rotation with tobacco to control *Meloidogyne javanica* (root-knot nematode). A four year ley is recommended (Martin, 1967) to overcome the longevity of nematode eggs even in bare fallow soil. Potential area of use is in the region of 200,000 to 250,000 ha with annual reseeding of up to 60,000 ha.

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Katambora, a diploid Rhodes grass, came into use in the nineteen fifties in Zimbabwe (West, 1952). It is less productive and palatable than tetraploid strains such as Zimbabwe Giant. The more productive cultivars are less effective in controlling root-knot nematode (Shepherd, 1968; York, 1989 a).

Primary aim of the breeding project is the inclusion of good nematode resistance in a variety with greater forage production. For a grass used in arable rotation requiring resowing every fifth year or more frequently, seed yield is also an area of concern. A valuable export market for Katambora seed magnifies this requirement.

Aimed initially at the commercial sector in Zimbabwe, the successful combination of yield and root-knot resistance could encourage the use of grassland/arable rotation in communal farming. Such a variety would serve a multiple role in controlling root-knot nematode, improving soil structure, reducing erosion as well as providing valuable forage and seed as a cash crop.

Aspects of the breeding project have included hybridization studies, variety and germplasm assessment - agronomic, nematological and flowering behaviour. The breeding programme has two separate approaches; interploid hybridization between Katambora and tetraploid Rhodes grass, and enhancement of nematode resistance and other characters within tetraploid strains.

BREEDING HABIT

Rhodes grass has been variously described as outcrossing Bogdan (1961) and apomictic (Hutton, 1961). Barnard (1971) described Katambora as 'probably apomictic'. However the stock for which Hutton claimed apomixis although diploid was not Katambora, but commercial (Pioneer) which according to Hutton was similar to Nzoia - this appeared uniform in Marondera nursery and had good nematode resistance (York, 1987; 1989 b). Later Australian work discounted apomixis in various material (Jones & Pritchard, 1971). Hybridization studies at Marondera (York, 1987) using cellophane bags to effect selfing and crossing only resulted in seed set when Katambora flowers of different plants were bagged together. Outcrossing was clearly demonstrated in tetraploids by Bogdan (1963).

GERMPLASM ASSESSMENTS

A range of diploid and tetraploid Rhodes grass cultivars and collections has been obtained from various sources. An observation nursery was established at Marondera in 1987. Plants were spaced at 1/5m and kept distinct by trimming. Accessions showed inter and intravarietal variation in vigour, habit, foliage type and flowering rate. Flowering date was amongst the most quantifiable characters. Table 1 shows the range of flowering behaviour observed.

The range of variation exhibited by most accessions supports the normal outcrossing mode of reproduction for this species. Boonman (1978) showed that early flowering resulted in improved seed yield and was related to vigour in Kenya. Earliness was sufficiently heritable for selection purposes and led to the creation of Elmba from Mbarara and Boma from Masaba.

Table 1: Summary of flowering data of 81 *C. gayana* accessions at Marondera as days to first flower emergence from 1.1.87.

Group	Accession	with ...	Accession e	Accession l	Accession r	Group $\bar{r}$	Group r	Group n
	57	earliest plant	30	51	21			
Diploids excl	37	latest plant	71	96	25	21	66	14
Katambora	55	widest range	35	76	41			
	21	smallest range	32	49	17			
Katambora	75	earliest plant	33	83	50			
	72	latest plant	51	94	43	30	61	35
	77	widest range	33	83	50			
	97	smallest range	46	59	13			
Tetraploids	39	earliest plant	36	93	57			
		& widest range				35	60*	32
	many	largest plant	-	96*	-			
	18	smallest range	64	77	13			

* Plants with first flower emergence later than 6/4 not recorded

e, 1 = earliest and latest plant of accession

r, $\bar{r}$ 0 overall and mean range respectively n= number of accessions

Low night temperatures have been associated with poor seedset in Rhodes grass (Loch & Butler, 1987). In Zimbabwe low night temperatures (below $10^{0}C$) occur in many parts of the tobacco - hence Rhodes grass - areas by mid-April. Ideally flowering should be timed so that the majority of seed has been set and filled by this date, mainly hardening thereafter. Katambora is managed so that it flowers in a flush and is harvested late April/early May. Tetraploid varieties which may be quantitative short day plants (Dirven et al. 1979; Loch, 1984) tend to flower later and reach a peak more slowly. The data from the observation nursery showed as wide a range in date of first flower emergence amongst tetraploid plants as diploid; some could flower as early as Katambora. Photoperiod differences aside, it should be possible to select for earliness and improved seed yield as achieved in Kenya.

VARIETY ASSESSMENT

Agronomic Characters: Field trials were established in December 1986 to compare the forage yield, flowering behaviour and seed production of eight tetraploid varieties with those of diploid Katambora. Sites were Chiredzi, which was irrigated to give total water similar to the other sites, Marondera and Mazowe. Forage yields for the year after establishment are given in Table 2. Tetraploids generally outyielded Katambora as expected. The better varieties overall were Elmba, Boma and Mt. Makulu 56. The greatest difference between tetraploids and Katambora was 80%; average superiority of tetraploids was in the order of 30%. The varieties retain a large degree of plant to plant variation. Taking individual plants during screening for nematode resistance would result in 30-40% yield gain over Katambora and possibly more. The forage productivity attained compares favourably with 18-19 t OM/ha in more heavily fertilized trials (Rodel, 1969) with Giant in Zimbabwe. At a seasonal at N fertilisation rate of 120 kg/ha Chiredzi site gave over 20 t DM/ha from some tetraploids.

Table 2: Dry matter yield of 9 Rhodes grass varieties at 3 sites in Zimbabwe during the growing season 1987/88.

Variety/Site	kg/plot Chiredzi	Mazowe	Marondera	Mean t/ha
Katambora	41	34	37	13.6
Mt. Makulu	60	42	43	19.6
Samford	54	39	39	17.6
Callide	54	41	37	17.4
Giant	53	36	37	16.8
Mbarara	57	43	42	18.9
Elmba	52	52	49	20.4
Masaba	53	43	43	18.5
Boma	59	42	43	19.2
S E 5%	3.5	2.9	2.7	-

Seed yield data are given in table 3 and flowering progress in Figure 1. The tetraploid cultivars and strains showed poorer seed content than Katambora throughout, but the potential seed yield is very high as shown by crude yield at Marondera. All heads were taken which tended to depress seed content unrealistically compared to farm practice. Given this, the true seed yield of Katambora and Callide were reasonable. Late harvesting favoured the tetraploids over Katambora. Germination of rubbed and extracted caryopses was high for all varieties. 1988 was a good year for tetraploid seed - one local farmer obtained PLSC (pure live seed content) in excess of 30% from his Giant Rhodes grass.

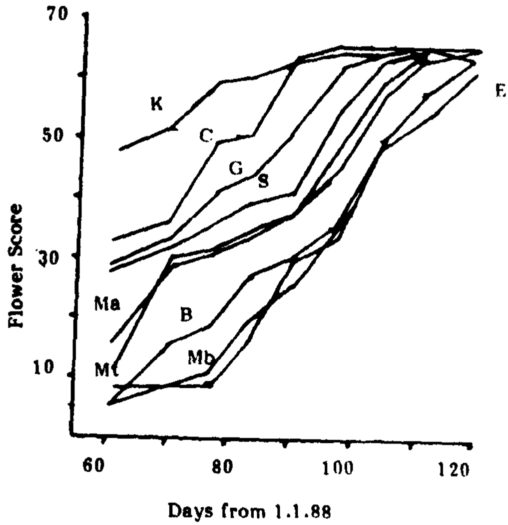
Table 3: Seed yield of 9 Rhodes grass varieties at Marondera

Variety	g/plot Crude seed	*Caryopses	'PLS'
Katambora	516	106	20.5
Mt Makulu 56	474	21	4.4
Samford	509	42	8.0
Callide	785	106	15.3
Giant	551	61	10.9
Mbarara	250	32	12.9
Masaba	348	17	4.9
Elmba	288	10	3.5
Boma	491	17	3.2
S E 5%	78.0	9.8	-

*150 kg @ 25% PLSC = 94 g/plot
PLSC = Pure Live Seed Content

Similar flowering patterns were obtained at the three sites. The earlier flower flush of Callide at Marondera largely explains the better seed production of this compared with other tetraploid varieties. The locally adapted Giant also showed an earlier flower flush than other tetraploids. The varieties Elmba and Boma selected on the basis of their flowering pattern in Kenya (Boonman, 1978) were not different from their respective progenitors, Mbarara and Masaba. The similarity of the Kenyan cultivars may result from genetic drift since their release (Boonman, pers. comm.) or may be due to photoperiod differences between their selection site in Kenya and Zimbabwe. The Kenyan varieties were consistently later than Callide and Giant: selection on the basis of earliness in one environment need not lead to earliness in another. The performance of Callide gives some hope that even a small improvement in date of flower flush will give a boost to the seed content of other tetraploid lines in Zimbabwe.

Figure 1. Flowering progress of 9 Rhodes grass cultivars at Marondera in 1988 based on semilogarithmic assessment of numbers of flowers, means of 4 replicates.



Nematode Host Status Assessments: The susceptibility of a range of diploid and tetraploid Rhodes grass accessions was compared using nematode eggs in suspension as inoculum (York, 1989 b). The level of nematode eggs and range of response are presented in Table 4. Generally tetraploid accessions comprised more susceptible plants with susceptibles being more extreme than among diploids. Some tetraploids were less susceptible than others but all allowed more nematode reproduction than Katambora. The better forage yielder, Elmba was the most nematode susceptible. The distribution of host status suggested that susceptibility at least was under polygenic control. The number of egg-masses developed was the major determinant of susceptibility, and size of root system was not a factor in number of egg-masses produced. Although diploids supported fewer egg-masses per plant on average and more plants were completely resistant than with tetraploids, this generalization was not strong enough to recommend diploid varieties for root-knot control.

BREEDING PROGRAMME

Interploid Hybridization: The basis for this approach is the genetic affinity of diploid and tetraploid Rhodes grass. Japanese cytological studies indicate a degree of autoploidy (Nakagawa and Sato, 1981) hinted at by earlier workers (Moffett 1944). The occurrence of a natural triploid is also encouraging (Pritchard & Gould, 1964). Interploid hybridization has proved possible with other autoploids, e.g. cocksfoot (Dactylis glomerata) (Caroll & Borill, 1965). The sufficient homology of genomes and the 'spotaneous' non-reduction or restitution of diploidy in gametes from diploid plants allow the formation of tetraploid zygotes by fusion with normally reduced gametes from the tetraploid. Other configurations may occur especially triploids which would require backcrossing to restore the tetraploid condition.

The usefulness of this approach depends on the existance of a recessive genetic marker stock anthocynanin-free (Bogdan, 1963) which will facilitate the identification of hybrids without recourse to labourious cytological techniques. The anthocynanin-free flowers are distinctively 'yellow-heads'.

Seedling bases are also free of purple pigmentation in this stock, but Katambora is normally purple pigmented, so that purple based seedlings from a 'yellow head' stock has been isolated at Marondera. Hybridization in cellophane bags between Katambora and anthocyanin-free tetraploid plants suggests that 1% of caryopses formed on the tetraploid may be interploid (York, 1987).

To be of value, clearly large numbers of crosses have to be attempted. This is being accomplished on a field scale this season. There are two advantages to this approach; i. if the cross is successful a resistant yet anthocynanin-free line may be selected from the heterozygous stock - in the absence of adverse linkage. This would permit the ready identification of resistant material in seed certification schemes; ii. The 'yellow head' stock was produced by selfing and although itself vigorous, a small proportion of the progeny when the stock is intercrossed are albino. Inbreeding depression would result rapidly if selection for resistance within this were attempted, especially as the 'yellow heads' are very nematode susceptible (York, 1989 c). Interploid hybridity would release some variation and vigour.

Selection for Root-knot Resistance in Tetraploid Material: Screening tests at the Tobacco Research Board of Zimbabwe showed that the Zambian strain Mt. Makulu 56 (Van Rensburg, 1969) may be less susceptible than some tetraploid varieties (Way, pers. comm). This variety was assessed during 1987 to determine the proportion of resistant plants and degree of susceptibility of individual plants. Figure 2 shows the frequency distribution obtained. 14% of the parent stock were devoid of egg-masses 12 weeks after inoculation with 5900 eggs of M. javanica (York, 1989a). 37% of the population would allow maintenance or increase the nematode population. The resistant plants have formed the basis of a mass and recurrent selection programme to increase the proportion of resistant plants in this tetraploid background.

After two selection cycles the proportion of resistant plants as measured by mf (ratio egg-masses/inoculum egg-mass equivalents) is as shown in Figure 3. There has been a significant increase in the proportion egg-mass free plants. Some plants still support more than maintenance level of nematode reproduction. The rapid increase in proportion of resistant plants suggests that resistance itself is governed by fewer genes.

The selected susceptible stock shows a greater degree and wider range of susceptibility than the parent stock. Already the resistant selection is comparable with Katambora. Further selection will be undertaken to increase and fix resistance. Progeny of paired hybridizations of plants of known nematode susceptibility/resistance will be screened to investigate genetics of resistance.

From the first selection cycle, plants showed a range of flowering rates as demonstrated in Figure 4. 10% of these plants were not significantly different from Katambora in date of first flower emergence. Earlier plants had significantly more flowering tillers at 90 days (from 1.1.88) than later plants. The proportion of resistant plants among progeny of maternal plants selected for earliness and vigour showed some variation, but overall the level of resistance was comparable with that of the bulk selection. There was no apparent adverse correlation between nematode resistance and earliness. The results indicate that root-knot resistance and early flowering can be combined in a tetraploid background.

Figure 2. % Frequency distribution of host status of Mt. Makulu 56 plants expressed as egg-masses per plant.

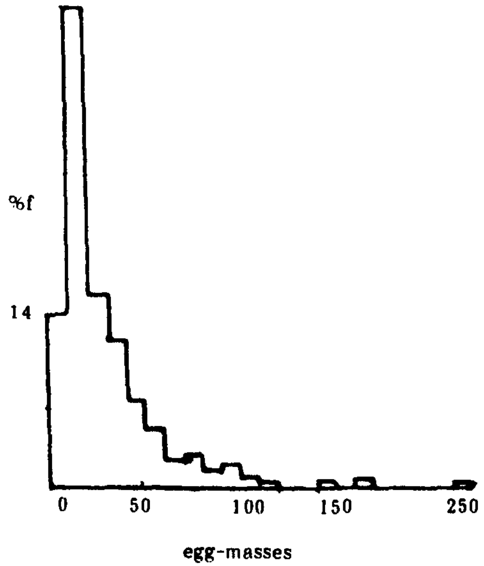


Figure 3. % Frequency distribution of susceptibility of parent stock (P) and resistant (R) and susceptible selection (S) from Mt. Makulu 56 a mf (ration eff-masses/inoculum).

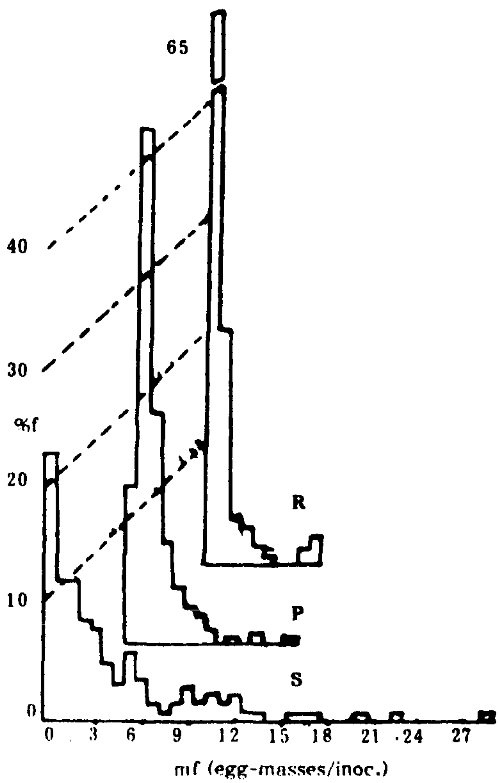
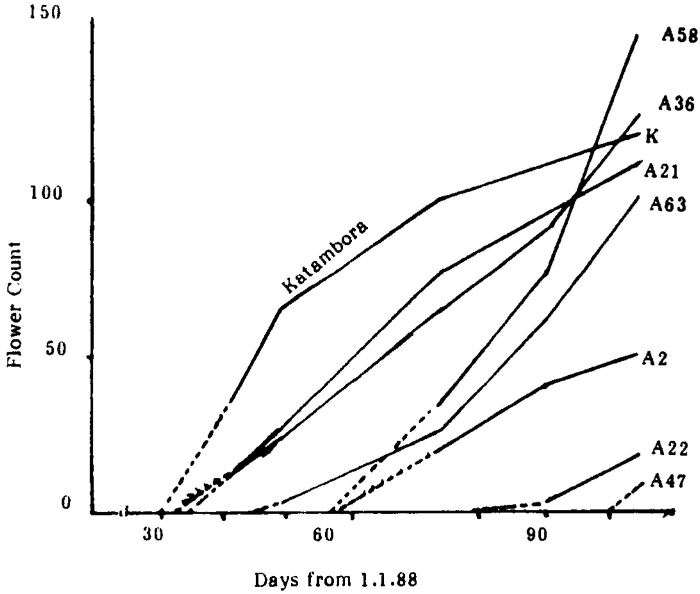


Figure 4. Flowering of selected root-knot resistant lines from Mt. Makulu 56.



PROSPECTS

The desired combination of root-knot resistance, at least as effective as that of Katambora, improved seed quality through earlier flowering and a yield superiority of a minimum 40-50% over Katambora seem quite achievable. What is required is sufficient time to take selection for all traits to the optimum level and for fixation of these characters.

ROUTE TO AGRICULTURAL APPLICATION

The keenness of commercial farmers in Zimbabwe to improve on the forage production of grass in the tobacco rotation without sacrificing root-knot control will ensure the popularity of a new cultivar with the above features. There is legislation on Plant Variety Rights and on Seed Certification in Zimbabwe. However, the most widely sown pasture cultivar, Katambora is subject to an 'informal' scheme. Control of seed quality is excellent, but the view that Katambora was apomictic led to relaxed standards of seed increase on the assumption that all stocks were identical. It is pretty uniform but was never stabilized for root-knot resistance; stocks may differ to some degree in resistance, although Katambora generally is more resistant than tetraploid cultivars.

The successful product of this breeding programme will demand more careful management. Mother plants of a resistant tetraploid will be established to give Breeder's Seed, some of which will go to long term storage. Mother plants will be propagated vegetatively periodically and give rise to successive sequences of Prebasic, Basic and Certified seed as with temperate grasses (Anon, 1978). An improved outcrossing variety must be multiplied through as few generations as practicable from its basis to seed for farm use. This is more critical in a variety incorporating specific pest resistance: Seed certification and documented provenance of seed will be essential. To capitalise on breeding gains tight control will remain necessary throughout the useful lifespan of the variety. To ensure resistance is not lost periodic monitoring of host status of different generations of seed stocks to *M. javanica* is advisable. This should be

Table 4. Host status of *C. gayana* to *M. javanica*.

	Diploids				Tetraploids		
Accession	n	Mean egg-masses/ plants	% plants over 5 egg masses	Accession	n	Mean egg-masses/ plant	% plants over 5 egg masses
2	24	36	63	34	23	33	74
12	25	14	60	38	23	17	61
21	19	7	21	40	26	43	69
29	20	3	20	Giant	7	86	86
52	26	16	39	Mbarara	27	46	89
53	28	20	43	Masaba	23	43	87
54	24	20	50	Elmba	23	90	92
55	23	20	61	Boma	23	55	74
56	24	17	50	Callide	25	49	80
57	10	15	60	Samford	22	27	50
74	25	2	41	Mt Makulu 56	245	45.8	76

coupled with virulence tests of different _M_. _javanica_ populations to detect resistance breaking races as soon as possible.

Short term funding of such projects can result in outright loss of material - few of van Rensburg's selections are available now-or reduced value of material e.g. through inadequate seed isolation after varietal release as occurred in Kenya (Boonman, pers. comm.). Sustained breeding effort with pasture species could be done on a co-operative regional basis with longer term joint funding or external support.

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PRACTICAL APPLICATIONS OF *IN VITRO* TECHNIQUES TO FORAGE GERMPLASM

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ABSTRACT

Lack of seeds for collection, conservation, multiplication and distribution of forage germplasm is a major constraint to greater availability and utilisation of germplasm of some forage species. *In Vitro* culture techniques can be applied to overcome these constraints. Procedures are being developed at ILCA for the collection and conservation of the forage grasses, Cynodon and Digitaria, and the multiplication of these and browse species. The results and their current and potential application to increase availability of selected forage germplasm from the ILCA genebank are discussed.

INTRODUCTION

The genetic resources activities of collection, multiplication, storage and dissemination are conventionally carried out using seeds. However, some vegetatively propagated species seldom produce viable seeds and other species only produce seeds after several years. Other outbreeding species produce heterogeneous seeds which do not represent the original genotype. Until recently the only means of collecting these materials was by cuttings, tillers or whole plants which are bulky and short-lived. Conservation of these species was in field genebanks, where the material is maintained in the vegetative state requiring considerable space, careful management and plants are at risk from pests, diseases and natural disasters.

The development of *in vitro* methods for genetic resources has been possible due to recent advances in *in vitro* culture. Many species have been successfully collected (IBPGR, 1984), cultured (Sharp *et al*, 1984, Ammirato *et al*, 1984), multiplied

(Hussey, 1983) and some maintained for long periods in vitro (Withers, 1980). In vitro methods use less space and fewer pests inputs than conventional methods and cultures are protected from pests and diseases, including viruses. In genetic resources, in vitro technology can also be used for disease elimination giving rise to higher yielding plants which are subject fewer quarantine restrictions and for creating variability in genotypes through adventitious regeneration. Work in progress at ILCA on appropriate methods of collecting Digitaria decumbens, conserving Cynodon and Digitaria species and multiplying these former species and Leucaena leucocephala, Erythrina brucei and Sesbania sesban in vitro is reported. Their potential use in forage genetic resources is discussed.

MATERIALS AND METHODS

Materials

The plant species used in this work and their ILCA (accession) numbers are given in Appendix 1. The grasses and Leucaena were harvested from plots at the Zwai Seed Multiplication Site of ILCA whilst the other legumes were collected at ILCA headquarters.

Surface sterilisation

Leaves were removed to reveal axillary buds from stem cuttings.

The stem cuttings used in the collection experiment were then washed for 30 minutes in 1.0g/l of Halazone water purifying tables in the open air.

Stem cuttings used in the rest of the experiments were divided into cuttings of one node each and the rest of the work was carried out in a laminar flow cabinet. The cuttings were washed thoroughly in distilled water, surface sterilized by dipping in 90% alcohol, washed in sterile water, and shaken in locally available bleach (formula unknown) for five minutes followed by at least five washes in sterile distilled water.

Inoculation

Stem cuttings for the collection experiment were divided into nodal cuttings and inoculated straight onto medium containing five different combinations of Benlate with Rifamycine under non-aseptic conditions.

Nodal cuttings used for other experiments were prepared for culture by cutting off the severed edges exposed to the sterilizing agents. Axillary buds and meristems (2-3 leaf primordia) were dissected asceptically in a laminar flow cabinet with the aid of a stereoscopic microscope at a magnification of X10.

Green pods with mature but green seeds of _Sesbania_ _sesban_ were washed in tap water and opened to remove the seeds in the laminar flow cabinet without surface sterilization for research on adventitious regeneration of _Sesbania_. The embryos were squeezed out of the seed coat and divided into embryo axes, cotyledons and hypocotyls for culture.

Excised nodal cuttings, buds and meristems were placed on a culture medium solidified with 0.7% (w/v) agar in glass test tubes which were covered with cotton wool plugs and aluminium foil. The culture media used were based on Murashige and Skoog (MS) medium (Murashige and Skoog, 1962). The media were denoted; MS3, 1/2MS3, MSS, MSSG, and MS2 (Appendix 2). The media were supplemented with 3% (w/v) sucrose, 1.07×10^{-7}M naphthalene acetic acid (NAA), 2.22×10^{-7}M benzylamino purine (BA) and 1.44×10^{-7}M gibberrelic acid III. All media were autoclaved for 15 minutes at 121°C after adjusting the pH to 5.6.

Embryo-derived explants of _Sesbania_ were cultured on agar solidified MS3 medium supplemented with 10^{-6} and 10^{-5} benzyl aminopurine.

Incubation

Cultures for the collection experiment were incubated under ambient conditions in the laboratory.

Cultures were kept for normal growth in an incubator between 25 and 29^{o}C and illuminated for about twelve hours by white fluorescent light (36uE$M^{-2}s^{-1}$ PAR). After four to six weeks some well established cultures were transferred to incubators which were kept at 15^{o}C and 5^{o}C for slow growth conservation. These were observed monthly and ten cultures were sampled and put back in the normal growth incubator after every 100 days.

Rooting

Where there was no spontaneous rooting, shoots were rooted by dipping their bases in 10^{-6}M indole-3-butric-acid (IBA), inoculating on fresh medium and incubating them under normal growth conditions.

Transfer to soil

Cultures of C. aethiopicus (ILCA 2006 and 6624) and C. dactylon (ILCA 13828 and 13831) were retrieved from the agar solidified medium, washed with distilled water to remove agar and transferred to sterilized vermiculite, sterilized forest soil and unsterilized forest soil in clear plastic boxes and kept in the normal growth incubators. After two weeks the cultures were transferred to unsterilized forest soil in plastic pots and covered with plastic bags to maintain a high relative humidity. The humidity was kept high by frequent watering. The pots in plastic bags were transferred to the greenhouse after two weeks in the normal growth incubator. The plastic bags were opened after two weeks in the greenhouse and finally removed after another week.

The procedure of using unsterilized soil has been modified into a minimal facility method which is successful for the transfer of cultures to untreated soil. The cultures are transferred to unsterilized forest soil in pots, covered with plastic bags and kept in an uncontrolled environment greenhouse throughout their establishment.

RESULTS

Collection

55% of Digitaria decumbens cuttings collected under minimal facility conditions and cultured on MS2 medium supplemented with 1.5g/l Benlate and 0.1g/l Rifamycine in the open air were successfully recovered without contamination after eight weeks (Plate 1). It was also observed that some cuttings grew in spite of visible bacterial contamination. Whilst fungal contamination was only 5% in this, the best treatment, bacterial contamination was high at 40%.

Initiation and multiplication

In vitro cultures of all the accessions of grasses and legumes were initiated from axillary buds, meristems and nodal cuttings in all media tested. Whilst cultures were successfully initiated in the different media, the accessions showed preference for different media irrespective of the species (Table 1). Both grasses and legumes have been successfully multiplied using nodal cuttings of the in vitro cultures.

Slow growth conservation

Established cultures were kept under slow growth conditions for up to 300 days. Retrieved cultures were successfully re-established under normal growth conditions except for Digitaria decumbens (ILCA 9729) which did not survive 5^{o} for 200 days (Table 2).

Adventitious regeneration

Adventitious shoots were recovered from embryo-derived cotyledons (19% and 24%) and hypocotyls (35% and 62%) of S. sesban cultured on MS3 medium supplemented with the two highest levels (10^{-6} and 10^{-5} of BA respectively (Plate 2). In addition to caulogenesis from these explants, some embryo axes cultured on these media formed multiple shoots.

Establishment in Soil

In vitro cultures of two accessions of *C. aethiopicus* (ILCA 2006 and 6624) were successfully transferred to sterilized vermiculite without any plant mortality. 67 and 92% of *C. dactylon* (ILCA 13828 and 13831) and 38% of *C. aethiopicus* (ILCA 6624) were successfully established in sterilized forest soil. More significantly, 67 and 83% of *C. dactylon* (ILCA 13828 and 13831 respectively) and 50% of *C. aethiopicus* (ILCA 6624) were successfully established in unsterilized forest soil directly from *in vitro* conditions (Plate 3).

Plate 1. Rooted plantlets *Digitaria decumbens* from in vitro collection (8 weeks)
Plate 2. Adventitious regeneration from hypocotyl tissue of *Sesbania sesban*.
Plate 3. Establishment of *Cynodon aethiopicus* cultures in soil

Plate 1

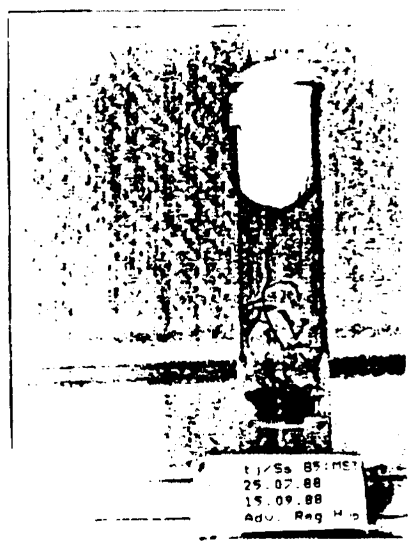

Plate 2

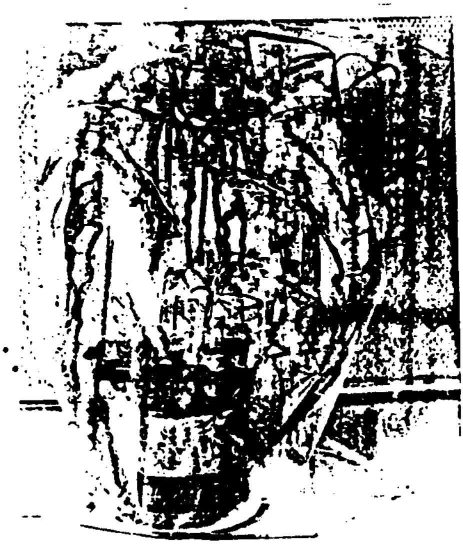

Plate 3

Table 1. Establishment of cultures from different explants on 3 media.

Species	Accession Number	Medium	Percentage establishment		
			Axillary bud cultures	Meristems cultures	Nodal cutting cultures
C. dactylon	13828	MS3	66	77	53
		MSSG	60	--	
		MSS	84	80	--
	13829	MS3	33	40	--
		MSSG	15	--	--
		MSS	9	60	--
	13831	MS3	56	60	--
		MSSG	64	--	--
C. aethiopicus	2006	MS3	50	--	93
		MSSG	23	--	--
		MSS	74	--	--
	6624	MS3	76	43	--
		MSSG	91	--	--
		MSS	90	100	--
D. decumbens	9729	MS3	60	--	75
		MSS	66	40	--
D. smutsii	6611	MS3	17	--	--
		MS3	4	--	--
L. leucocephala	11662	MS3	--	--	90
		1/2MS3	--	--	35
E. bruceii	--	MS3	--	--	75
		1/2MS3	--	--	42
S. sesban	10865	MS3	--	--	21
		1/2MS3	--	--	58

Table 2. Survival of cultures after retrieval from slow growth storage.

Species	Accession	Medium	Temperature (%C)	% survival after storage 100	200	300 days
C. dactylon	13831	MSS	15	100	100	100
		MSS	5	100	100	--
		MS3	15	60	100	100
	13828	MSS	15	90	82	--
		MS3	15	100	100	--
C. aethiopicus	6624	MS3	15	90	50	--
D. decumbens	9729	MS3	5	60	0	--

So far an eighty percent success rate has been achieved using the minimal facility method for transferring in vitro cultures to soil. Plants derived from in vitro field collection and slow growth conservation have been directly transferred to untreated soil using this method.

DISCUSSION

In vitro collection methods have already been developed for other crops. Using minimal facility in vitro field collection methods, Altman et al (1987) reported 83% success for wild species of *Gossypium* whilst Assy Bar et al (1987) reported 90% success for coconut, after keeping the cultures for four weeks. Great care must be taken in interpreting results because the best treatment at four weeks became heavily contaminated after eight weeks using minimal facility methods for the collection of *D. decumbens*. Time factors are therefore important since collection missions can be for very long periods of time.

Over the past two decades it has been shown that even within species, different genotypes can have different requirements for optimum growth in vitro (Evans et al, 1981). In the grass and browse species used here, medium preferences were observed in the establishment of different accessions. Since genetic conservation intends to capture the whole gene pool of an accession it is important that the conditions under which optimum numbers of explants and accessions can be established as cultures be determined and adopted. Work is in progress to evaluate the possibility of in vitro selection.

Obligate bacteria, fungi and viruses can be eliminated from in vitro cultures by using meristem culture together with thermotherapy (Kartha, 1986). These techniques rely on the establishment of cultures from meristems with three or fewer leaf primordia. Thermotherapy techniques will be eventually developed for the species which were successfully initiated from meristems in this work.

Growth suppression using low temperatures is the most promising approach to *in vitro* conservation. The temperate forage grass species *Lolium, Festuca, Dactylis* and *Phleum* can tolerate 2-4^{o}C (Dale, 1978, 1980); even so, some tropical species such as *Ipomea batatas,* (Alan, 1979) and *Manihot esculentum* (Roca, 1978) cannot tolerate temperatures below 15^{o}C. Despite the varied temperature tolerance of accessions, the grasses used here show good recovery rates for up to 300 days at 15^{o}C. Further investigations are necessary to adequately establish survival rates at lower temperatures.

In vitro multiplication of forage grasses and legumes has been routinely carried out in this work using nodal cuttings which give rise to genetically stable plants. It may be hastened by using adventitious regeneration forming masses of shoots from parts of the plant without meristems. Apical axillary meristems can also be induced to form multiple shoots. Whilst multiple shoots from pre-existing meristems and plants that form adventitiously directly on the explant are usually genetically identical to the mother tissue, those from indirect adventitious regeneration through a callus stage have been found to be genetically heterogeneous in some species (Scowcroft, 1984). Of particular interest is the genetic enhancement of desirable agronomic characters in some of these so called somaclonal variants when compared to the mother plants (Larkin and Scowcroft, 1981; Scowcroft, 1984). Work is in progress at ILCA to root and establish adventitious regenerants from cotyledons and hypocotyls of *S. sesban* in soil for eventual evaluation.

A successful *in vitro* genetic resources programme also requires minimal facility techniques for re-establishment of cultures in soil. The results obtained at ILCA have been very significant because plantlets have been established in soil with very high success rates using minimum facilities.

ACKNOWLEDGEMENTS

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Appendix 1. Plant species used in the experiments

Species	ILCA accession number
Cynodon dactylon	13828, 13819 and 13831
Cynodon aethiopicus	2006 and 6624
Digitaria decumbens	9729
Digitaria smutsii	6611
Sesbania sesban	10865
Erythrina brucei	--
Leucaena leucocephala	11662

Appendix 2. Culture media used

MS3 MS medium without IAA or kinetin and with 3% sucrose

1/2MS3 medium diluted to half the normal concentration maintaining 3% sucrose

MSS Salts of MS medium with myo-inositol, thymine.HCI and 3% sucrose

MSSG MSS medium with glycine

MS2 MS medium without IAA or kinetin and with 2% sucrose

PRODUCTIVITY OF OVERSOWN NATURAL PASTURES IN NORTHERN TANZANIA

M.L. Kusekwa[1], S.N. Bitende[2] and M.D. Ngowi[1]

ABSTRACT

Natural pastures are the cheapest and main source of feed for the ruminant livestock population in Tanzania. These pastures occupy about 60 million hectares of Tanzania mainland's approximately 87 million hectares. The majority of the cattle, goats and sheep are kept by small holder livestock keepers in rural areas where communal grazing is commonly practised (Anon, 1983). Herbage production of these pastures is contained by overgrazing, poor species composition and general land degradation.

Oversowing of natural pastures with improved forage species, particularly legumes, improves the production and quality of resulting pastures. At Tengeru, Arusha it was found that natural pastures oversown with Desmodium intortum produced an average of 15.6 tonnes DM/ha annually as compared to annual yield of 13.0 of tonnes DM/ha from natural pastures alone. Liveweight gains of heifers grazing oversown natural pastures were, however, only slightly higher (10%) than those of heifers on natural pasture alone.

This paper discusses the potentials of oversown natural pastures in the improvement of livestock productivity with special reference to work done at Tengeru, Arusha, northern Tanzania.

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INTRODUCTION

Natural pastures are important in Tanzania in that they support most of the ruminant livestock population. However, their productivity is low due to the inherent low production and quality of the component species (French, 1957; Calo 1976; Mwakatundu, 1977).

Natural pastures can be improved through employing the following ways:-

i) Improvement of the management and utilisation of the existing natural pastures.

ii) Replacement of natural pasture species with improved ones and

iii) The use of the combination approach involving oversowing of natural pastures with improved species, particularly legumes.

Improvement of management and utilisation of natural pastures is in itself constrained by the inherent low productivity and quality of herbage of the existing plant species (Calo, 1976). Replacing them with improved species by cultivation and seeding is unlikely to be adopted due to the high costs involved. A more realistic approach would appear to be the employment of oversowing techniques for natural pastures development. Limited experience in Tanzania has shown that desired species could be successfully introduced into the natural pastures with minimum operations such as hard grazing, burning, use of herbicides and minimum cultivations (Northwood and Macartney, 1969; Lane and Lwoga, 1978; Kusekwa, 1982; Lwoga, 1983). The work by Anderson and Naveh (1968) and Naveh (1967) in northern Tanzania, that reported by Lane and Lwoga (1978) and that of Rukanda and Lwoga (1981) in Morogoro have suggested that a number of legumes could be grown in these areas. Therefore it was a matter of importance to carry out studies on how to successfully establish these species in natural pastures by techniques that employed oversowing methods.

This study has endeavoured to throw some light on oversowing techniques to be used, what species are most suited for oversowing performance of oversown natural pastures under grazing and the growth of animals grazing these pastures.

The objectives of this study were:

(a) To determine the best method of seedbed preparation for the establishment of pasture legumes by oversowing.

(b) To determine the role of phosphatic fertilizers in the productivity of oversown natural pastures, and

(c) To determine the most suitable legume species for oversowing purposes and their role in increasing the productivity of natural pastures in terms of herbage and animal production.

MATERIALS AND METHODS

Plot and grazing experiments were conducted from April, 1979 to December, 1983 at the Livestock Training Institute, Tengeru, in Arusha, Northern Tanzania. Detailed description of the research site and the methodology used for the plot experiment are given in earlier reports (Kusekwa and Lwoga, 1986; Kusekwa, 1988).

Grazing Experiment

Two legumes, out of the 9 tested for suitability for oversowing in the plot experiment, Macroptilium atropurpureum (Siratro) and Desmodium intortum (Greenleaf desmodium) were selected and oversown into paddocks after the natural pastures had been hard grazed. The oversown pastures were given one year for establishment before grazing was introduced.

At grazing, two stocking rates were used and the basis for their selection was the recommendations by Pratt et al (1966) that the carrying capacity for Ecological Zone II (i.e. Humid to dry subhumid) was 1-2.5 ha/stock unit. Yearling dairy heifers grazed the pastures for six months of the year during the growing season and part of the dry season. The experiment lasted for 3 years (1981, 1982 and 1983) and, each year, a new batch of heifers was used.

Pasture types (treatments):

(a) Siratro oversown natural pastures (Siratro)
(b) Greenleaf desmodium oversown natural pastures (Greenleaf desmodium)
(c) Natural pasture alone (control).

Stocking Rates

Only two stocking rates were used instead of three or more as generally recommended (Mannetje _et al_ 1976) because land and animals available for experiment were limited.

(a) High stocking rate (SR_1) = 2 animal units/ha or 4 heifers/ha (liveweight ranged from 120-150 kg).

(b) Low stocking rate (SR_2) = 1 animal unit/ha or 2 heifers/ha.

Experimental design

The randomized block design was used in which 12 paddocks made up of all combinations between the three pasture treatments and 2 stocking rates were replicated twice. Three heifers were allocated to each paddock. Thus the paddocks for the high were 0.75 ha each and those for the low stocking rate were 1.5 ha each.

Measurements

Various measurements were taken during the course of the study which included soil tests, botanical composition, dry matter production, pasture quality and liveweight gains.

Botanical composition

The Dry Weight Rank (DWR) method as described by Tothill *et al* (1978). The rank BOTANAL computational package as described by Tothill *et al* (1978).

Dry matter production

Dry matter production was determined by placing cages in the paddocks to exclude grazing animals. The growth of the pastures was then monitored, that within and outside the cages, by cutting regularly samples for dry matter production assessement.

Liveweight gains measurements

The animals were weighed twice a week during the entire grazing period. Weighing was done in the mornings, from about 7.00 hrs to about 9.00 hrs. The weighing of the animals was arranged such that it coincided with spraying for tick control (on Tuesdays and Fridays).

RESULTS

In this paper, results showing the effects of oversown pasture legumes on natural pasture and animal productivity, dry-matter yield, botanical composition and liveweight gains, will be given. Results on pasture legumes suitability for oversowing, establishment, persistence (survival), dry matter production and responses to phosphatic fertilizer application are reported elsewhere (Kusekwa and Lwoga, 1986, Kusekwa, 1988).

Annual dry-matter yield

The annual DM yield (kg/ha) was not significantly affected by oversowing with legumes as shown in Table 1. However, the 1983 DM yield (11,626 kg/ha) was significantly lower than those of 1981 and 1982 (16,007 and 15,182 kg/ha, respectively). This represented decreases in DM yield of 27% between 1981 and 1983 and 23% between 1982 and 1983. Within pasture treatments the decline in DM yields in 1983 was lower than that for 1981 and

1982 ($P<0.05$) except for the control pasture where the 1983 DM yield was significantly lower ($P<0.05$) than that of 1981. However, it was in the control pasture where the decrease in DM yield was largest, 33% as compared to 27% and 21% in the Siratro and Greenleaf desmodium pastures respectively.

Table 1. Effects of oversown pasture legumes on annual dry-matter yield (kg/ha)

Pasture treatments	1981	1982	1983	Means	LSD (0.05)	S.E
1 Siratro	15410	15343	11142	13965	3629.5	1411.7
2 Green leaf desmodium	17210	16554	13485	15570	2951.7	1148.1
3 Control	15402	13650	10251	13101	3887.7	1512.1
LSD (0.05)	NS	NS	NS	NS		
S.E.	2596	2901	1193	1350.9		

Table 2. Effects of stocking rate on annual dry-matter yield (kg/ha) SR_1 = High Stocking rate, SR_2 = Low Stocking rate.

Stocking rate	1981	1982	1983	Means	LSD (0.05)	S.E.
SR_1	15965	14586	11101	13884	3721.2	1447.4
SR_2	16049	15779	12151	14660	3231.2	1256.8
Means	16007	15182	11626	14272	3455.8	1344.1
LSD (0.05)	NS	NS	NS	NS		
S.E.	670.0	841.0	975.0	388.1		

Table 3. Overall botanical composition (%) of an oversown natural pasture over three years (1981-1983).

Pasture component	1981	1982	1983	Means	LSD(0.05)	S.E.
Grasses	78.8	80.9	79.3	79.7	NS	0.63
Sown legumes	10.7	8.8	11.9	10.5	NS	0.90
Volunteer legumes	4.0	3.6	5.5	4.4	NS	0.58
Weeds	6.7	6.8	3.5	5.7	NS	1.08

Table 2 shows that stocking rate had no significant effects on DM yield. However, DM yield declined with time: at SR_1 (high stocking rate) there was a decline of 30% between 1981 and 1983. Similarly at SR_2 (low stocking rate) there was a decline of 24% between 1981 and 1983. Both these declines in DM yield were significant ($P<0.05$).

Presentation yield (kg/ha) during the grazing period.

Presentation yield or available DM during the grazing period, determined by sampling at the beginning, middle and end of each grazing period (H_1, H_2 and H_3 respectively) did not differ significantly between pasture treatments. However, the mean DM yield for sampling dates were significantly different ($P<0.05$). Mean DM yield at H_3 (4,995 kg/ha) was lower ($P<0.05$) than that at H_1 (10,856 kg/ha, a reduction of 54% in available DM between these sampling dates.

Stocking rate had no significant effect on presentation yield (available DM) at the various sampling stages during the grazing periods. The declines in available DM between H_1 and H_3 were, however, significant ($P<0.05$). At SR_1 the reduction in yield was 58% while at SR_2 it was 49%.

Botanical composition of pastures

Table 3 shows that pasture component species, grasses, sown legumes, volunteer legumes and weeds, did not differ significantly between years. However, in Table 4, all the pasture component except volunteer legumes changed with years. The contact of the sown legume, Siratro in 1983 (2%) was significantly lower than that of 1982 (9.8%) ($P<0.05$). In the Greenleaf desmodium pastures in Table 5 sown legume and the weed contents differed significantly between years ($P<0.05$). Greenleaf desmodium content in 1983 (33.6%) was higher than in 1982 (16.7%) while weed content in 1983 (4.0%) was lower than in 1981 and 1982 (7.1% and 7.3% respectively).

Pasture quality

The crude protein contents and digestibility coefficients of leaf herbage from the pastures declined significantly ($P<0.05$) with time during the grazing period. In the Siratro pasture, CP content dropped from 14% at H_1 to 10.8% at H_3 and digestibility dropped from 66.8% to 60% at H_1 and$_3$ respectively. In the Greenleaf desmodium pasture CP content declined from 15.6% at H_1 to 11.2% at H_3 while digestibility declined from 64.3% at H_1 to 55.9% at H_3. In the control pasture, CP content varied between 12.0% at H_1 and 7.3% at H_3 while digestibility was 62.3% at H_1 and 50.3% at H_3. The control treatment, natural pasture alone, tended to drop in quality faster than the Siratro and Greenleaf desmodium pastures. This was indicative of a general improvement in the quality of herbage of legume oversown natural pastures.

Table 4. Overall botanical composition (%) of a Siratro oversown natural pasture over three years (1981-1983).

Pasture component	1981	1982	1983	Means	LSD(0.05)	S.E.
Grasses	83.3	80.1	90.8	84.7	6.94	1.91
Siratro	6.5	9.8	2.0	6.1	5.38	1.48
Volunteer legumes	4.4	3.7	4.4	4.2	NS	0.23
Weeds	6.4	6.9	2.9	5.4	2.43	0.67

Table 5: Overall botanical composition (%) of Greenleaf desmodium oversown natural pasture over three years (1981-1983).

Pasture component	1981	1982	1983	Means	LSD(0.05)	S.E.
Grasses	63.4	73.1	56.2	64.5	12.14	3.34
Greenleaf desmodium	25.7	16.7	33.6	25.4	10.46	2.88
Volunteer legumes	3.4	2.8	6.5	4.2	NS	1.88
Weeds	7.1	7.3	4.0	6.1	2.18	0.60

Liveweight gains (LWG) of grazing animals

The LWG per head of heifers was not significantly affected by pasture treatments but was influenced significantly by stocking rates ($P<0.05$). At SR_1, LWG per head was 56.0 kg and at SR_2 it was 77.2 kg, working out to the equivalent of 311 gm and 429 gm LWG per head per day at SR_1 and SR_2 respectively. Although pasture treatments did not affect significantly LWG per head of the heifers, there was an overall improvement in the growth of the animal grazing oversown natural pastures as shown in Figure 1 and Appendix Figures 1-3.

LWG/ha of heifers during the 6-month grazing period was significantly affected by pasture. At SR_1 and SR_2 LWG/ha was higher, 224.1 kg than at SR_2, 154.3 kg. This represented a LWG/ha/day of 1245 gm and 857 gm at SR_1 and SR_2 respectively. Figure 2 and Appendix Figures 4-6 show the relationship between LWG/head and LWG/ha at the two stocking rates.

DISCUSSION

Dry-matter (DM) yield

The annual dry-matter yield of the natural pasture was not significantly affected by legume oversowing (Table 1). However, legume oversown natural pastures in particular, Greenleaf desmodium, consistently produced more DM than the Siratro and control pastures. Clatworthy (1984), in Zimbabwe, observed increased DM production of a natural pasture oversown <u>Desmodium uncinatum</u> (Silverleaf desmodium). Other workers have reported increases in pasture production when suitable pasture legumes were successfully incorporated (Walker, 1969; Stobbs, 1969 and Lwoga, 1983).

The general decline in DM production over the three years could be attributed to effects of defoliation and hence fertility decline and depletion of food reserves for regrowth. It is shown that DM yield declined the least on the Greenleaf desmodium pasture, 21.6% as compared to 27.7% and 33.4% on the Siratro and control pastures respectively. This follows closely the legume content in the pasture in that, the higher the legume content in the pasture the smaller the decline, a function of fertility build-up through N-fixation by the legume component. The abnormally low rainfall in 1983 (Appendix Table 1) is thought to have further depressed DM yield that year.

Presentation yield

Presentation yield at the various sampling dates was not significantly affected by oversowing with legumes although Greenleaf desmodium pastures had consistently more dry-matter yield at all sampling dates during the grazing period. Keya *et al* (1971) observed a 28% and 31% increased in DM yield in a natural pasture oversown with *Desmodium intortum* and *D. uncinatum* respectively. Presentation yield declined at each sampling date and decline was more severe at SR_1 than at SR_2. This could be attributed to faster removal of herbage than was being replaced by regrowth during the grazing period while the differences between SR_1 and SR_2 could be attributed to more severe defoliation at SR_1. Other workers have reported declines in DM yields with increase in stocking rates caused mainly by increase in stocking rates caused mainly by increase in bare ground and unproductive species (Jones *et al*, 1984; Mannetje, 1984). However, in this study, there was no evidence of pasture deterioration caused by grazing pressure exerted by SR_1 and SR_2.

Figure 1. Monthly cummulative liveweight gains of heifers kg/head.
Mean of 3 years (1981-1983)

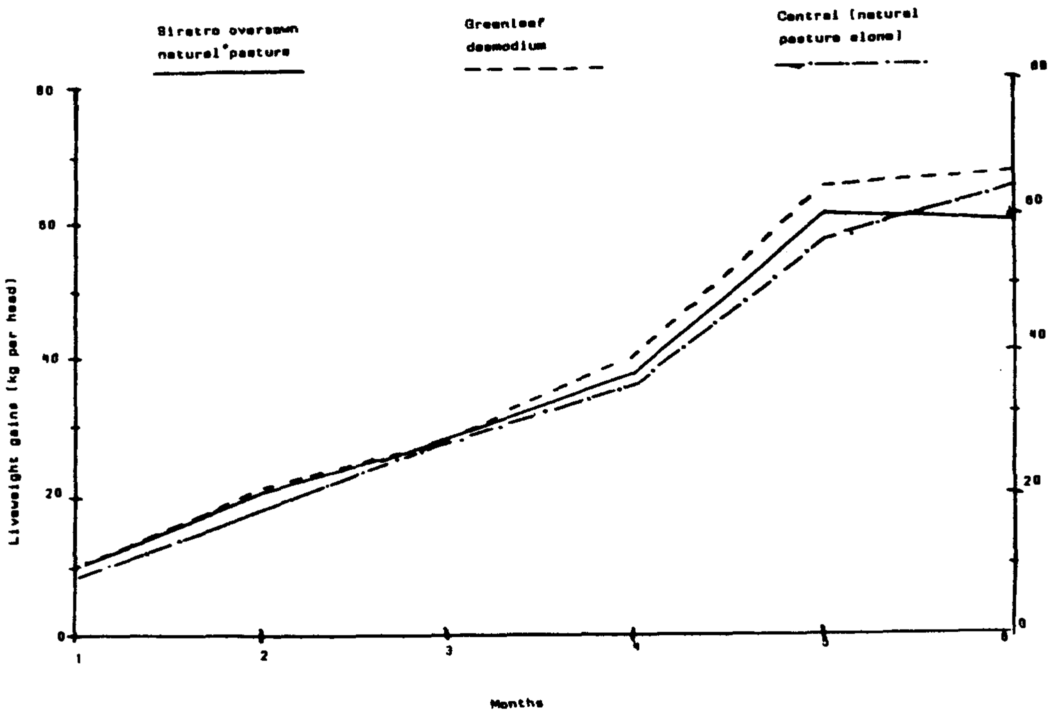
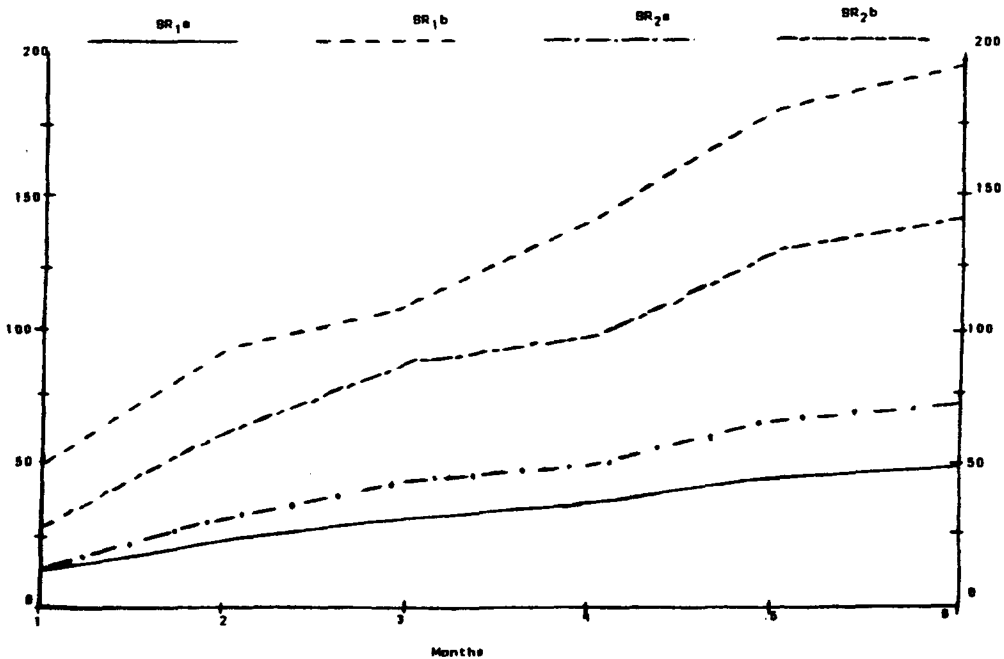


Figure 2. Monthly cummulative liveweight gains of heifers kg/head and per hectare.
Means of 3 years (1981-1983)



Legend: SR_1a - LWG/head at the high stocking rate
SR_1b - LWG/ha at the high stocking rate
SR_2a - LWG/head at the low stocking rate
SR_2b - LWG/ha at the low stocking rate

Botanical composition

Botanical composition was not influenced significantly (P>0.05) by either pasture treatment or stocking rate. It has been reported that high stocking rates tended to encourage weed invasion and depletion of desirable species (Humphreys, 1981). In this study, both SR_1 and SR_2 were significantly lenient to maintain stable pastures.

Botanical composition did not change significantly (P>0.05) between sampling dates or between years. However, the Siratro pastures dropped significantly (P<0.05) in their legume content (from 2.8% in 1982 to 2.0% in 1983). This suggests that Siratro was being selectively grazed and that regeneration through seed setting was hampered (Jones, 1981; Tothill and Jones, 1977).

Pasture quality

Pasture quality in terms of CP content and digestibility was found to be higher in legume oversown natural pastures than in natural pastures alone. The decline in quality was also slower when initial values were higher (Tothill, 1986). This points to the usefulness of grass pastures as overall feed quality is improved. Oversowing of forage legumes into natural pastures has also been reported to increase the quality of the resultant herbage where *Macroptilium atropureum* and *Stylosanthes guianensis* were oversown in *Themeda.* *In vitro* OM digestibility and CP content were 55.7% and 9.1% respectively on oversown natural grasslands as compared to 51.9% digestibility and 8.1% CP on natural grassland alone (Rukanda and Lwoga, 1981).

Liveweight gains

The liveweight gains of heifers was not significantly influenced (P>0.05) by pasture treatments. However, the liveweight gains, per head and per hectare, on the Greenleaf desmodium were consistently higher than those on the Siratro and control pastures. The lack of a significant difference in the LWG's between pasture treatments is in agreement with observations by other workers who found that, in the wet season, animals performed similarly on natural pastures and on improved pastures (Mannetje, 1984; Tothill, 1985 pers. comm; Tothill, 1986). Feed quality improvement resulted in increases in LWG's and that the quality factor was more evident in the dry season. In this study quality of pasture in terms of CP did not fall below the suggested critical level of 6.5% CP (Jones et al, 1984).

Stocking rate influenced significantly ($P<0.05$) LWG per head and per hectare with the higher stocking rate giving higher LWG's/ha than the low stocking rate while the pastures remained fairly stable. Intermittent 6-month continuous grazing of oversown natural pastures appear to have been appropriate at both SR_1 and SR_2 evidenced by the relatively stable botanical composition. The higher DM yield, presentation yield, legume content and leaf CP content on the Greenleaf desmodium pasture than on the Siratro and control pastures reflected the overall better LWG's of heifers on this pasture.

Relevance of oversowing to pasture improvement in Tanzania

It is our view that this technology has a role to play in the development of forage resources in Tanzania. The majority of the reasons advanced for poor adoption of innovations by small-scale farmers also apply with regards to oversowing. However, we specifically consider the following factors to be important:- Oversowing was best suited to systems where some form of land ownership existed, namely commercial holdings under governmental, parastatal or private control. Here the technology has been and is being employed for pasture development. Small-scale farmers could readily adopt this technology (all other things being equal) through setting aside a piece of land, on communal land, for development. The rule practised here was "use the land, gain it and vice versa" (Anon, 1986).

Necessary inputs such as seeds, appropriate machinery and management were in short supply. This was likely to slow the adoption process.

Inadequate research-extension linkage was a limiting factor to adoption of this technology.

Oversowing, being a low-cost pasture development method, is likely to be widely used when and if the rightful settings are developed including its promotion through extension leaflets and demonstrations.

CONCLUSION

In this study it has been shown that pasture development could be achieved through oversowing natural pastures with legumes. Oversown natural pastures were shown to be more productive, in terms of DM yield and LWG's, than untreated natural pastures. However, management of the oversown pasture and the forage legumes to be used varied with agro-ecological zones involved. Thus there was a need of extending this kind of study to cover the various zones of the country so as to develop this technology for each situation.

ACKNOWLEDGEMENT

We are grateful for advice and assistance from various people in the Ministry of Agriculture and Livestock Development, the Tanzania Livestock Research Organisation (TALIRO), Sokoine University of Agriculture (SUA) at Morogoro and the International Livestock Centre for Africa (ILCA) in Addis Ababa, Ethiopia, notably Professor A.B. Lwoga and Dr. J.C. Tothill for their supervisory role to the senior author. Special thanks are due to Mr. J.J. Mbekelu for his diligence in the day-to-day supervision of the field work. We are indebted to the Royal Netherlands Government, Research Council, (Tanzania), World Food Programme (WFP) (Tanzania), International Development Research Centre (IDRC) (Ottawa, Canada), ILCA, TALIRO and SUA, for their support in this study. Last but not least, we wish to thank the PANESA and ARNAB Steering Committees for involving us to prepare this paper.

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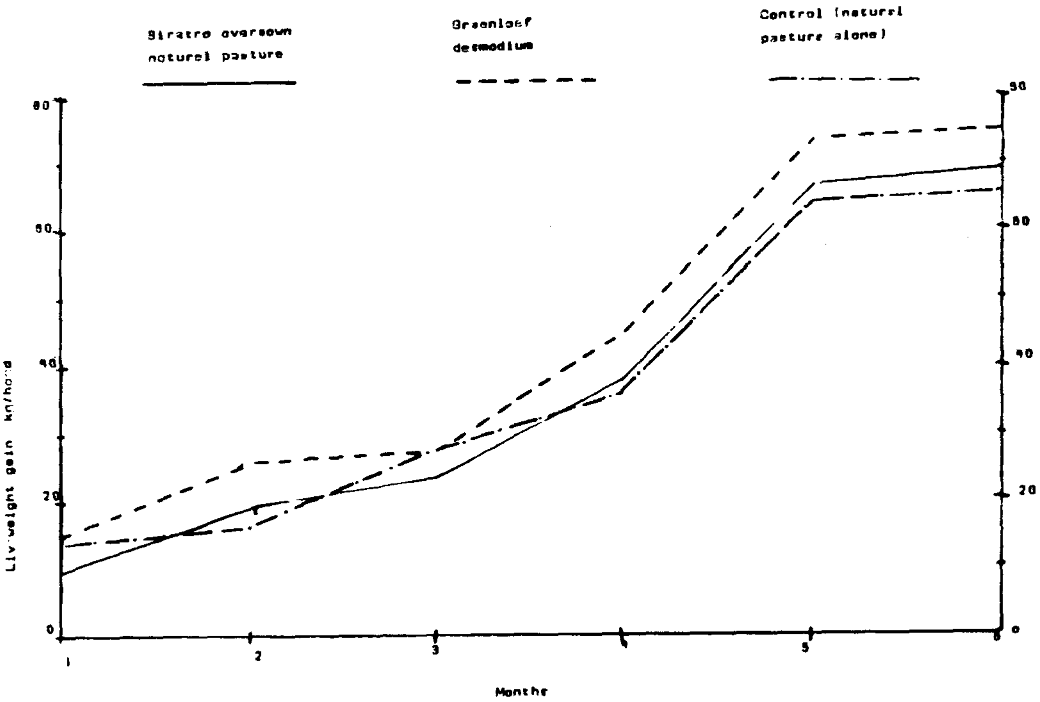
Appendix Table 1: Rainfall during the study period (1979-1983) along with the 20 year rainfall means at Tengeru, Arusha, Tanzania.

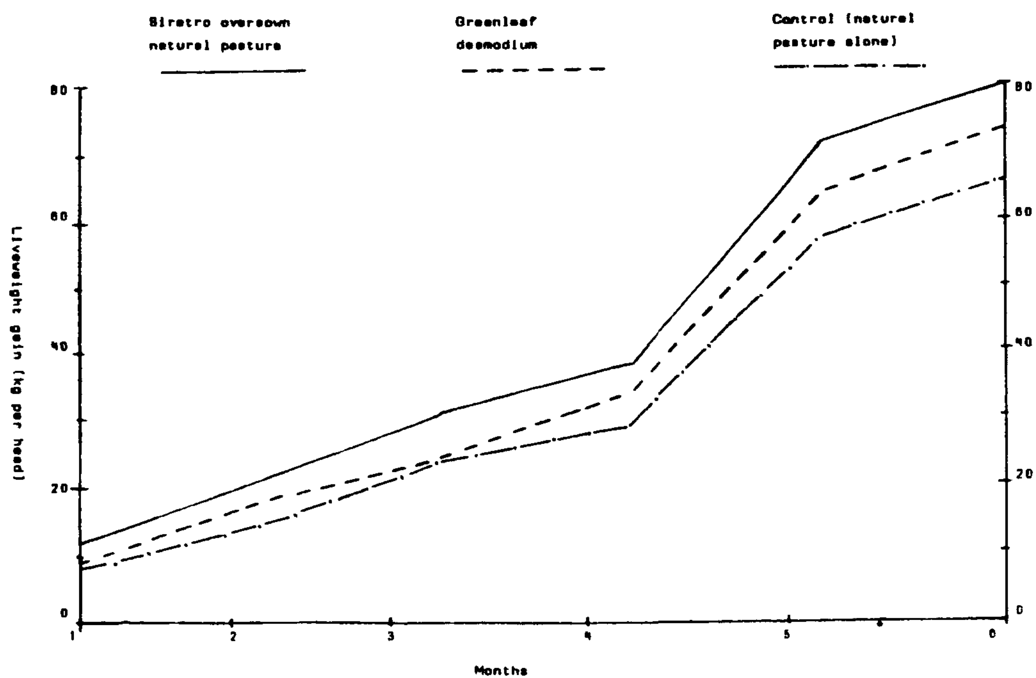
Month	1979		1980		1981		1982		1983		20 year mean	
	mm	Days	mm	Days	mm	Days	mm	Days	mm	Days	mm	Days
January	17.1	3	28.8	4	32.0	5	6.4	3	36.1	8	59.0	4
February	53.5	5	62.4	6	24.1	7	9.1	2	43.9	4	61.9	3
March	47.1	5	49.2	6	294.6	14	36.0	5	56.1	3	143.0	8
April	305.1	21	259.2	15	304.1	21	294.6	17	90.2	10	365.0	19
May	241.0	21	101.7	16	241.0	21	234.4	22	123.3	18	145.0	18
June	2.7	2	1.4	2	3.1	3	16.0	4	34.8	10	30.0	4
July	1.4	2	2.1	4	1.5	2	53.8	10	1.9	2	15.0	6
August	12.0	3	53.4	10	11.9	4	18.4	3	1.1	4	13.0	7
September	25.8	6	7.6	2	26.0	6	65.3	11	1.2	3	12.0	5
October	57.2	11	12.1	3	81.1	11	183.2	14	2.4	2	47.0	12
November	0.0	0	72.5	14	17.7	5	297.5	15	51.0	4	93.0	13
December	21.1	6	47.8	9	58.8	14	122.6	10	142.4	15	101.0	9
Total	784.0	85	698.2	91	1096.9	113	1327.3	116	584.4	83	1084.0	108

Source: Meteorological facilities set-up experiment site (rainfall) figures for 1979-1983) at the Tengeru meteorological station (20 year rainfall means)

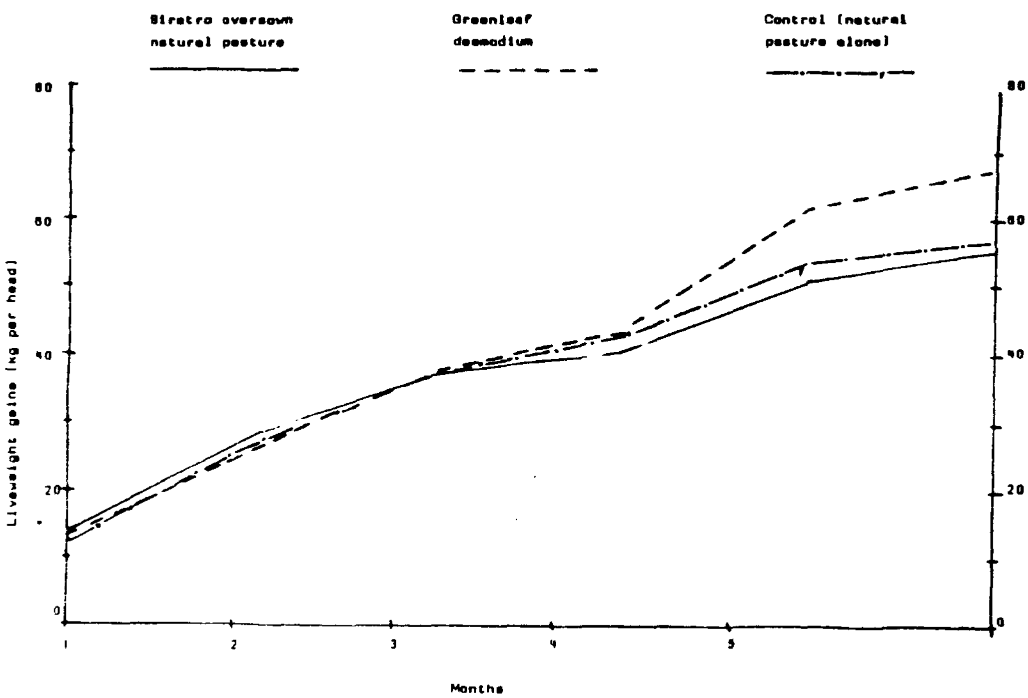
Appendix Figure 1. Monthly cummulative liveweight gains of heifers kg/head, 1981.



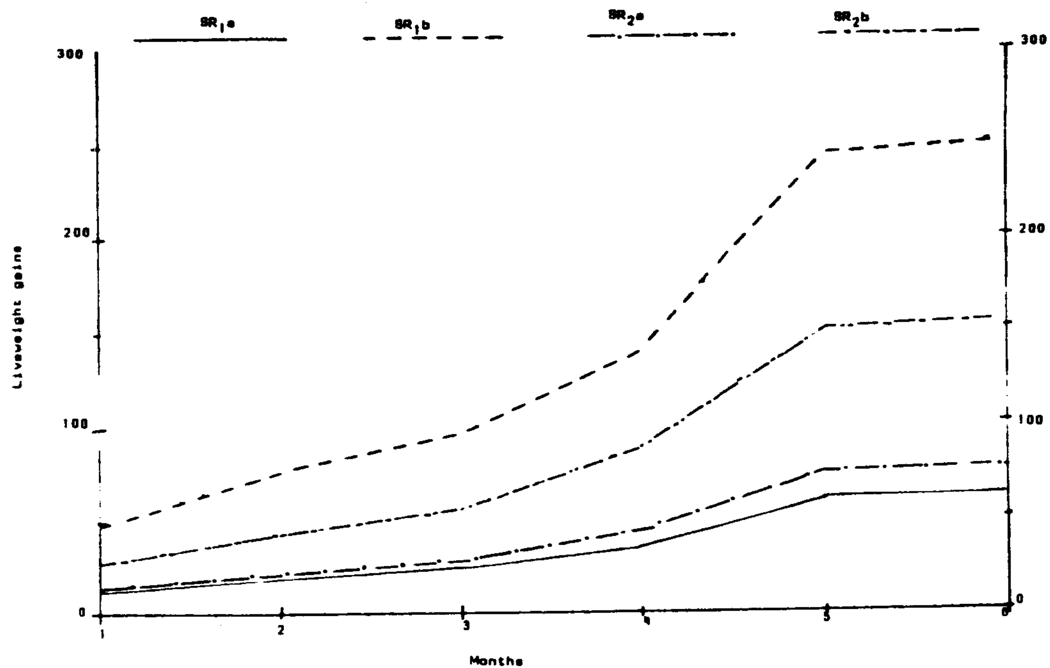
Appendix Figure 2. Monthly cummulative liveweight gains kg/head, 1982.



Appendix Figure 3. Monthly cummulative liveweight gains of heifers kg/head. 1983.

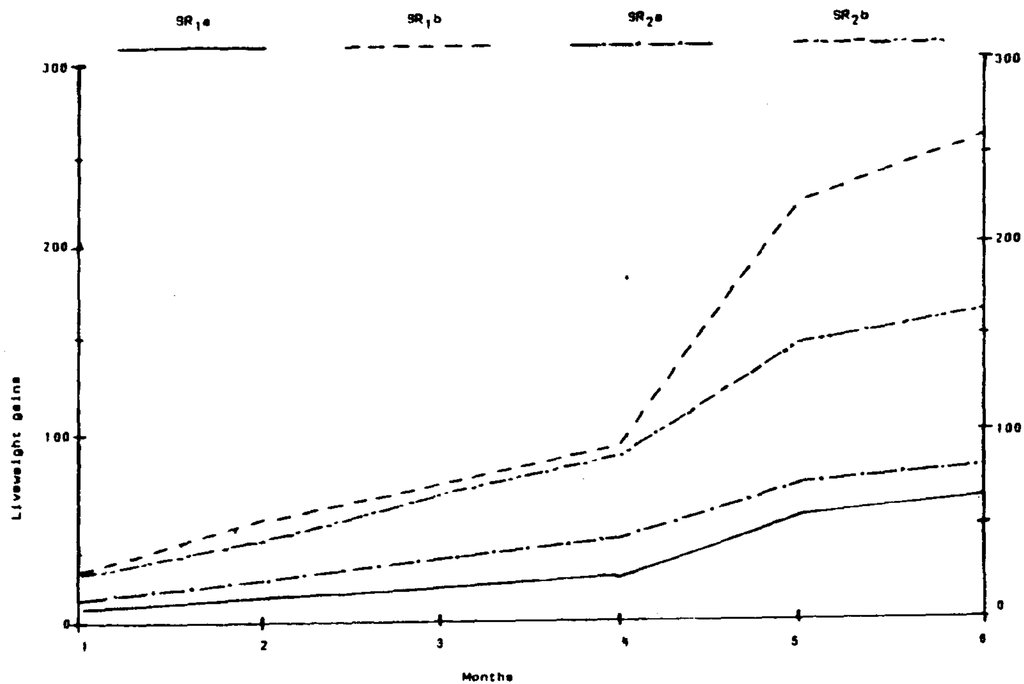


Appendix Figure 4. Monthly cummulative liveweight gains of heifers. kg/head and /ha. 1981.



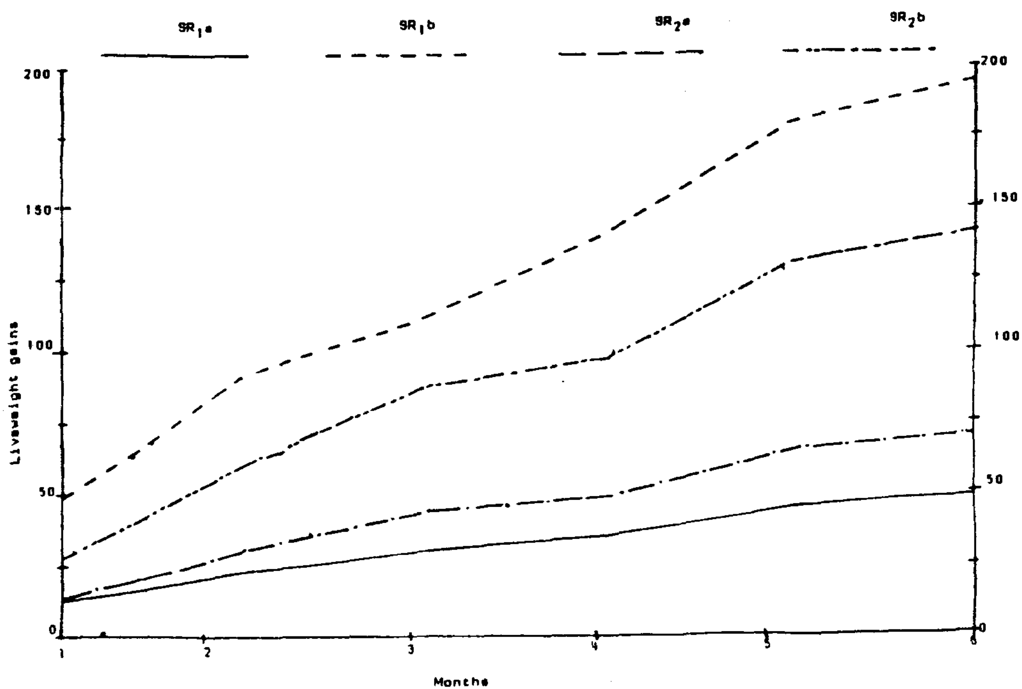
Legend: SR_1a - LWG/head at the high stocking rate
SR_1b - LWG/ha at the high stocking rate
SR_2a - LWG/head at the low stocking rate
SR_2b - LWG/ha at the low stocking rate

Appendix Figure 5. Montnly cummulative liveweight gains of heifers, kg/head /ha. 1982.



Legend: SR_1a - LWG/head at the high stocking rate
SR_1b - LWG/ha at the high stocking rate
SR_2a - LWG/head at the low stocking rate
SR_2b - LWG/ha at the low stocking rate

Appendix Figure 6. Monthly cummulative liveweight gains of heifers kg/head and / ha. 1983



Legend: SR_1a - LWG/head at the high stocking rate
SR_1b - LWG/ha at the high stocking rate
SR_2a - LWG/head at the low stocking rate
SR_2b - LWG/ha at the low stocking rate

TECHNIQUES FOR INTRODUCING FORAGE LEGUMES TO THE SMALL-SCALE FARMERS OF THE SEMI-ARID REGION OF KENYA

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ABSTRACT

A range of forage legumes which are well adapted to the semi-arid mid-altitude environments of Kenya have been identified in trials lasting several growing seasons. Growth habits and persistence within the plant genotypes selected vary from short-lived annuals to perennials. Data have been obtained on agronomic performance and phenological characteristics in a range of temperature - moisture environments in eastern Kenya.

Possible ways of integrating these forage legumes into existing farming systems will include undersowing or intercropping with cereals, use on erosion control bunds or terrace banks, in the improvement of degraded, non-productive grassland, or in simple cut-and-carry fodder plots. The possibility of using these techniques with individual legume genotypes is discussed in this paper. With successful introductions into farm systems, it is likely that the legumes will increase soil fertility, reduce soil erosion and consequently increase livestock and cereal production.

INTRODUCTION

Semi-arid regions cover about 59% (342,000 km^2) of the total land area in Kenya. Soils range from clays to well drained reddish and stony sands. The eastern region has a marked bimodal rainfall pattern with two pronounced wet and dry seasons (Kusekwa, 1985). Annual rainfall averages 500-800 mm, but is irregular and erratic with pronounced erosive downpours and long drought periods. These attributes make mixed farming (crops/animal production) in the semi-arid environment a risky enterprise (Rukandema, 1984).

Rapid increases in population densities and intensity of cultivation and grazing within the smallholder farming systems have resulted in severe depletion of soil fertility and severe soil erosion. On the cultivated lands, contour bunds and terraces are commonly used for controlling erosion. These are sometimes planted with grasses but commonly left bare, making them a target of erosion. On grazing lands continual intensive defoliation and trampling have led to land denudation, insufficient regrowth and the development of marked erosion in many areas.

In some grazing lands, adequate perennial grasses are present but it has been estimated that livestock carrying capacity in lowland Machakos (and similar semi-arid areas) is 1.5 ha to 6 ha/livestock unit, an indication of poor quantity and quality pastures (Wheeler and Jones, 1984).

Forage legumes do not feature prominently in the existing farming systems, despite their potential to improve soil fertility, check soil erosion and contribute to the livestock feed resource base. It has been suggested (Thairu and Tessema, 1987) that productive legumes are absent from pastures in the semi-arid regions for various reasons including:-

i) failure to tolerate heavy grazing
ii) drought susceptibility and
iii) non-availability and high cost of seeds

The research programme described in this paper has concentrated on the search for adapted species over the last 4 years and is now shifting emphasis to the search for places where the adapted species identified can be fitted into the farming systems. Special techniques may be required to integrate forage legumes into the farming systems of the semi-arid regions.

MATERIALS AND METHODS

More than 160 accessions of forage legumes from 23 genera were tested over six growing seasons. The main experiments were conducted on row plots at Katumani (altitude 1600 m, mean annual rainfall 717 mm, mean annual temperature 19.6°C, soil type: chromic luviso, pH 6.5) and Kiboko (975m, rainfall 595 mm, mean temp. 25.7°, soil type: rhodic ferrasol, pH 5.8). Further assessments were made of swards in selected accessions at four other locations (Kiboko, Mua Hills, Maruba and Ithookwe) (See Menin et al, 1989).

The evaluation was in double row plots (2 m row x 1.5 m inter-row) and in multi-planting sward plots (16 m^2, of 20 best-bet accessions) in a randomized complete block design with 3 replaces. Two weeks after legume seedling emergence a basal fertilizer was applied along one row of the row plots and evenly broadcasted over the entire sward plots.

Monthly agronomic and phenological characters recorded included plant population, heights, plant development (e.g. flowering, seeding) visual bulk ratings (cumulative herbage on a scale of 1-5) and pest/disease incidence. In addition, the multi-planting swards had the objective of measuring seasonal dry matter production.

In the multi-planting swards, at 4 sites, a total of 12 plantings were done in 5 seasons although not every site was planted in each season. Each planting consisted of 3 reps of 20 accessions. Eleven accessions were common to all plantings while another 12 accessions were grown in a reduced number of plantings.

RESULTS AND DISCUSSION

Results of the row plot experiments, involving numerous observations of yield (bulk dry matter assessments), persistence, drought tolerance, seed production etc., allowed a ranking of the performance and adaptability of the individual accessions. These are listed below, and in Tables 1, 2 and 3 and in Figure 1.

The sward experiments allowed a more systematic analysis of yield and adaptability. An example of the data being obtained is given in Figures 1. Each curve on Figure 1 represents either linear or quadratic regressions with 10-12 data points per accession and coefficients of determination (r^2) normally in the range 80 to 90%.

Individual assessment

(a) Short-lived annual forage legumes

Because of the prolonged dry period in this environment, annual legumes might be better adapted than the perennials. Annual legumes can often self-regenerate from seed where the wet season is short.

Suitable potential species and cultivars of annual legumes have been identified, notably Centrosema pascuorum cv. Cavalcade (K14418), Aeschynomene americana cv. Glenn (K19897), Macrotyloma africanum CP 24972 (K14348) and Centrosema virginianum CP 2748 (K14399).

These are fast growing, prolific seeders with excellent regeneration. A difficulty with cv. Cavalcade is that its seeds are carried away by harvester ants into their nest. Otherwise establishment of these annuals is easy. They are non-aggressive in their growth pattern, and thus suitable for cereal intercropping. Because of their fast maturity, they are able to escape the dry period.

b) Long-lived annual forage legumes

These are sometimes referred to as short-lived perennials. Favourable soil temperatures and moisture initiate fast germination followed by excellent herbage growth during warm weather.

A good example is Lablab purpureus cv. Rongai - a rampant and vigorous multi-purpose legume. The grain can be used as human food and the residues can be fed to animals. It forms a
Table 1: Short-lived annual legumes for use in the semi-arid region.

Table 1. Short-lived annual forage legumes for use in the semi-arid region.

Species	Cultivar/ CPI	K. No.	Morph.	Evaluation* Early growth	Rege	Seed yeild	DM Prod	Uses
<u>Centrosema</u> <u>pascuorum</u>	Cavalcade	14418	herb	E	F	E	G	1.5
<u>Aescjnomene</u> <u>americana</u>	Glenn	19897	herb	E	E	E	6	4.5
<u>Macrotyloma</u> <u>africanus</u>	24972	14338	herb	E	E	6	F	1.5
<u>Centrosema</u> <u>virginianus</u>	C02748	14399	herb	F	P	G	F	1.5

Table 2. Persistent annual forage legumes for use in the semi-arid region

Species	Cultivar/ CP1	K. No.	Morph	Evaluation* Early Growth	Rege Pere	Seed Yield	DM Prod	Uses
<u>Alysicarpus</u> <u>rugosus</u>	52351	14384	herb	G	F	G	G	1.4
<u>Cassia</u> <u>rotundifolia</u>	Wynn	18177	herb	E	E	E	F	2.5
<u>Lablab</u> <u>purpureus</u>	Rongai	14420	herb	E	P	F	E	1,4,5
<u>Stylosanthes</u> <u>hamata</u>	Verano	14428	herb	E	E	G	F	2,5

Table 3. Perennial forage legumes for use in the semi-arid region

Species	Cultivar/ CPI	K. No.	Morph	Evaluation* Early growth	Rege Pere	Adapt	Seed yield	DM prod	Uses
Clitoria ternatea	48337	14403	herb	F	G	E	E	G	1,2,4
Desmanthus virgatus	40071	14456	herb/ shrub	P	E	E	E	E	1,3,5
Macroptilium atropurpureum	Siratro	14461	vine	G	G	E	E	E	1,2,4,5
Macrotyloma axillare	Archer	14462	herb/	E	E	E	E	E	1,2,4,5
Neonotonia wightii	Cooper	(35)	Vine	F	E	G	E	E	2,4,5
Rhynochosia malacophylia	-	18189	herb/ shrub	E	E	E	F	E	2,3,5
Stylosanthes guianensis	Cook	18189	herb	F	G	F	F	E	1,2,3
Stylosanthes scabra	Fitroy	14431	herb/ shrub	F	E	E	G	E	1,2,3,4,5
Stylosanthes fruticosa	41219A	14426	herb	F	G	E	G	F	2,4,5

Key for table 1,2,3

USES

P - Poor
F - Fair
G - Good
E - Excellent

1 - Intercropping
2 - Improvement of grazing land
3 - Terrace bank stabilisation
4 - Cut-and-carry fodder banks
5 - Ley farming

Rege - regeneration
Pere - Perennation
Adapt - Adaptability

* based on VBRS.

Figure 1. Dry matter yields of some forage legumes relative to the mean yield of all accessions when grown as awards in a number of environments. (* - 1:1 line)

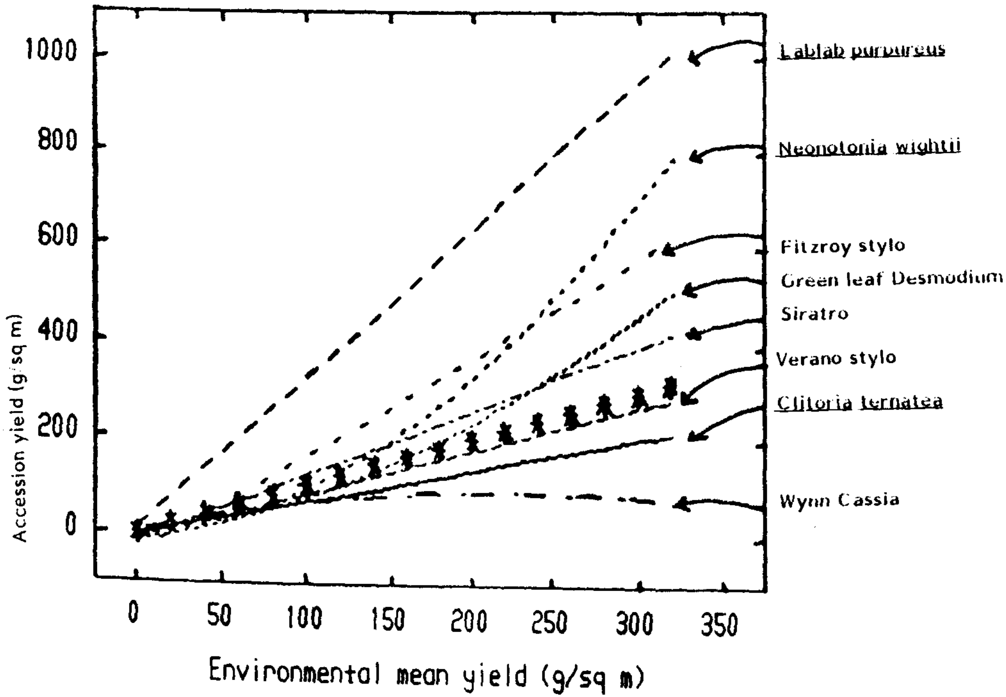
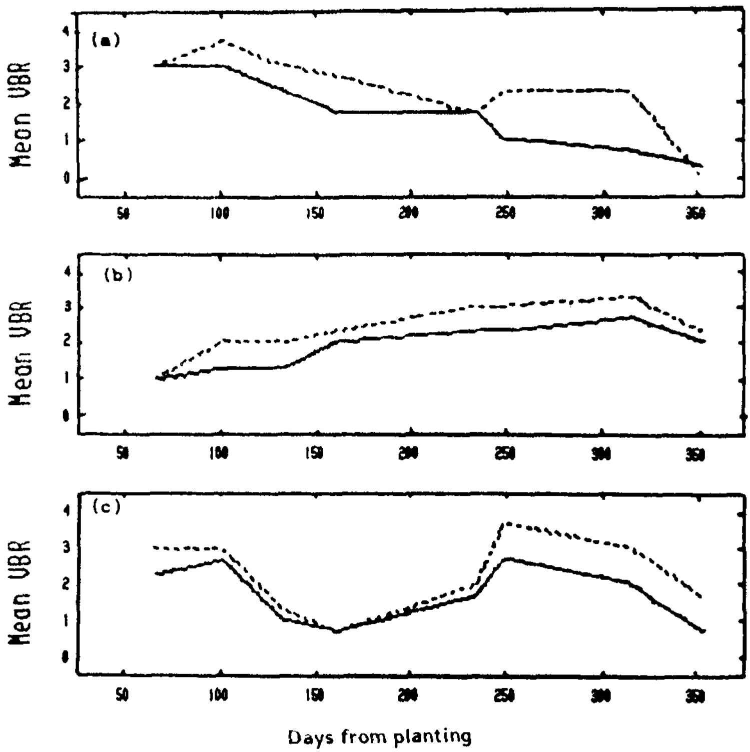


Figure 2. Changes in visual ratings of bulk dry matter (VBR) with time for three forage legumes at Maruba, Machakos.

(a) _Lablab purpureus_
(b) _Desmanthus virgatus_
(c) _Macrotyloma africanum_

- - - - - with basal fertilizer

------- no fertilizer



suitable intercrop with cereals. Cassia rotundifolia cv. Wynn (K18177) and Stylosanthes hamata cv. Verano (K14428) are prolific seeders. They have ability to colonise quickly due to excellent regeneration from seed. Seeds of Cassia rotundifolia cv. Wynn are usually carried by harvester ants thus lowering the regenerative capacity. Alysicarpus rugosus CP 52351 (K14384), is a good seeder but regenerates poorly due to hard seedness. It establishes a good stand if seeds are well scarified. It is non-aggressive and thus suitable for intercropping.

c) Perennial forage legumes

Although rainfall limits production in semi-arid areas, favourable temperatures, light intensities and substantial storage of moisture after rains offer opportunities for growing reasonable good quality herbage from mixtures including perennial legumes.

Some Stylosanthes, Desmanthus and Macroptilium spp are outstanding in dry matter production and wider adaptability in the semi-arid zone. They have excellent perennation, good regeneration and remain green during the dry period. Other notable genera are Macrotyloma, Rhynchosia, Neonotonia and Clitoria. Initial establishment of most of these perennials is slow, but they tend to be more productive in the second season. This is an advantage if intercropped with cereals since the cereal crop will have time to establish without much competition.

Desmanthus virgatus cv. CPI 40071 (K14456) is a deep rooted species, which firms the surrounding soil, making it suitable for stabilizing terrace banks. This species tends to shed leaves during the dry season, but this forms a mulch which releases nitrogen after decomposition.

The Stylosanthes spp are prolific seeders. Their ability to colonize low fertility soils is an advantage. S. scabra cv. Fitzroy and Stylosanthes fruticosa cv. CPI 41219A (K14426) are slow to establish but persist well and are vigorous in the second season. Similarly, Clitoria ternatea, cv. CPI 48337 (K14403) grows quickly in the second season. This species is attacked by powdery and downy mildew at maturity. There are wild types growing on the semi-arid zone of eastern Kenya especially in black cotton soils.

Macrotyloma axillare. cv. Archer (K14462), Neonotonia wightii, cv. K2366 and cv. Cooper and Macroptilium atropurpureum cv. Siratro (K14461) all form a good early stand. Together with their excellent perennation, this makes them suitable for several farm situations.

INTRODUCTION OF LEGUMES INTO FARMING SYSTEMS

Forage legume research in the semi-arid Kenya has lagged behind that in the high potential areas, so that relevant technology for farmers has not been developed. Forage legumes can best be introduced as part of an overall farming system. Legumes which could be used to provide ground cover on arable land and high quality livestock feeds during the dry season should be given priority.

a) Intercropping

Intercropping is defined as growing a mixture of two or more crops simultaneously on the same field. In semi-arid eastern Kenya, most of the legume/cereal intercropping involves grain legumes, such as Cajanus, Lablab and Vigna (Chabeda, 1986). The extent to which forage legumes can be used in such mixtures is not known. The advantages that have been advanced (Nnadi and Haque, 1986) for such an intercropping are:

i) the possibility of nitrogen accretion from the legumes to cereals,

ii) maintenance of a continuous feed supply during the dry season,

iii) more efficient utilisation of low quality cereal residues through the addition of high-potential forages

iv) increased crop productivity, and

v) greater security of return compared to sole cropping

Forage legumes growing in association with cereal crops will compete for limiting resources, particularly water. More research is needed before we can determine whether the short term negative effects of such competition is balanced by the potential long-term benefits of forage legumes.

b) Improvement of grazing land

Eroded, infertile land could provide significant additional forages. Legumes are commonly good pioneer plants (Russo, 1986; Lazier, 1987). If legumes are oversown into existing grass, they can dominate pastures and substantially improve their production and quality over dry periods. Persistence of the legumes depends on the existence of a sufficient quantity of germinable seed at the start of the growing season and persistent effective rhizobial associations (Wheeler and Jones, 1984).

In view of excessively high stocking rates, farmers will have to adjust livestock numbers to the available feed supply by selectively culling unproductive animals and increasing animal feed production per unit area. Initially, avoidance of grazing on areas where young forage legumes have been introduced is a pre-requisite to any improved management. Later, light grazing can be allowed to reduce competition from native vegetation and promote establishment of the sown species. Grazing of stylos which are hard-seeded can enhance germination since the seed passes through the ruminants' alimentary canal where there is slight scarification. Soil disturbance by grazing animals can allow seed cover and germination at the onset of rains.

A main target area for introducing legumes will be denuded bare areas where there are scattered grasses. The use of "matengo pit" technology can provide micro-catchments to aid establishment (Gichangi, E.M.G, Soil conservation, Ministry of Agriculture, Kenya, personal communication). Attempts will be made to oversow strips and broadcast seeds into native pastures during the more reliable short rainy season.

The success of forage legumes in grazing lands will depend very greatly on the grazing pressure they experience. The possibility of raising production per animal and reducing animal numbers per unit of grazing land is an important subject for research.

c) Terrace bank stabilisation

Although rainfall is limiting in the semi-arid region, usually it occurs as large erosive storms which can, among other effects damage the bare banks of terraces on cropland. Perennial grasses are used in some cases to stabilize these structures, but the potential role of deep-rooted, perennial shrub legumes has received little attention. During the dry season, they could be slashed for animal feed. They could also provide some mulch and improve soil fertility within the cultivated terrace bank.

d) Cut-and-carry fodder plots

Fodder banks, concentrated units of forage legumes, (Mohammed-Saleem et al 1986) could be planted and maintained for several seasons near homesteads or in a block of land which is fenced to deter grazing and allow protein accumulation. During the dry season, these could be cut to provide additional protein for sedentary animals. Labour would be required to cut-and-carry forages and to manage the animals.

Farmers could restrict feeding of fodder banks to only the most responsive animals in the herd (e.g. lactating cows). It is probably important to ensure sufficient seed-drop and stubble at cutting for regeneration in the following seasons.

e) Ley farming

Ley farming, rotation of cereals and forage legumes, emphasizes long-term soil fertility management for sustained crop production. In many farming systems across the world, the presence of legumes has been found to increase soil nitrogen through fixation of atmospheric N and decay of plant residues or root nodules.

Although fertilizers can replenish soil nutrients and meet crop requirements, they are too expensive for the low income small-scale farmers. A fast-growing legume cover crop would protect the soil, improve soil structure, improve water infiltration and reduce erosion. If in the subsequent season a cereal crop is grown, it may benefit from the residual effects of the legumes.

However the inclusion of forage legume leys in the cereal crop rotation means that some land is taken out of food crop production for at least one and possibly 2-3 seasons with the slower growing species. Hence research is needed to determine this loss in production is balanced by enhanced production from the cereal crops following the legumes.

CONCLUSIONS

The potential productivity of semi-arid environments could be more fully exploited by better and greater use of grain and forage legumes. Total land area is not such a limiting factor, in introducing cultivated pastures and forage crops because farmers cultivate no more than 56% of their holding (Tessema and Emojong 1984; Tessema et al 1985). The fact that most land is demarcated and privately owned offers scope for both intercropping legumes with cereals improving natural pastures with legumes and instituting proper grazing management.

Although at present farmers find it difficult to allocate their land and labour to growing forage crops, once the benefits from forage legumes in providing nitrogen for increased livestock and crop production are realised, this barrier might be overcome.

Seventeen potentially useful forage legume accessions are being multiplied. These are legumes identified from the GOK/ACIAR legume evaluation programme for the semi-arid region of Kenya (Njarui et al - unpublished). See Appendix 1. Harvested seeds will be distributed to farmers through extension officers and to interested researchers. However, small quantities of the seed could be obtained through the Director, NDFRS, Katumani, P. O. Box 340, Machakos, Kenya.

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Appendix I: List of accessions under seed multiplication.

Species	CPI/Cultivar	K No.	Origin
1. *Aeschynomene americana*	cv Glen	19897	Mexicc
2. *Alysicarpus rugosus*	52351	14384	Malawi
3. *Cassia rotundifolia*	cv Wynn	18177	-
4. *Centrosema pascuorum*	cv Cavalcade	14418	-
5. *Clitoria ternatea*	48337	14403	Tanzar
6. *Desmanthus virgatus*	40071	14456	Brazil
7. *Desmodium intortum*	cv Greenleaf	14455	-
8. *Lablab purpureus*	cv Rongai	14420	Kenya
9. *Macroptilium atropurpureum*	cv Siratro	14348	Mexicc
10. *Macrotyloma africanum*	24972	14348	Zambia
11. *Macrotyloma axillare*	cv Archer	14462	-
12. *Neonotonia wightii*	cv Cooper	cv Cooper	Tanzar
13. *Stylosanthes guianensis*	-	A. composite	Kenya
14. *Stylosanthes guianensis*	cv Cook	18189	Colomt
15. *Stylosanthes hamata*	cv Verano	14428	Venezue
16. *Stylosanthes scabra*	cv Fitzroy	14431	-
17. *Stylosanthes scabra*	cv Seca	14430	-

LABORATORY EVALUATION OF THE EFFECTS OF PROCESSING METHODS, TREATMENT AND COFFEE CULTIVAR ON CHEMICAL COMPOSITION AND *IN VITRO* DIGESTIBILITY OF COFFEE PULP

Getachew Gebru[1], Beyene Chichaibelu[2] and Jess D. Reed[3]

ABSTRACT

Experiments were conducted to study: (1) the effect of dry processing of coffee cherries and ensiling with urea on the chemical composition and *in vitro* digestibility of coffee pulp, and (b) the effect of variety of fibre and phenolic components. Zero, 40, 50 and 60 grams of urea were dissolved in a litre of water and added to dry-processed coffee pulp (DCoP) (1 litre/kg of air-dried DCoP) sealed in plastic bags (3 replicates) and incubated for 15 and 30 days.

The experiment on the relationship of variety to chemical composition was studied on the wet processed pulp. Fourteen varieties of coffee cherry were collected from high and low altitudes in Kaffa Administrative Region.

Treatment level had a significant effect ($P<0.05$) on the neutral detergent fibre (NDF), acid detergent Fibre (ADF) and content of soluble phenolics. Nitrogen (N) and content of soluble phenolics showed a significant increase at 5 and 10% levels respectively. However, urea treatment did not alter the *in vitro* dry-matter digestibility (IVDMD).

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There was a large difference in the content of soluble phenolics (15-41%), potassium, iron and manganese. There was a trend for the content of phenolics to increase in varieties harvested at higher altitude. NDF showed negative and positive correlation with the soluble phenolics and insoluble proanthocyanidins respectively. Varietal and environmental effects on the nutritive value of coffee pulp appear to be of considerable importance.

INTRODUCTION

The low productivity of livestock in Ethiopia, which has the largest animal population in Africa, is caused in part by poor nutrition. Though natural grasslands are important feed resources, their present capacity to support increased livestock productivity is reduced by their low yield and poor quality. Seasonal growth pattern of the grasslands and high grazing pressure further limit the availability of herbage. Lack of feed resources often imposes a major constraint on animal production, particularly during the dry season. Rapid development of improved pasture and cultivated forages is not always possible because of limitations imposed by technical, economic and human factors. Therefore animal production must be integrated with crop production and allied processing agro-industries.

It is anticipated that mechanization will increase cultivated land area in Ethiopia devoted to food production, and that this will increase the availability of agro-industrial by-products some of which can find use as feed as-is or as components in compounded feeds. However, the bulk of the available by-products are presently not effectively utilised amongst other resources due to inadequate knowledge of their value in feeding systems. The potential use of the by-products is also determined by the time and place they become available and the alternative use. Use of by-products ensures that ruminant animals are complementary rather than competitive with man in meeting their feed requirement.

Coffee is an agricultural crop of significant economic importance in Ethiopia. Coffee pulp is the major primary by-product from the processing of coffee cherries. The bean is the main crop. After processing the pulp and hull are either dumped or utilised rather unproductively. Better utilisation of the by-products could make the cultivation and processing of coffee more economical. For years the only use for coffee pulp has been as a fertilizer for the coffee plant, a practice dictated more by the lack of alternative usage of the pulp than by its effectiveness as a fertilizer. Coffee pulp should be considered as a means of alleviating the scarcity of animal feed.

Different approaches have been used to improve the nutritive value of various coffee residues, such as physical (grinding, heating and drying) and chemical treatments (calcium, and sodium hydroxide) and their combination have been used to eliminate the anti-nutrition physiological factors such as caffeine, and tannins. The economics of AIBP treatment should not be viewed only in relation to increased livestock production. Sustaining animal production during periods of fodder shortage and preventing death due to starvation has economic advantage (Jayasuriya, 1984).

The chemical treatment of fibrous residues using urea has been known for some time now. Enzyme urease hydrolyses urea and releases ammonia. Ammonia in water is an alkali that can improve the digestibility of low quality roughages (Sundstol, 1981).

Fresh coffee pulp is an abundant by-product, but its nutritive value as an animal feed is limited by the presence of anti-nutritive physiological factors like caffeine and tannins. If adverse effects could be eliminated by physical or chemical treatments then the utilisation of nutrients in the pulp could increase. Sodium hydroxide and sodium metabisulfite have been used and with some success. However chemical treatment of feeds in the tropics is restricted by costs, availability and necessary machinery, available technical ability and safety. Urea seems promising in this line, because it is cheap and easy to get and has minimal hazards.

It is also essential to understand how much of the variation in the nutritive value of coffee pulp is attributed to the effect of processing methods. Genetic and environmental factors may also affect the nutritive value of coffee pulp. In order to develop feeding systems which utilise coffee pulp as a main ingredient of the ration, factors which affect nutritive value need to be determined.

The objectives of this study were to determine the effect of cherry variety, processing method and treatment on chemical composition and *in vitro* digestibility of coffee pulp.

MATERIALS AND METHODS

Experiment 1: Urea treatment of dry-processed coffee pulp.

Coffee pulp: Source and processing procedure. Pulp was obtained from coffee-processing centre of the Ministry of Coffee and Tea Development in Gelemso, Hararge, Eastern Ethiopia. Coffee cherries are processed by the dry method. The cherries are left on the tree to dry. The dried cherries are collected and mechanically separated into the bean and other fractions.

Treatment procedure

40, 50, 60 grams of urea were dissolved in l litre of water. The urea solutions were applied at the rate of 1 litre/kg of air dried pulp. The 1 kg lots of pulp were thoroughly mixed and transferred into plastic bags. The bags were tightly closed and left at room temperature, for a 15 and 30 days reaction period. The control (water treated) was stored in similar manner.

Sample processing and method of analysis

The contents of all bags were removed, oven dried at 60°C for 25 hrs, ground to pass a 1 mm screen and bottled for chemical analysis at the ILCA nutrition laboratory. All samples described were assayed for IVDMD, NDF, ADF and ADF-lignin (Goering and Van

Soest, 1970), omitting decahydronaphtalene and sodium sulfite in the NDF procedure (Van Soest and Robertson, 1980).

Hemicellulose was estimated as the difference between NDF and ADF contents. DM and ash were analysed by the methods of the AOAC (1980). Nitrogen and N in NDF (NDF-N) were determined by the macro-kjeldahl procedure using sodium sulfate and copper sulphate in the digestion mix and collecting the distillate in a boric acid solution. Phenolics and tannins soluble in aqueous acetone were determined by a gravimetric procedure based on precipitation with ytterbium acetate (Reed et al, 1985). All determinations were conducted in duplicate.

Proanthocyanidins that are insoluble in neutral detergent were determined by methods described by Bate-Smith (1973) as modified by Reed et al, (1982). Five milligram of NDF were placed in a test tube, 5 ml of 5% concentrated HCL in a n-butanol were added and tubes heated at 95^{0}C for one hour. Absorbance was read at 550nM using UV-VIS spectophometry. If Proanthocyanidins were present in the NDF, the n-butanol-HCL solution turned red. Results were expressed at A_{550} per gram NDF.

Experiment 2: Laboratory evaluation of wet-processed pulp obtained from 15 cultivars of coffee cherries in Ethiopia.

Description of experimental materials

Ripe coffee cherries of selected coffee cultivars (Table 1) were collected from two coffee plantation projects in Kaffa Administrative Region and were brought to ILCA laboratory (Addis Ababa, Ethiopia) for studies involving the chemical analysis of the pulp and fractionation of the components of the fruit.

Separation of the pulp from the cherries

The pulp was separated from the beans manually. Following separation, the pulp was transferred into plastic bags, labelled and frozen until the time of analysis.

The coffee beans (containing mucilage + hulls) were washed to remove the mucilage and then dried in a forced draft oven for 5 days. The dried beans plus hull were threshed by hand and separated by using an electrically operated seed blower. The weight of the beans and hulls were recorded for each cultivar.

Preparation of the pulp for analysis

The pulp from each cultivar was weighed and the weight recorded. It was then oven-dried at 60^{o}C for 24 hours, ground to pass 1 mm sieve and bottled for laboratory analysis.

Table 1. List of coffee cultivars used in the study.

Identification	Area of collection	Remark
7440B	Bebeka	
7440G	Gummar	
744G	Gummar	
75227G	Gummar	
75227B	Bebeka	
7454B	Bebeka	
744B	Bebeka	
741G	Gummar	
741B	Bebeka	
O.C.B	Bebeka	Native unimproved cultivars
O.C.G	Gummar	Native unimproved cultivars
74112B	Bebeka	
74112G	Gummar	
74158G	Gummar	
74165G	Gummar	

Chemical Analysis

NDF, ADF and N were determined as stated under experiment 1. Lignin was determined by treating ADF with sulphuric acid (Goering and Van Soest, 1970). Proanthocyanidins that are insoluble in neutral detergent, phenolics and tannins that are soluble in aqueous acetone were determined by methods as described in experiment 1.

Statistical analysis

Pearson correlation coefficients were calculated to estimate correlation between NDF, ADF, Lignin, soluble phenolics and Insoluble proanthocyanidins.

RESULTS AND DISCUSSION

Experiment 1: Effect of dry processing and urea treatment.

Chemical composition of dry-processed pulp is compared to wet-processed in Table 2. Pulp obtained from the dry method of processing coffee cherries shows a high level of NDF, ADF and Lignin. This suggests that the material has low nutritive value. The dry processing of cherries results in a by-product comprising mucilage, hulls and pulp. The presence of the hulls or the parchment along with the pulp contributes to the high content of fibre components. Coffee hull is reported to have high concentration of lignin, pentoses and hexoses (Murillo et al, 1977). Phenolic compounds show a higher concentration in the

dry-processed pulp. These compounds can form insoluble complexes with proteins and may reduce OM and N digestibility (Getachew et al, unpublished data).

Table 2. Chemical composition of the dry and wet processed pulp (% DM)

	Dry processed	Wet processed
Crude protein	11.12	10.6
Crude Ash	7.09	4.8
NDF	57.14	29.5
ADF	52.08	25.7
Lignin	16.40	5.6
Insoluble proanthocycanins*	20.00	11.5
Soluble phenolics	32.48	24.6
Calcium	.422	.554
Phosphorus	.153	.116

* expressed as A_{550}/g NDF

The urea-treated and ensiled pulp had a strong odour at opening. Mould presence was detected in all samples ensiled, but it was only severe in the un-treated pulp. The reason for the mould growth could be inadequate seal and presence of air in the ensiled material.

The ensiled material showed a dark brown colour as opposed to the light brown colour of the material before ensiling. The colour change could possibly arise from reactions such as phenolic condensation or condensation of aldehydes formed by sugars with nitrogenous bases (Maillard reaction). N in complexes formed by Maillard reaction is unavailable to the animal and thus reduce the utilisation of the feed.

The urea treatment effects on the chemical composition and IVDMD are shown in Table 3. Treatment level had a significant effect ($P<0.05$) on the content of CP and soluble phenolics but no significant effects were observed on other parameters. Sub-division of the urea level sum of squares showed a linear trend of the effects of treatment level on nitrogen, lignin and soluble phenolics.

Treatment time had a significant effect on NDF, lignin and insoluble proanthocyanidins. The 15 days treatment time had lower contents of NDF, lignin and insoluble proanthocyanidins. Different roughages show varying responses to ammonia treatment (Coxworth et al, 1976; Arnason and Mo, 1977). Cereal straws are very different than coffee pulp in the type of lignin and susceptibility of alkali treatment. Also urea is not as effective as other alkalis. The inferiority of urea treatment

could also be due to reaction of ammonia with carbon dioxide to form ammonium carbonate which reduces the efficiency of urea treatment (Mason and Owen, 1986).

Table 3. Chemical composition and _in vitro_ dry matter digestibility of urea treated and untreated pulp.

	% DM				
	CP	NDF	Lignin	soluble Phenolics	_in vitro_ Digestibility
Urea level (g/Kg DM)					
0	11.5	64.0	20.2	33.0	47.3
40	15.6	61.9	20.3	30.3	51.4
50	16.8	66.1	21.3	27.1	49.0
60	17.2	64.8	21.6	30.0	47.9
Significance	*	*	NS	*	NS
Treatment days					
15	15.6	62.6	9.9	31.2	49.9
30	14.9	65.9	21.8	29.3	47.8
Significance	NS	**	**	NS	*

* $P<0.05$

NS = Not significant

Experiment 2. Variation in the chemical composition of coffee pulp among several Ethiopian coffee cherry cultivars processed wet.

The yield of fractions from cherries of eight randomly selected cultivars is shown in Table 4; the yield of coffee pulp on dry matter basis represents 28% of the weight of the whole fruit. The variation in content of DM, N, NDF, ADF and lignin was low (Table 5) but the range in content of soluble phenolics was large, between 15 and 41%. Altitude did not have a large effect on the composition of coffee pulp although there was a tendency (Table 6) for fibre components to be lower and soluble phenolics and insoluble proanthocyanidins to be higher in cultivars grown at higher altitudes. It appears that cultivars had a greater effect on the composition of pulp than the altitude.

Table 4. Average yield of fractions from cherries of eight randomly selected cultivars.

Fractions	0 % (Range)
Coffee pulp	27.38 (25 - 31)
Coffee hulls	17.50 (15.5 - 20)
Beans	51.68 (40 - 62)

Table 5. Chemical compositin of the pulp from 15 coffee cultivars.

Cultivar	Composition (% DM)						
	DM	N	NDF	Lignin	ADF	Soluble phenolics	Insoluble proanthocyanidins A 550/g NDF
7440B	87.5	1.7	28.0	4.7	23.7	30.5	8.3
7440G	86.9	1.6	31.1	8.1	27.8	15.9	14.3
744G	87.3	1.9	26.8	4.2	23.2	24.3	9.3
75227G	88.8	1.5	22.5	6.9	28.4	18.8	14.5
75227B	86.0	1.5	32.5	7.0	28.3	24.8	14.1
7454B	87.7	1.7	32.1	8.6	29.0	21.0	12.2
744B	87.4	1.7	28.9	6.9	25.5	23.6	10.0
741G	87.1	1.9	26.5	2.9	23.0	25.7	10.5
741B	87.1	1.6	33.5	5.6	27.2	20.5	10.0
O.C.B	87.1	1.9	26.5	5.1	21.6	32.8	11.0
O.C.G	88.6	1.5	27.0	5.6	22.4	40.6	12.6
74112B	87.5	1.4	33.3	5.9	25.8	18.5	12.7
74112G	87.5	1.5	33.4	5.0	29.0	18.9	10.5
74158G	85.2	2.2	30.2	4.4	25.1	27.2	10.4
74165G	87.7	1.6	30.4	5.0	26.3	25.1	11.8
Mean	87.3	1.7	29.5	5.6	25.7	24.6	11.5
S.D.	0.88	0.21	3.24	1.54	2.52	6.40	1.88

Table 6. Effect of altitude on pulp composition.

Constituent	1200 mts	1800 mts
NDF	29.1 ± 2.7	26.7 ± 3.5
ADF	25.8 ± 2.4	25.7 ± 2.8
Lignin	5.9 ± 1.5	5.4 ± 1.8
Soluble phenolics	24.9 ± 5.0	25.2 ± 8.1
Insoluble proanthocyanidins	11.1 ± 1.8	12.9 ± 2.0

Cultivars with a high content of NDF seem to have a low to moderate content of soluble phenolics. This relationship led to a negative correlation between NDF and soluble phenolics (Table 7). However the correlation between NDF and insoluble proanthocyanidins was positive. Correlation of soluble phenolics and insoluble proanthocyanidins with other fibre components had the same sign as correlations with NDF and ADF. Large quantities of soluble phenolics if absorbed and excreted in the urine may lead to an over estimation of energy value (Reed, 1986). Soluble phenolics form indigestible protein and carbohydrate complexes in the digestive tract that increase fibre and lignin excretion in the faeces (Osbourn et al, 1971). Thus prediction of digestibility based on fibre components need to be adjusted for the content of soluble phenolics. Moreover the assumption that NDF represents cell wall carbohydrate and lignin in such residues is incorrect as NDF is associated with insoluble proanthocyanidins and may contain tannin-protein complexes.

Table 7. Correlation between NDF, ADF, Lignin (LIG), soluble phenolics and insoluble proanthocyanidins (A_{550}/g NDF) in pulp of 15 Ethiopian coffee cultivar.

	Soluble phenolics	Insoluble Proanthocyanidins A_{550}/g NDF	NDF	ADF
A_{550}/NDF	-.28			
NDF	-.76**	.32		
ADF	-.41	.48	.52*	
LIG	-.40	.65**	.21	.61*

* P<0.05

** P<0.01

Utilisation of the research results

This work was conducted as a basic study to look into some of the inherent constraints of the material and possible improvement by chemical treatment. Past studies of coffee pulp have suggested that coffee pulp has potential as livestock feed even though problems in its utilisation were encountered (Squibbo, 1950; Colborn and Hoxey, 1974, and Abate, 1986). Urea treatment, therefore was tested to asses its effect on the nutritive value of coffee pulp. Moreover the study on the relationship between coffee varieties and chemical composition was conducted to shed some light on the possible effects of plant genetic factors on the concentration of certain anti-nutritive factors in the pulp. The salient features of this research results were:

(a) Coffee pulp, depending on the methods of processing employed on the cherries, showed variations in nutritive value (Table 2). Effort, therefore, need to be made in adopting the method of processing (wet) that gives a better coffee grain yield and also a by-product with a better nutrient concentration for livestock feed.

(b) Weak alkalis like urea in water do not have significant effect in improving the energy status of coffee pulp in view of the effect of alkalis on the ligno-cellulose complex. However the urea may impart nitrogen and thus improve rumen fermentation.

(c) Due to high moisture content and bulkiness, coffee pulp cannot be utilised in areas far away from the processing site. Drying of coffee pulp at the site of production is not practical because of the use of the drying patios for the coffee grains. Ensiling coffee pulp without additives is practical. The coffee pulp ensiled for 5 months did not spoil except the top layer that showed mouldiness.

(d) The feeding value of coffee pulp in relation to the cultivars of the coffee tree is a point that could open further research into the investigation of the genetic factors associated with the coffee tree as they affect nutrient concentration. This enables one to develop plant-specific screening methods to determine the nutritive value of by-product of various coffee cultivars. Coffee cultivars resulting from the joint selection for the feed value of the coffee pulp as well as coffee bean yield and quality will result is substantial economic gain.

Problems concerned with full utilisation of the research results

Extension and research linkage

In putting research into practice, research, development, extension and farming are equally important and interrelated. The limited attention and priority often given to extension does not allow feed-back mechanisms to function properly and thus the time attention given to solving problems which limit production may be long passed.

With very little effort made in understanding the system, it will be difficult to develop interest in utilising the research results. Lack of a viable national extension programme has resulted in the shelving of research results in research institutions and in poor integration of research scientists into the local community. The development of the peasant cooperatives in Ethiopia is a welcome trend that would allow the recognition of the importance of extension, and of course, research institutions have a lot to offer in this respect. Strengthening the weakest link in the chain i.e. extension, would allow researchers to work on feed-back mechanisms that follow the understanding of the constraints and development options of the current feeding system.

CONCLUSION

It may therefore be concluded that the availability of certain by-products like coffee pulp, per se does not warrant their immediate inclusion in livestock feeding. This calls upon the characterization of the material so that the inherent nutritional problems are defined. Further understanding of the nature of the complexing of nitrogen with the polyphenols and simple and cheaper methods of splitting this complex may allow efficient use of coffee pulp. The wet method of processing the coffee cherries could provide a by-product that has a better nutritive value and help in realizing the integration of livestock production with the crop production and allied processing industries.

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AN INTEGRATED APPROACH TO NATURAL RESOURCE MANAGEMENT: EXPERIENCE FROM NORTHERN KENYA

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ABSTRACT

It is through the realisation that to minimise the effect of natural calamities on man, man himself and his relationship to his environment had to be studied and understood thoroughly, that the Man and Biosphere (MAB) programme was set up by the United Nations Educational, Scientific and Cultural Organisation (UNESCO).

The paper gives a brief overview of one of the pilot projects, the Integrated Project on Arid Lands (IPAL), under MAB that has looked at livestock production and problems of environmental degradation and desertification in arid and semi-arid land inhabited by nomadic pastoralists. The paper looks at how production in these nomadic pastoral systems could be increased for the good of the country as a whole especially in the supply of meat and livestock products. It also looks at some of the constraints to improved livestock production, problems encountered and offers some suggested remedies.

INTRODUCTION

The integrated approach to resource management in northern Kenya has been carried out under the auspices of the Integrated Project on Arid Lands (IPAL) in the Man and Biosphere (MAB) programme. MAB is a United nations Educational, Scientific and Cultural Organisation (UNESCO) - sponsored programme started in 1971 as a result of the existing climate of general awakening to all manner of environmental concerns sparked off by the experiences and enthusiasm generated by the International Biological Programme (IBP), the first major venture in International Biology Research (di Castri et al, 1981). Following the recognition that there was general deterioration of major world ecological systems and predictions of a gloomy outlook for the world by the year 2000, a biosphere conference convened by UNESCO in 1968 recommended the setting up of an inter governmental and interdisciplinary programme of research. At about the same time, natural resource managers all over the world had discovered that a lot of the research information available at that time was of little value for their planning purposes because man had been ignored and yet the research results were supposed to be of most benefit to him, plus the haphazard nature in which the research topics had been chosen. MAB activities officially began following the first session of its co-ordinating council in November 1971 (UNESCO 1971).

Its objectives are:

1. To encourage both natural and social science research on environmental problems. Man and his interactions with the environment play a central role in the research.

2. To encourage research that has direct and pragmatic application for improved land use and resource management.

3. To encourage the training and promotion of environmental education as an essential component of research.

4. To test the feasibility of integrating research findings in both natural and social scientific disciplines through specific research projects.

Fourteen major themes of research were identified covering the whole range of major ecosystems from polar to tropical zones excluding oceanic ecosystems. Due to financial and human resources constraints, the MAB programme has up to now been restricted to six main areas (UNESCO, 1987):

1. Coastal areas and islands;

2. Humid and sub-humid tropics;

3. Arid and semi-arid zones;

4. Temperate and cold zones;

5. Urban systems and;

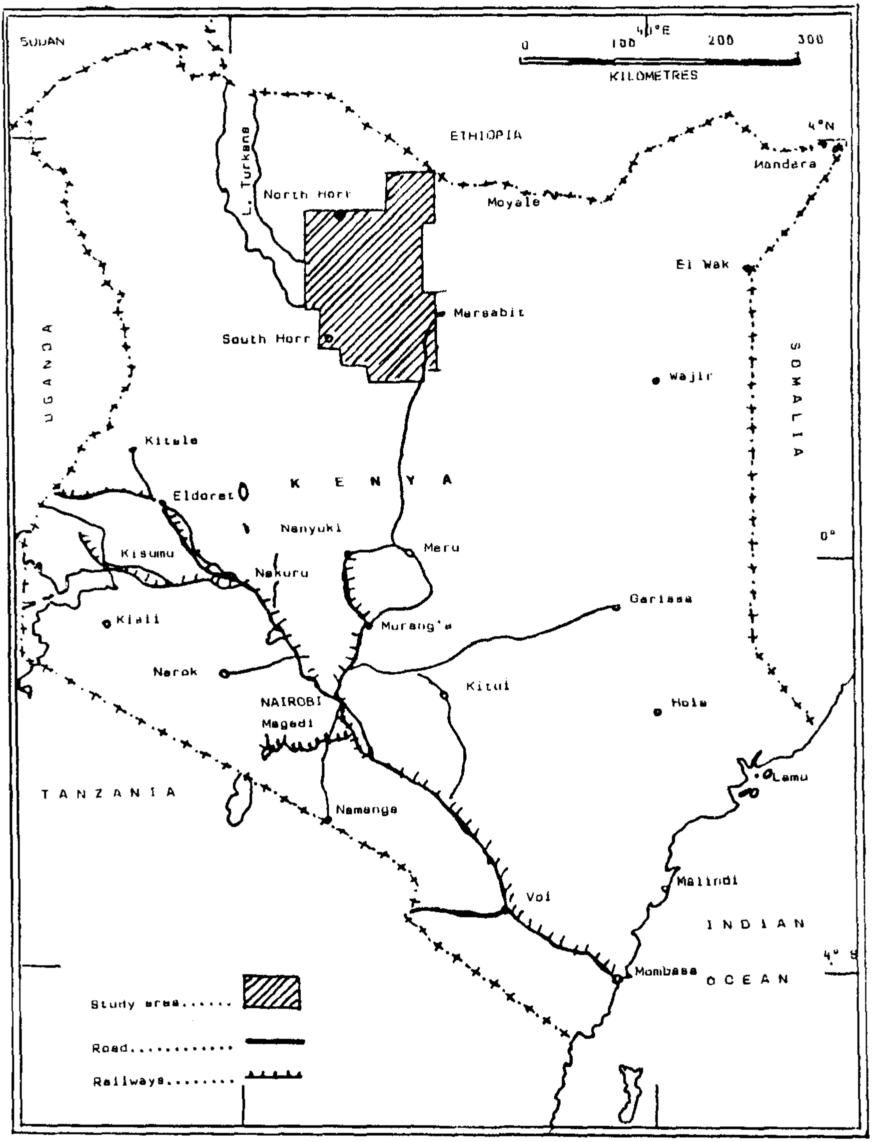
6. Biosphere reserves.

IPAL PROJECT

The tendency by many natural science researchers in the 1950's was to choose singe plant or animal species and study them in detail in complete isolation of their interaction with other plants or animal species and the environment in general. With the establishment of ecology as a major scientific and research field and the evolution of the ecosystem concept in the 1960's, there emerged a trend towards defining the environment in terms of major global ecosystems and the development of global models from which global solutions to environmental problems were designed. In the late 1960's and early 1970's there was an impatience to put long-discussed ideas on ecological approaches to land development to rest at the field level, a trend which itself implies a willingness to experiment and to accept failure (Lusigi, 1986).

The IPAL project developed in northern Kenya in 1976 (Figure 1) was an outgrowth of this concern to bring multi-disciplinary research to the field level where it could address some of the most urgent problems of the deterioration of arid lands - inhibited largely by pastoral nomads (Lusigi, 1986).

Figure 1. Location of IPAL study are.



The IPAL programme had a working hypothesis: Through research and training improved land use systems can be devised to reverse the trend of land degradation and to sustain land production for needs of a growing (and partially sedentarised) population of northern Kenya (Figure 2). Man is a central factor having significant influence on the ecosystem. Due to this influence, his way of life and interaction with his environment had to be clearly understood through the human component of the study. As the study was looking at productivity of the whole ecosystem, two other components also had to be understood.

1. Abiotic component - climate, geomorphology, soils, hydrology
2. Biotic component - primary production and secondary production

STUDY AREA

The choice of a suitable study site is critical in an ecosystem study if the objectives of the study are to be adequately realised. It is important that the site be representative in order to incorporate all situations and processes being observed or investigated (Lusigi, 1986).

The IPAL study site was selected to meet this criterion. With an area of 22,500 km^2 it is sufficiently large and covers the major biotic communities found in the area. From near woodland in the south, where Ngurunit station is located, it extends northwards up to the edges of Chalbi Desert. On the west it is bounded by Mr. Kulal, a major water catchment area and to the east by Mt. Marsabit. The study area covers the home ranges of the Rendille, Gabbra, Boran and Samburu pastoralists who are the major nomadic tribes in the area. The problems of aridland deterioration are to be observed to varying degrees in this area. The area is undergoing a process of man-made desertification largely due to the following factors.

1. deterioration of the herb layer due to overgrazing;

2. deterioration of the woodlands due to wood cutting for boma (livestock night enclosures) constructions;

3. fuelwood needs and house construction

4. increase in both human and livestock numbers as they become sedentarised.

Recurrent drought and loss of their livestock base has forced many pastoralists into famine-relief villages and there is a gradual reduction in the practice of a nomadic lifestyle as a survival strategy.

EVOLUTION OF THE PROGRAMME

The IPAL programme evolved through three main phases: 1) Inventory and description phase, 2) Management plan phase and 3) Pilot programme phase programme phase.

Inventory and descriptive phase.

This phase involved the compilation of an inventory of all the natural resources in the study area and the productivity. In the range and woodland ecology component, vegetation was the most important renewable natural resource. Answers to the following questions regarding vegetation were sought during this phase.

a) What major plant communities occur in the region and what are their species and structural characteristic?

b) What is their distribution (plant communities) in relation to climate, altitude, soils topography, human and animal influence.

c) What are the characteristics biomass densities of the two main layers (herb/tree) in each major plant community in relation to mean rainfall, drainage, soil conditions, human and animal influences?

d) What are the annual primary production levels in each major plant community in relation to recent rainfall under different conditions of soils, drainage and use.

The answers to the above questions constituted the baseline data upon which future ecological monitoring depends. A further series of questions were posed, the answers of which relate more directly to the management of vegetation resources.

a) What proportion of annual primary production is available to livestock and what proportion is actually consumed.

b) What proportion of the biomass and annual production of wood is used by the pastoralists for building, fencing, fuel and what are their annual requirements?

c) What is the spatial distribution of utilisation of the vegetation ?

d) What are the tolerance levels of different plant communities to exploitation?

e) What are the rates of change in plant biomass and productivity in different areas of region in response to animal and human impact?

In human ecology answers to three basic questions were sought during this phase:

a) What was the population structure of the nomadic pastoralists?

b) What were their needs and how do they relate to their environment?

c) What were their aspirations

On livestock which is the basic resource upon which the livelihood of the nomadic tribes depends, answers to several questions were sought during this phase:

a) What is the livestock species composition?

b) What is the traditional animal husbandry for the different animal species?

c) What are their nutritional requirements

d) What are their feeding habits?

e) What major diseases affect the livestock?

f) What are the main constraints to increased production?

The management plan phase

The information obtained from the above questions was used in formulating a management plan for the study area. The management plan was intended to contribute to the improvement of the well-being of the pastoral people in all ways, but in particular (assisted by an appropriate education), by the development of an improved land-use a system that will reverse the trend of land degradation and sustain land production for the needs of the growing and partially sedentarised pastoral population (Lusigi, 1984). The resource management plan was based on the following principles:

a) That the people of the range areas must be allowed the opportunity for full development in terms of modern world and in accordance with the principle of human rights;

b) That range areas should be developed, conserved and managed in accordance with the ecological principles of proper land-use;

c) That, in so far as other principles allow, the range areas should be developed to yield benefit to the national economy.

The Pilot Programme Phase

This was a testing phase whereby the ideas recommended in the resource management plan were put to test on the ground on a small-scale to determine their workability. This was necessary so as to remove any unworkable ideas from the plan before recommending it to the general public. At this phase the project was not only looking for the success of some of the recommendations but was also ready to accept failure.

RESULTS

Most of the results have been published in the IPAL Technical Report series (Lusigi, 1984). This paper will highlight only some of the major findings.

On livestock

1. There were five major livestock species kept in the study area - sheep, goats, cattle, camels and donkeys. The pastoralists try as much as possible to have a good mix of all the livestock species.

2. Livestock are kept mainly as source of food (milk, blood, meat) and as a sign of wealth and prestige.
3. Three major constraints to improved livestock production in the area are disease, nutritional deficiency and non-availability of water.

4. Livestock husbandry is also a constraint to improved production especially due to the fact that many pastoralists keep too many unproductive animals.

On the Range

1. The problem of overstocking is concentrated around permanent settlements with permanent water supply and guaranteed security while the rest of the area is under utilised and about 40% of the study area is hardly used at all.

2. The range in the area can support up to twice the current livestock numbers without causing any serious damaged to the environment with proper water distribution.

On the Pastoralists

1. There is an increasing tendency for the pastoralists to become sedentarised in line with the official government policy. The nomads are settling down to take advantage of public services

provided for by the government and other donor agencies: schools, health services, water, security, etc.

2. Most of the settlement is taking place in areas that were formerly reserved for drought and dry season grazing. These areas are now lost to the nomadic pastoralists.

3. Mortality rate amongst the pastoralists especially in children has bone down and general life expectancy improved resulting in an increase in population and hence pressure on the available resources.

DISCUSSIONS

In recent years, the arid and semi-arid areas in Kenya which cover over 70% of the total area have been receiving more attention as population and hence pressure on the land resources in the rest of the country increase. These areas are being looked upon increasingly to provide meat and other livestock products to the rest of the country. As demand for these livestock products increases there is great need to increase their production. One way of increasing production is by the removal of the constraints mentioned above. To ensure increased forage availability, the pastoralists should be encouraged to continue keeping mixed herds that should be constantly moved, and formerly under utilised areas should be opened up for greater utilisation.

In arid and semi-arid environments, the pastoralists over hundreds of years have developed several survival strategies, which include constant movement of their herds and the keeping of several livestock species. In areas where most of the herb layer consists of annual plants and the majority of perennial plants are either dwarf shrubs, shrubs or bushes, the most prudent way to utilise the range and ensure survival is to keep a diverse herd of livestock species that are able to utilise the whole range of available forage. In cases of drought, which are common in these areas, the diverse herd has got its advantage. During any drought, the small stock and cattle are the first to be affected while the camel continues to provide milk and blood for much longer periods. Following the drought, small stock recover fastest and provide food for the pastoralists as the cattle and camel recover at a slower pace.

Rainfall is erratic and sporadic in both its temporal and spatial distribution in these arid areas. Therefore constant mobility is essential if the pastoralist wants to take advantage of new plant growth following the rains.

About 40% of the study area is not utilised due to lack of water. If these under utilised areas were opened up for use, it is possible to increase livestock production to twice its current levels. These areas can be opened up through a controlled grazing regime based on provision of drinking water. The grazing regimes have to take into consideration the customs and traditions of the local people.

Another major constraint to increased livestock production is the disease factor. IPAL studies showed that with the input o simple veterinary packages coupled with education on proper animal husbandry, it is possible to increase tremendously livestock production from the arid lands. The animal husbandry should also lay emphasis on the culling of unproductive animals such as excess males and those that are too old.

There has been a lot of effort put into improving the lives of the nomadic pastoralist through improved livestock production. Most of these efforts have had no noticeable effects on the lives of the nomads for various reasons:

1. The blue print for many of the development programmes had been developed elsewhere and just super-imposed on the nomadic pastoralists. IPAL studies have shown that no two sites are similar even if they border each other but are inhabited by different nomadic tribes. Therefore, each area should be understood thoroughly before initiating any development activities especially where it involves pastoralists.

2. The technological base available in an area was not taken into consideration especially in the provision of water for

livestock. No due consideration was given to what would happen or would run the programmes started when the time came for the donor agencies to pull out. If one has to improve livestock production in arid areas through provision of better distributed watering points, then the technology involved must be simple enough for the local pastoralists to manage on their own, e.g. simple hand pumps that can be repaired in the field or techniques of protecting shallow wells to prolong their life span.

3. Traditional grazing patterns, if not taken into consideration, can lead to failure of any new recommended grazing regime. This was evident in the study area where four times a year, the livestock had to be brought to the permanent settlements for blessing and thanks giving by the whole family of the pastoralist in the ceremony of sorio. Therefore, any recommended grazing regime in this area which fails to accomodate this traditional sorio ceremony is bound to meet with little success at the moment.

4. Any new recommendation concerning development and improvement of livestock production that deviates from the traditional practices should be tested and its viability ascertained in a pilot scale before being recommended for wider application.

5. The current education curriculum does not lay much emphasis on traditional agriculture even in the schools in arid areas where there is little chance of putting that knowledge into practice. Even at the institutes of higher learning much emphasis is placed on the traditional livestock species in the higher potential areas and those best adapted for the arid areas like the camel are normally just mentioned in passing. Now that these arid areas are being incorporated into the main economy there is also a need for special curriculum more applicable in these areas to be developed.

With increased livestock production, there will be a need to remove the excess production if degradation to the environment through overstocking is to be avoided. Therefore, all these management interventions designed to improve livestock production in arid areas should be accompanied by improvement in the marketing infrastructure. The pastoralist has got to be assured of any outlet for his livestock with guaranteed attractive prices. There must be other goods which can acquire with the money from the livestock sales.

CONCLUSION

In conclusion, as population increase in most African countries, the people will look more and more towards the arid and semi-arid areas as a source of meat and other livestock products. There is an increasing need to improve livestock production in these areas to meet the increased demand. There is a need to incorporate these formerly neglected areas into the national economy. The only way to do this is through an integrated approach to management of the fragile natural resources based on sound ecological knowledge of the concerned ecosystems that will ensure sustainable production without degrading the range.

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A GUNNY-BAG ENSILING TECHNIQUE FOR SMALL-SCALE FARMERS IN WESTERN KENYA

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ABSTRACT

Maize (Zea mays) stalks, sugarcane (Saccharum officinarum) tops, sorghum (Sorghum bicolor) stalks and bana grass (Pennisetum purpureum x P. typhoides) were chopped and compacted in synthetic gunny bags which were then buried in a trench silo 5 m long, 3 m wide and 1.5 m deep. To some bags of each crop, molasses was added at the rate of 5% by weight of the material in the bags on green matter basis. The molasses was diluted with an equal amount of water before application. The silages was then sampled after two months. The pH of all the silages was in the range expected for good silages (pH 3-4) except that of bana grass without molasses which had a pH of 5.18. Addition of molasses thus improved the fermentation quality of bana grass. Maize stalks, sugarcane tops and bana grass with molasses silages had the highest condition scores based on appearance and smell. Bana grass without molasses had the lowest score. Ensiling appeared to lower the in vitro dry-matter digestibilities of maize stalks, bana grass and sugarcane tops by approximately 4.68%, 11.45% and 16.18% respectively and increased that of sorghum stalks by 1.91%.

INTRODUCTION

Western Kenya (Figure 1) has a bimodal rainfall pattern with the long rains occurring in March, April and May, and short rains in September, October and November with an annual mean rainfall of about 1600 mm.

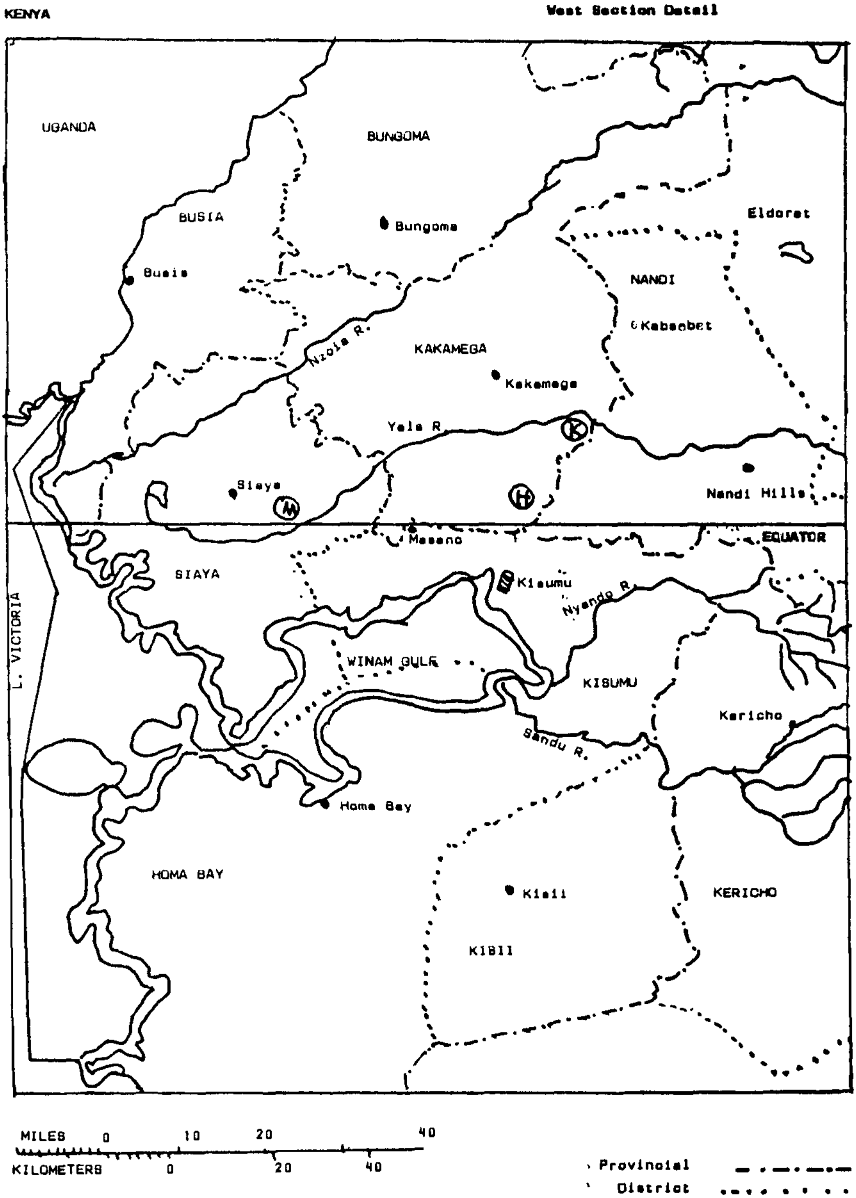
[1] Ministry of Livestock Development/SR-CRSP, Maseno, Kenya.
[2] Winrock International Institute for Agricultural Development, Morrilton, Arkansas, USA.

The distribution of livestock feeds closely follow this pattern resulting into periods of feed shortage in between the rainy seasons with the effect that there is often a deficit between feed availability and its demand on the farms. To stabilise the supply throughout the year and ensure adequate nutrition of the livestock, there is a need to conserve the excess feeds that occur during the rains. This can also enable the farmers to increase the herd size on a given farm (Hart et al., 1984). Conservation would also be important in that it would be in line with the government's policy on the development of production in high and medium potential areas through investment proposals which emphasise zero and near zero-grazing of livestock (Anon, 1981).

Feeds can be conserved either as hay or as silage. However, the major limitation to the use of these methods by small-scale farmers is the lack of simple and appropriate technologies for hay balling and ensiling. The feed resources (FR) project of the Small Ruminants Collaborative Research Support Programme (SR-CRSP), Kenya has already developed a simple hay balling box for small-scale farmers (Onim et al., 1985). However, there are certain feeds available on these farms which would be more suitable to conserve as silage than as hay.

This paper reports on a study undertaken to evaluate the technical feasibility of using synthetic gunny-bags and molasses (or jaggery sugar) as an additive for ensiling small batches of some forages commonly available on the small-scale farms in western Kenya.

Figure 1: Western Kenya



MATERIALS AND METHODS

Materials:

a) Crops ensiled.

Maize stalks

Maize is the most important food crop grown in Kenya and since its introduction in the middle of the 16th century (Miracle, 1966) it has become the main staple food of most Kenyans. It is grown practically everywhere in the country with the small-scale farmer playing an important role in its production. The greater proportion of small-scale output comes from holdings with less than five hectares in size (Senga, 1976) and this is a common feature in western Kenya. The sum total of maize output from both large and small-scale sectors puts western Kenya as the major growing area in the country (Maritim, 1982).

Apart from its importance as a food crop in the region, maize is equally important as livestock feed and it is used either as thinnings, leaf strippings, toppings or as stover which is left over after harvesting the ears. The toppings and the stovers are, however low in quality and usually the animal would select only the softer and more palatable leaves rejecting the tough and stemmy portions. To miximise the use of maize as a livestock feed, it would be appropriate to harvest the stalks while still green, chop everything including the stem and ensile. When cut at this stage the quality of the stalks will still be higher than that of the dry stover and there would be little wastage in the form of refused stems.

However, unlike in the developed countries where it is common to ensile a whole maize plant with ears, in the developing countries the high demand for grains for human consumption militates against the use of a whole maize plant for ensiling. Fortunately, in western Kenya, a lot of maize is harvested green for sale as boiled or roasted maize for human consumption. This is done when the ears are at early-dough to hard-dough stage which coincidentally is also the time recommended for cutting maize for silage in western Kenya (Sheldrick, 1975).

The maize crop used in the study reported here, was thus harvested when the ears were ready for roasting, and that was 125 days from planting. The cobs were sold for consumption and the green stalks chopped for ensiling.

Sorghum stalks

Sorghum (Sorghum bicolor) is also a popular crop especially in lower parts of western Kenya (altitude below 1300 m a.s.l.) such as South Nyanza, Kisumu, Busia and Siaya districts (Figure 1). It is often made available to livestock as feed either by defoliating the leaves which are then fed to the livestock while tethered or by grazing the livestock in the sorghum fields after harvesting the heads. An alternative to leaf stripping and field grazing would be to harvest the heads and then ensile the green stalks.

However, unlike in maize where the ears can be harvested and utilised when still green, the sorghum heads have to be fully mature before they can be harvested and sun-dried for threshing.

The sorghum stalks used in this study were thus obtained from a local farmer near the Maseno research station after he had harvested the heads and this was about 150 days from planting.

Sugarcane tops

Sugarcane (Saccharum officinarum) is increasingly becoming one of the major cash crops for small-scale farmers in Kenya. In 1981 for instance, of the estimated 3.8 million metric tons of sugarcane produced in Kenya, 1.7 million metric tons of sugarcane was produced by smallholders (Schluter, 1984). The figure increased to 57% in 1982/83. However, it should be indicated here that a key policy issue in Kenyan agriculture is the balance to be maintained in land allocation between sugarcane and maize.

Western Kenya is a major sugarcane growing area in the country and most of the cane goes into white sugar manufacturing or into jaggery factories. However, the cane tops are often burned before harvesting cane or thrown to waste and only a small proportion of it is used for livestock feeding. This could be mainly due to lack of appropriate methods for conserving it since after it dries it becomes rough and less palatable.

In this study the cane tops were obtained from a small-scale sugarcane farmer near the Maseno research station when he was harvesting his cane for sale to a nearby jaggery factory.

Bana grass

Napier grass (Pennisetum purpureum) and its derivatives such as bana grass (P. purpureum x P. typhoides) is the most widely grown cut-and-carry fodder crop in Kenya. Over 30 types of Napier grass have been tested in Kenya and currently bana is the most popular type especially for dairy cattle feeding. Yields of upto 10 tons of dry matter (DM) per hectare (ha) after 8 months of growth have been reported in Kenya (KARI, 1985). In western Kenya Mathuva et al (1985) reported a cumulative dry-matter (DM) yield of 40 tons/ha after 3 cuts in a year with an application of 100 kg N/ha of NPK (20-20-0) fertilizer. Because of these very high yields there is often excess of it on the farms especially during the rainy seasons. The recommended cutting height for utilisation is when the grass has attained a height of 1 m and when the grass is left in the field for a longer duration it overgrows into canes which are of little use to livestock. When the excess is conserved as hay it becomes very brittle and rough, making it less palatable to livestock. The alternative would be ensiling. The bana grass that was used for this study was harvested when about 1 m high and that was 101 days from planting.

b) The additive used: Molasses:

Molasses, which is a by-product of the sugarcane and sugarbeet industries is a relatively cheap source of fermentable carbohydrates which is widely available in the tropics and which is not a staple of the human diet (Preston and Leng, 1985).

In industrialised countries, molasses has been used in the manufacture of drinking alcohols e.g. rums, industrial alcohols for mixing with petrol to constitute gasohol, fattening livestock, e.g. in Cuba (Preston and Willis, 1974) and in compounding livestock feeds to improve palatability, pelleting and reducing dustiness. However, in the developing countries molasses is more available than the other potential feed ingredients. It can be used as a source of fermentable carbohydrates providing the basis of the diet for ruminants, as a palatable carrier for urea, minerals and other nutrients for improving the efficiency of utilisation of low-N diets (e.g crops residues, sugarcane and agro-industrial by-products) and as a source of trace minerals and some macro-elements e.g. sulphur, calcium and potassium (Preston and Leng, 1985).

It has also been used widely from the beginning of this century as an additive in silage (Castle and Watson, 1985) and excellent results have been obtained with lucerne silages (Reed and Fitch, 1917).

In the study reported here it was used mainly to provide the fermentable carbohydrates for appropriate lactic acid ($CH_3.CH(OH).COOH$) fermentation that would result into a well-preserved silage. It was also hoped that it would improve the palatability of the silage and that by acting as a source of trace minerals and some macro-elements it would improve the overall quality of the silage. The molasses was purchased from a nearby white sugar factory at the price of Ksh.100.00 per ton*.

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* 1 US$ = 16.00 KSh., 1986.

c) Synthetic gunny bags

These are commonly available in retail shops in the country and are traditionally used for packaging sugar, salt, rice and maize flour. The empty bags are then sold in the local open markets at a price of about Ksh. 7.00 per bag. The decision to use these bags in the study were based on the assumptions that:-

1. It would be easier to ration the silage at the time of feeding if it is in small batches of known quantity.

2. Spoilage at feeding due to aerobic deterioration would be reduced since the bags would be easier to remove and this would reduce the length of exposure to air.
3. It would be easier to apply the desired amount of molasses to the small batches which are known quantity than to unknown quantity (by weight) of materials in a trench or pit silo.
4. Since the different crops available on the farms for ensiling reach physiological maturity at different times, the gunny bags would allow each to be ensiled as it becomes available.
5. If any of the crops is more susceptible to spoilage, this spoilage would be confined to only a few bags containing that crop.
6. The bags would allow the ensilage of small batches of the available forages, and
7. The bags would be reused in ensiling several times before they got old.

The bags used in this study had no polythene liners inside.

d) The trench silo

The silo that was used in this study was a trench dug 5 m long, 3 m wide and 1.5 m deep giving a total volume of 18 m^3 as recommended by Stotz (1983). Neither the floor nor the walls of the trench were cemented.

Methods

The different crops were each chopped separately using a double-bladed hand operated chaff cutter and the chopped materials subsequently packed tightly into the synthetic gunny bags. Each bag was then weighed using a spring balance and each weighed 38 kg. For each of the crops used half of the bags received molasses while others did not. The molasses was applied at 5% by weight of the materials in each bag on green matter basis. Thus each bag received about 2 kg of molasses which was diluted with an equal amount of water before applying uniformly on to the materials in the bags. The dilution was to ensure uniform spread of the molasses which is normally thick and viscous. Samples were taken from each of the bags for DM estimation and chemical analysis.

Each bag was then tightly knotted using sisal twines and then arranged horizontally in rows in the pre-dug trench silo. A polythene sheeting was then overlaid on top of the bags before covering with soil which was then tightly pressed by trampling on it. The silo was then left undisturbed for two months after which it was opened for the first sampling of the silages. The subsequent samplings followed after four and six months respectively.

Duplicate samples were taken per crop and treatment, one sample being dried in an oven at 100°C for 24 hours for DM determination while the second sample was sun-dried for four days and used for laboratory analyses.

Nitrogen determination on the samples was done in duplicate according to the Association of Official Analytical Chemists (A.O.A.C., 1975) methods. Neutral detergent fibre (NDF), acid detergent fibre (ADF), sulphuric acid lignin (ADL) and cellulose were determined according to the procedure described by Goering and Van Soest (1970). The digestibility was determined by the *in vitro* technique of Tilley and Terry (1963). The percentage of lignin in ADF was merely calculated from the results.

The pH of the silages was determined by soaking 20 g of the materials overnight in 100 ml of distilled water. This was then divided into three portions, filtered and pH determined using a pH meter. The mean pH for each crop was then calculated.

During the sampling the silages were visually assessed in terms of appearance. The smell of each silage was also noted. An arbitrary condition score was then used to compare the silages in terms of appearance and smell.

RESULTS AND DISCUSSION

Table 1 shows a summary of the mean values of quality parameters for the treatments two months after ensiling. The DM levels of the ensiled crops together with the additional water soluble carbohydrate (WSC) from the molasses had marked effects on the fermentation quality of the silages. The pH values were all in the range expected for good silages (pH 3-4) except in the case of unmolassed bana grass silage which also had a foul smell attributable to putrefaction. In the molassed bana grass silage, the pH was not very different from that of maize stalks, sugarcane tops and sorghum silages. This difference in pH between the unmolassed and molassed bana silage was caused by high contents and hence low DM of 15.90% (c.f. 22.58% for maize) and the WSC content of the ensiled crops. Grasses are generally inherently low in WSC and this means that they have less substrate for lactic acid fermentation. Where molasses was added the level of WSC was raised and this improved the quality of the fermentation thus lowering the pH. In the unmolassed bana grass silage, the acidity was not sufficient to suppress the growth of clostridal bacteria which were responsible for secondary fermentation of lactic acid to butyric acid (C_3H_7COOH) and deamination and decarboxylation of amino acids resulting into putrefaction (Stoskopf, 1981).

Table 1: Mean value of quality parameters for the ensiled crops and their respective silages (1st sampling).

CROPS	%DM	%CP	IVDMD	ADL	ADF	LIGN/ ADF %	NDF	pH
<u>MAIZE STOVER</u>								
Material ensiled	22.58	6.08	51.05	10.83	49.70	0.22	77.82	-
Silage without mol.	20.83	9.28	47.31	7.25	43.48	0.17	64.31	4.50
Silage with mol.	22.77	6.85	50.00	7.29	37.34	0.20	66.49	4.10
<u>BANA GRASS</u>								
Material ensiled	15.90	12.59	68.97	15.71	47.19	0.33	78.48	-
Silage without mol.	16.94	10.38	56.28	5.52	40.54	0.14	59.46	5.18
Silage with mol.	19.77	11.94	65.86	9.11	34.61	0.26	56.47	4.18
<u>SUGARCANE TOPS</u>								
Material ensiled	23.67	5.52	52.24	11.32	47.27	0.24	77.31	
Silage without mol.	33.97	3.88	45.51	11.61	42.86	0.27	71.43	4.70
Silage with mol.	36.12	4.85	42.06	10.77	42.19	0.26	75.41	4.00
<u>SORGHUM STOVER</u>								
Material ensiled	35.55	4.68	48.13	13.54	46.76	0.29	75.88	-
Silage without mol.	43.06	6.47	53.16	10.77	40.40	0.27	64.64	4.13
Silage with mol.	41.10	3.88	44.93	7.11	43.52	0.16	64.84	4.20

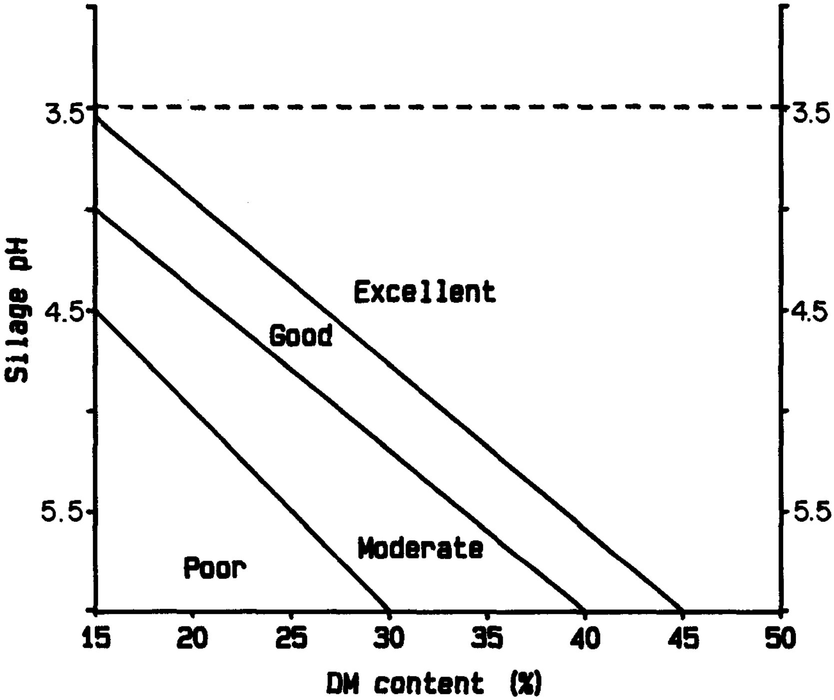
The pH level at which clostridial activity is prevented varies with water content of the ensiled material. At a water content of 50% silage can be well preserved at a pH of 5.0 whereas secondary aerobic fermentation can occur in silage with 85% water content even when the pH is below 4.0 (Thomas and Young, n.d.). With moist materials the content of water tends to counteract the preservative action of the primary fermentation acids. This explains why, without an additional source of WSC to ensure rapid drop in pH, it was not easy to achieve excellent silage in unmolassed bana grass. A pH below 3.5 was necessary to achieve this as illustrated in Figure 2. The data shows slight increases in DM of the silages where molasses was applied and this agrees with the observations of McDonald (1981) who also noted that losses of soluble carbohydrates in effluent, particularly from wet crops, can be high and this can also influence the type of fermentation in the silage. Table 2 shows a comparison of the silages using an arbitrary condition score.

Table 2. Conditions scores* of the different silages on the basis of appearance and smell.

Types of silage	Conditions scores		
	Appearance	Smell	Total score
Maize stover			
Silage without molasses	3	3	6
Silage with molasses	3	3	6
Bana grass			
Silage without molasses	2	1	3
Silage with molasses	3	3	6
Sugarcane tops			
Silage without molasses	3	3	6
Silage with molasses	3	3	6
Sorghum stover			
Silage without molasses	2	2	4
Silage with molasses	2	2	4

* The scores used are 1 = poor, 2 = moderate and 3 = good. For appearance, a condition score of 3 indicates a brownish, well pickled silage while for smell it refers to the typical silage smell without any foul odour often associated with putrefaction.

Figure 2. Fermentation quality in relation to silage and DM content.



Source: Thomas and Young (n.d.).

It can be seen that the bana grass silage without molasses had the lowest total score and the addition of molasses greatly improved the score.

In all the crops presented in Table 1, except bana grass, CP was lower than the minimum level of 7% below which the intake of forages is markedly reduced (Milford and Minson, 1966). Protein supplementation would therefore be necessary for efficient utilisation of these silages. This becomes even more crucial in cases where molasses is added. Studies elsewhere (Peralta and Hughes-Jones, 1981; Sutton, 1979) have shown that when molasses is used, even at restricted levels, as the sole supplement to low quality roughages, digestibility, rate of passage and voluntary feed intake may be reduced. This is because the molasses would promote a rapid growth of fast-growing sugar digesting microbes and these would deprive the slower-growing cellulolytic organisms of what little N is available in the rumen (Gilchrist and Schwartz, 1971). Bana grass had the highest in vitro dry-matter digestibility (IVDMD) with sorghum having the lowest (Table 1). It is not clear why bana grass which also had the highest lignin as a percentage of ADF (lignin/ADF%) had the highest IVDMD. Sands et al. (1982) reported a negative correlation between IVDMD and lignin/ADF ratio for certain feeds in western Kenya.

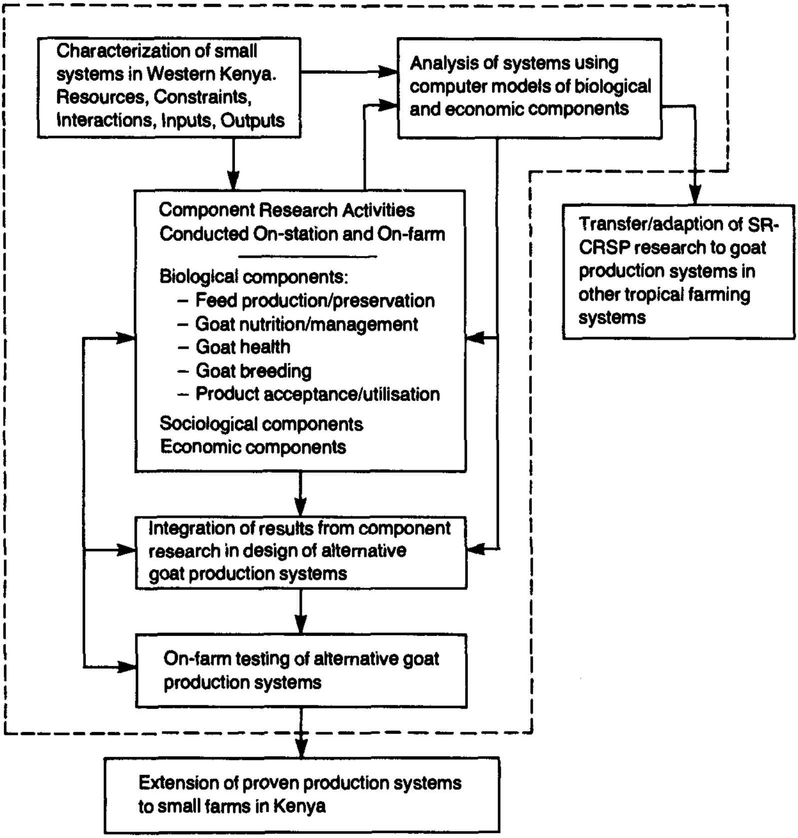
Ensiling appeared to lower the IVDMD of maize stover, bana grass and sugarcane tops by approximately 4.68%, 11.5% and 16.18% respectively and increased that of sorghum stalks by 1.91%. Deville and Cheong (1978) however, reported similar digestibility and volatile fatty acid pattern between fresh cane tops and cane tops silage with the addition of molasses and ammonia in a feeding trial with goats.

Although organic acids with and without formalin are currently being widely used as silage additives and are rated highly in terms of their effects on preservation and animal performance (Anon, 1983), it is claimed that many of them are unpleasant to use. This has caused a renewed interest in molasses and today simple effective methods of handling and applying it to crops have been developed. Ely (1978) has reviewed the effect of silages treated with molasses on milk production and he concluded that this additive was most successful with low DM, high protein crops.

Consideration for practical utilisation

The results from this study demonstrate the technical feasibility of ensiling maize stover, surgarcane tops, bana grass and sorghum stover in synthetic gunny bags. It also shows the importance of using molasses as an additive when the material to be ensiled has a high water content. Our immediate concern now is to extend this technology to our clientele, the small-scale farmers in Western Kenya. In our research programme we follow the systems approach as shown in Figure 3. Having developed the technology on the station, the next phase is to implement it on the farms, first as a researcher-managed trials, then as a researcher-farmer managed trials, before it is fully given over to the farmers themselves. As an initial step in this process we have conducted training workshops for our field staff and some representative farmers from the study communities in which we are operating. These representative farmers were also people with certain responsibilities in their respective communities e.g. assistant chiefs, primary and secondary school teachers etc. On the other hand we have also conducted training workshops for the farmers themselves in schools within their communities. The workshops involve theoretical packages developed on the station. These are conducted in the local languages of the farmers. In addition to this, we have regularly mounted field-days in our research station and invited the agricultural extension personnel and local farmers. We do also participate in the local agricultural shows. These activities have created a working relationship between us (researchers), our clients (the farmers) and the extension personnel. It also reduces the amount of work that the extension staff have got to do. In many instances the extension personnel are not able to make regular visits to farmers within their designated areas of work. This is usually due to the fact that they have too many farmers to serve across a very wide area with no proper provision for transport (Reynolds et al., 1984). Thus the diffusion of new technologies would be too slow if one relied entirely on the extension staff. Moreover, individual farm visits would be too cumbersome. Thus group extension approach can be more appropriate and practical.

Figure 3. *Implementation strategy for SR-CRSP research activities involving dual-purpose goat production system for small farms in Kenya.*



Important too is the question of whether the inputs in this technology would be readily available within reach to the farmers and whether they will be able to afford them. It has to be accepted that adoption of any innovation involves some initial capital inputs and sometimes these can be very substantial. The two major sources of capital inflow for smallholders in western Kenya can be categorised broadly into on-farm and non-farm (or off-farm). The non-farm sources of income are mainly in the form of urban migration and subsequent wage employment particularly by the male members of the households and remittances from sons and daughters employed in the urban areas.

Mukhebi et al., (1986) reported that on average 66% of the total household cash receipts of the families within the clusters where SR-CRSP works is derived off-farm. The importance of non-farm income and/or loans in financing innovation in the rural areas in Kenya only become evident when it is realized that if the average poor smallholder in Central, Nyanza and Western provinces, for instance, were to increase his purchased farm inputs to the level of the mean for all smallholders, he would have to reduce his household consumption by 25% if he has to meet the costs off his normal income (Collier and Lal, 1984).

One form of non-farm income is credit from financial institutions. Even though it is generally agreed that access to credit facilitates agricultural innovation in Kenya, self-financing has been more important than formal credit as a motivating force in increasing productivity for most smallholders (Commins et al. 1986). As Pischke (1977) argues, self-finance is simpler, involves the farmer in less financial risk than the formal credit and leaves the farmer in greater control over his activities. It is also compatible with gradual, risk-averting innovation with respect to enterprises not subject to indivisibilities. Moreover, formal credits are also often difficult to administer and this raises the question of whether they are really cost-effective. If seen in this light then it can be argued that rather than provide credit to marginal producers, the government should invest more in the productive infrastructure such as roads and marketing facilities. According to Ranjhan and Faylon (1987), strong institutional back-up is required to introduce a new technology in a way that it can be adopted by farmers.

In Tanzania, for instance, dairy farmers around Kilimanjaro area have been using molasses extensively for feeding their livestock. However, its use has been more or less limited only to a few "progressive" or well-to-do farmers. This is because they are the ones who could afford transport to bring in the molasses from about 20 km south of Moshi town. The Government therefore through the FAO/UNDP dairy development project has now established a distribution network for molasses in Arusha and Kilimanjaro area (Urio, 1987). This project has constructed a small plant for mixing urea and molasses and also established collection centres in selected villages where upto 10,000 litres of molasses can be stored and from where farmers can purchase them. For our smallholders in western Kenya we are also experimenting with jaggery sugar which is much easier to obtain as it is sold locally in the retail shops. Initial results are already encouraging.

It would be difficult at this stage to talk about the economic benefits of this technology since an attempt to quantity these at this stage when the farmers are still just being introduced to it would lead to an unrealistic assessment. Feedback from the on-farm trials will certainly be of value in pointing to us the strengths and the weaknesses of this technology.

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TECHNIQUES USED FOR TESTING THE DEVELOPED LIVESTOCK AND PASTURE METHODOLOGIES PRIOR TO THE EXTENSION OF RESULTS IN THE SEMI-ARID MID-ALTITUDE AREAS OF KENYA

F.P. Wandera[1], D.M.G. Njarui[1], S. Tessema[2], J.M. Kavoi[1], M. Nderito[1]

Summary

A comparison of two techniques (approaches) adopted by National Dryland Farming Research Centre (Katumani) Kenya, is discussed.

The "pre-extension" trial which introduced components of livestock production system, attempted to alleviate feed shortages especially during the dry seasons by providing farmers with forage planting material and encouraging them to adjust their livestock numbers to available feed resources. However, this approach came up with discouraging results as these component technologies were poorly adopted (Ockwell et al, 1987).

The "whole-farm" approach which involved an introduction of a "package" of technologies for improvement of livestock production and which recognises the importance of systems concept to farming has given indicators of success in evaluating the suitability of developed technologies on farmers' fields.

Indications of replacement of lower yielding indigenous livestock breeds with higher yielding crossbreds is seen, higher milk production (about 2000 kg/lact) and higher growth rates (325 g/day for heifers) are realised on the farms.

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Thus for successful testing and/or adoption of livestock pasture production research results by farmers, an understanding of the functions and functioning of the system is essential. Secondly, an appreciation of the need to introduce a package (feed, management, health care and possibly change of breeds), which will convincingly improve farmers return to labour and land could lead to higher rates of adoption of livestock/pasture developed technologies.

INTRODUCTION

Developed technologies through agricultural research for better management of livestock and crop production, have not been easily accessible to the farmers, in the semi-arid areas of Kenya. This has been due to poor linkage between researchers/extension services and farmers, an assumption by scientists that components within a farming system operate in isolation and are not interlinked, and that external factors to the farm unit e.g. communication, availability of credit facilities and marketing, among other factors, do not affect the farmers' ability to adopt technologies.

Thus in formulating research programmes no due consideration is normally given to these factors, with consequent results of limited adoption of the developed technologies.

The farming systems approach to research and development adopted by Katumani, first described the physical environment and farming systems of the semi-arid areas of eastern Kenya and identified constraints to the livestock production faced by the farmers, as follows:-

1. The dryland areas cover an estimated 46 million hectares (80.8% of total land mass) ranging from agroecological zones 4 to 6. 16% of this is under what is termed as the semi-arid lands (zones 4 and 5).

2. The semi-arid area is characterised by a bimodal pattern of rainfall with annual average of 500-800 mm, with two peaks in April and November. Two pronounced dry seasons are

experienced (Jan. 15 to March 6 and again July 1 to Nov. 3) (Dennet et al, 1982).

3. A freehold land ownership system is prevalent with farmers owning between 1 and >20 hectares, with a mean of 7.5 ha out of which 2.5 is cropped and 5 ha left for livestock production (Tessema et al, 1985).

4. Farmers avert risks by practising mixed cropping and livestock production.

5. Cattle, sheep and goats are kept by almost all farmers and normally under stocking rates which many times exceed the carrying capacities of the farms (Tessema et al, 1985; Ockwell et al, 1987).

6. Periodic short-fall in feed availability during the dry seasons and droughts imposes severe nutritional stresses to the animals with resultant low productivity (i.e. meat, milk and draught power) and even pre-disposes the animals to a number of diseases that frequently lead to high rates of mortality.

7. Livestock culture rather than livestock economy forms the main reason for livestock keeping. However farmers are forced to sell some of their livestock only during food shortages and when cash is required e.g. school fees for their children.

8. Availability of credit to the small-scale farmers for livestock improvement programmes is inadequate or in most cases, non-existent. This is because of the lack of economic data on proven technologies to support loans for livestock enterprises (Tessema et al, 1985; Ockwell et al, 1987).

Having defined the farming system and the attendant problems and constraints, the second stage was designing the research programmes and experimentation. This generated a package of technologies that could possibly alleviate the identified constraints.

Tessema et al (1987) outlined the improved package as follows:-

1. adjustment of livestock numbers to the available feed supply
2. improvement of natural grazing area by selective bush clearing, reseeding, burning, etc.,
3. improved use of crop residues,
4. conservation of excess forage for dry season feeding,
5. Maintenance of a systematic disease control schedule,
6. improvement of the stock through use of crossbred cows and/or dairy goats and
7. improvement of management - semi-zero-grazing, provision of stock shed, watering, manure collection etc.

In the third stage, testing of the developed technologies under on-farm situations is undertaken. Two approaches have been attempted. First a "pre-extension" trial in which component technologies were extended. Later a new approach was muted mainly due to experiences gained in the pre-extension trial. This approach introduced a "package" of technologies to the farmers, in full appreciation of the main factors that limit implementation of developed livestock technologies on farms.

PRE-EXTENSION 'COMPONENT' TECHNOLOGY TESTING APPROACH

The initial diagnostic survey (Rukandema et al, 1984) indicated that the rough unimproved natural pasture, supplemented with poor quality maize stover during the dry season, resulted in poor livestock responses (e.g. too weak oxen at the end of a dry season to plough effectively.

This prompted a feed resource improvement component to be formulated for testing on the farms. Together with this, a policy of destocking to adjust livestock numbers to available feed resources was encouraged for adoption by the participating farmers.

The two components were tested together with crop production technologies on 18 selected farmers throughout the mandate region.

The selection criteria (Bakhtri et al, 1984) were as follows;-

1. The person selected should be a full-time average farmer

2. He/she should have both crop and livestock

3. He/she should be willing to participate in the research activity, be able to accept and implement advice given, and be willing and able to collect simple data and share experience with other farmers.

4. His/her farm should be located near a road for easy access to enable frequent visits to be made by both research and extension workers.

Planting materials (root splits for Napier grass, Leucaena seedlings and seeds for Rhodes grass/Makueni guinea grass/stylo/siratro mixtures) were provided to the farmers and advice for planting given. Farmers were also encouraged to adjust their livestock numbers.

RESULTS

Although the farmers appreciated the problem of feed shortages, priority for labour use was given to cropping activities (planting and weeding) and it was only after weeding that the forage material was planted. This late planting generally resulted in poor establishments due to inadequate moisture and loss of viability of vegetative propagules.

Whenever there was successful establishment, farmers did not utilise the material to feed their indigenous animals and left the material to grow old. Traditionally farmers in this area did not plant forage for their indigenous stock and felt that the planted forage should be utilised by a more productive grade animal in order to realise profitable returns to labour and land used.

Farmers did not respond completely to advice to adjust their stock numbers. Thus in a nutshell, the pre-extension farmers did not adopt any of the introduced livestock improvement technologies.

This necessitated a serious assessment of the approach and a realisation that a new approach must be worked out: the whole farm as a production system.

THE 'WHOLE-FARM' PACKAGE APPROACH

Before formulating technological packages under this approach, an attempt was made to thoroughly understand the existing system. While more 'one-visit' data collection surveys were carried out (Kenya marginal/semi-arid lands pre-investment inventory 1982, Rukandema et al, 1984) a detailed case-study of the traditional livestock production system was undertaken (Tessema et al, 1985; and Ockwell et al, 1987).

From these studies farms could be classified in three different farm sizes (Table 1a): small, medium and large (average size of 3.3 ha, 7.6 ha and 12.8 ha respectively). Farm sizes do not conform to the agro-ecological zones and the cropped area is hardly more than 3.5 ha whatever the size of the farm.

Livestock numbers do not conform to the carrying capacity of the area (Table 1b) and there is more serious overstocking problem in the drier than in wetter areas (stocking rates being 2, 4. and 5.4 times the carrying capacity of UM4, LM4 and LM5 respectively). More goats are kept than sheep due to the preference for goat meat in the region. However the number of goats is more in drier areas and cattle in wetter areas (Table 1b).

Table 1a. Farms size characteristics in the areas in the Study area of eastern Kenya.

Farm Classification	AEZ	Farm size (ha)	Crop area (ha)	Grazing areas (ha)
Large	UM4	15.2	4.9	10.3
	LM4	10.4	2.0	8.4
	LM5	12.7	3.5	9.2
Medium	UM4	8.8	3.7	5.7
	LM4	5.0	1.5	3.5
	LM5	9.0	3.0	6.0
Small	UM4	3.2	1.9	1.3
	LM4	2.3	1.5	0.8
	LM5	4.5	1.7	2.8

Notes:

1. Agro-ecological zones are derived from Jaetzold and Schmidt (1983)

2. Farm sizes are compiled from Tessema et al (1985)

Table 1 (b). Livestock ownership in study area of eastern Kenya.

AEZ	Cattle	Sheep	Goats	LSU	LSU/ha	Tech.	Cap./ha
UM4	14.66	2.33	10.67	10.13	1.67	0.5	1.00
LM4	8.13	1.13	11.37	7.79	2.60	0.39	0.76
LM5	7.72	6.71	22.43	10.13	1.53	0.21	0.37

Notes:

1. Livestock numbers are derived from Ockwell et al (1987)

2. Technical carrying capacity is estimated from Jaetzold and Schmidt (1983)

Livestock production levels, Table 2, are relatively low mainly due to feed shortages and low genetic potential of the breeds kept.

Table 2. Production levels under unimproved system.

a) Milk yield

Mean daily yield (kg)	1.55
Mean lactation length (days)	286
Mean lactation yield (kg)	443

b) Growth rates (g/day)

Cattle		Goats		Sheep	
Calves	205	Kids	44	Lambs	29
Weaners	212	Yearlings	30	Yearlings	18
Heifers/young bulls	64	Does	17	Young rams	24
Cows	17	Breeding bucks	6	Ewes	4
Breeding bulls	15			Breeding rams	11

Source: Tessema et al (1985).

Although most improved technologies for livestock production are deemed labour intensive, Table 3 shows that there is likely to be adequate labour especially during lax cropping activity periods to carry out required livestock activities and in a sense provide more return to labour at that time.

Thus against this background, a new 'whole-farm' approach technique of testing livestock developed technologies was muted.

The design and the implementation of the on-farm research based on this approach, is clearly outlined by Tessema et al (1987). Farmers are selected on the basis of agro-ecological zones:-

1. UM4 - 700-800 mm rainfall

2. LM4 - 600-700 mm rainfall

3. LM5 - 500-600 mm rainfall

and three farm sizes: 1) <5 ha, 2) 5-10 ha, 3) > 10 ha. Two farms from each farm size class in each agro-ecological zone are selected. Thus a total of 18 farms is formed. To assess the performance of the introduced technologies a second group of farmers (18) is selected where data is collected on the existing systems.

Table 3. Family labour supply and demand for livestock activities

Average labour supply *AAME (hrs/day)	Milking (min)	Health care (Min)	Feeding (Min)	Herding add watering (Min)	Boma cleaning (Min)	Total livestock demand on labour (Hrs)
62.87	41	14	75	770	5	15 hrs 5 min

*AAME Average Adult Male Equivalent

Computer modelling and simulation are used to assess the potential applicability, input requirements, constraints and outputs.

Budgeting and sensitivity analysis techniques are used to determine optional farm plans. The farm plans developed are finally discussed with the farmers and modified to reflect their preferences and willingness to test the techniques.

The developed technologies are introduced step by step starting with feed resource base improvement (Table 4), then housing and introduction of the animals.

The introductions into the farms are under express management of the farmers. Therefore, to make the farmers feel responsible inputs are not provided free of charge but are to be repaid to the research station. However this is on condition that the innovation contributes substantially to the net income. Otherwise inputs are written off as research expenditure.

Two weekly data collections on livestock/pasture production parameters are done and analyses made by regression equations, variance analysis and cost benefit analyses to test the economic feasibility.

An integrated system of feeding, utilising the available feed resources is likely to ease the fluctuations of the feed availability and quality especially when conservation is incorporated into the production system. Figure 1 shows the distribution of dry and green seasons as far as feed availability is concerned and indicates the physiological status that a dairy cow could follow.

An integrated feeding regime thus should follow the physiological demand of the cow as follows:

Period I and III - growing season

graze natural pasture, give fodder grass *ad lib* and restricted fodder legume

Period II - Growing season/dry season (short)

Natural pasture grazing, restricted fodder crop residue and fodder legumes (higher intakes)

Period IV - Dry season (moderate)

Poor quality pasture grazing, crop residue (treated) plus fodder legumes, hay/silage feeding.

Although the outlined feeding regime has not yet fully been incorporated into the participating farmers, the response of what is already being practised by the farmers is seen in the improved production of milk, from 448 kg/lactation to 1471 kg/lactation and improved growth rates of their stock (calves growing at a rate of 800 g/day, heifer at 325 g/day, cows at 120 g and steers and bulls at 146 g and 169 g respectively).

Table 4. Feed resources on selected farms.

Feed description	DM yield in tons/ha	Nutrient Ash %	Composition CP %	NDF %	ADL %	In vitro DM digestibility
Natural pasture	2.15	8.32	7.73	72.36	6.41	44.52
Stover						
Maize	2.54	11.92	2.59	69.55	9.32	41.83
Sorghum	1.00	6.80	6.53	52.97	3.26	50.06
Fodders:						
Bana	6.80	15.54	9.08	63.37	3.93	59.08
Bajra	7.30	14.89	11.79	58.12	5.15	62.36
Panicum	5.10	13.16	12.98	60.28	5.32	56.62
Pasture grasses:						
Rhodes	3.00	9.95	11.15	73.88	6.28	54.76
Guinea grass	4.00	12.12	10.41	66.32	5.88	50.88
Cenchrus	2.60	7.73	8.21	71.10	4.94	50.22
Legumes:						
Leucaena	4.00	7.93	27.28	38.13	9.80	64.78
Pigeon peas	-	6.81	13.90	59.88	14.83	55.16
Dolichos	-	6.87	15.54	43.90	6.46	63.17

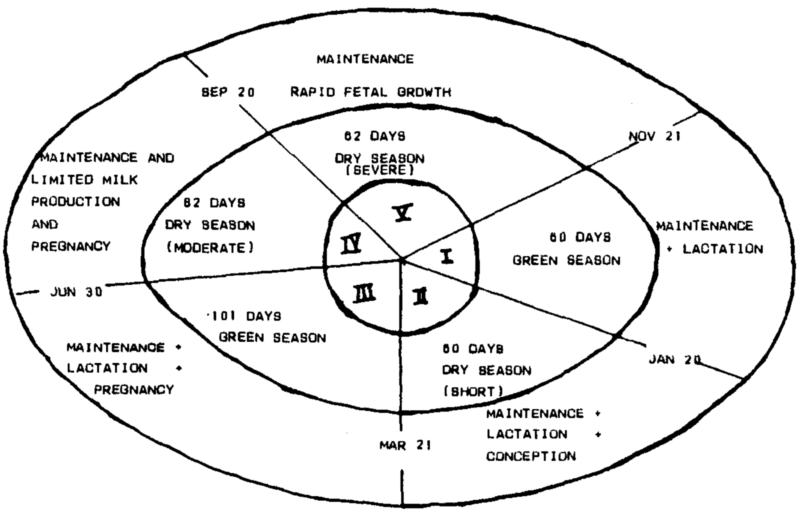
Notes:-

(1) Natural pasture figures are averages from 20-210 days old herbage while planted pasture figures are average from 20-80 days old.

(2) Maize and sorghum stover yields based on 1/3 of recommended populations commonly found in the area.

Source: Ministry of Livestock Development, 1983 annual report.

Figure 1: Annual reproduction cycle of the dairy cow in combination with seasonal changes and feeding systems. Feeding systems are indicated as period I to IV.



Other indicators of success of this package approach are:

1. Improved grade animals are now replacing the local breeds. One farmer out of six on whose farms innovations have been implemented has already replaced all of his indigenous livestock with grade ones.
2. Farmers have expressed the intention of payment for their livestock rather than return the initial cow to the centre.
3. Although initially the centre was providing for drugs and accaricides, now the farmers are buying these with money from the sale of milk.
4. Fodders introduced are well cared for.
5. Manure is regularly collected and applied to cropped area, other farmers have been extending manure application to fodders.

Thus although the study is not yet complete, indications are that this approach has been more acceptable to the farmers than the former 'component' approach. The main incentive here is the realisation of improved livestock production especially milk production, without which other components of the package might not have been adopted.

DISCUSSION AND CONCLUSION

The system concept as applied to the mixed farming situation in the dryland can be diagramatically represented as in Figure 2.

The major sub-systems are represented, the crops and the livestock subsectors. Within the livestock sub-system, about four major components are conceptualised; feed resources, health, animal and housing.

All the four components work towards achieving the same goal (output) which in this case is improved growth rates, more milk, more draught power and better reproductive efficiency. However under the concept of systems approach, change in any of these components is seen as an improvement only when the whole system is improved.

Thus before any technology is tested or extended at farm level, it is important to thoroughly define the system into which the technology will be injected, stating clearly the component(s) that is/are targeted for improvement.

The second important factor is to understand the managerial skills and factors that affect the decision-making process of farmers and their aspirations.

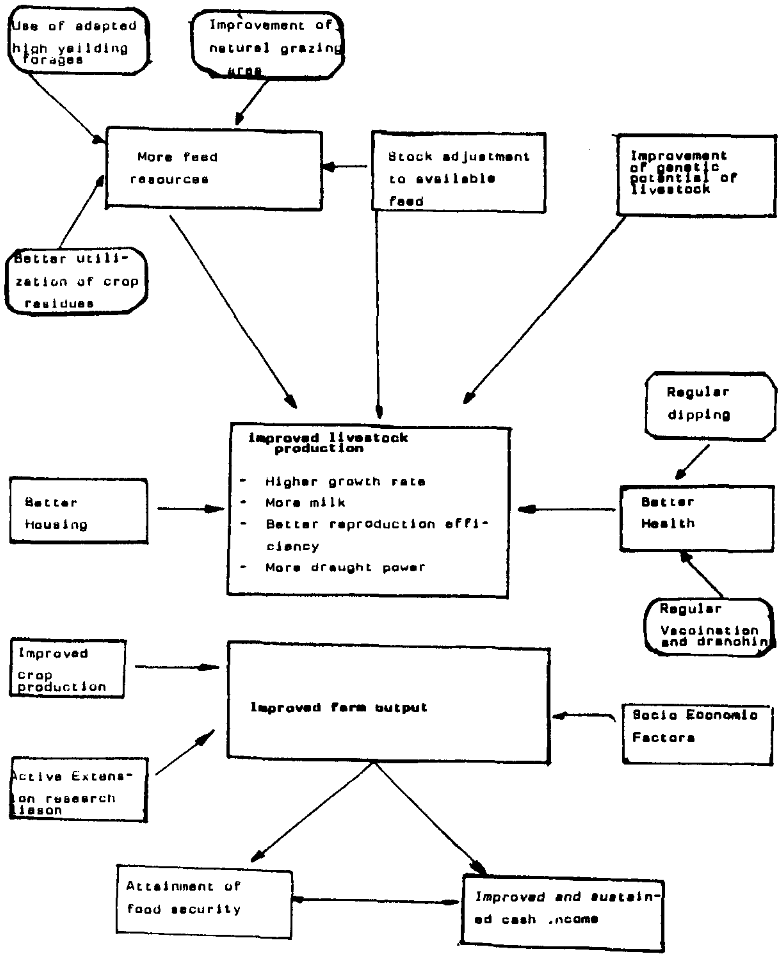
Pre-extension component approach was not successful because of inadequate understanding of the farmer's utilisation of his resource base (Ockwell et al, 1987). A detailed case-study approach was found to be more effective in gathering the information that led to a better understanding of factors that interplay in a livestock production sub-system (Tessema et al, 1985).

From this study it was envisaged that livestock and pasture production technologies required a system approach even much more than the crops since forages alone are not outputs on the farm and animals require a feed base establishment among other factors. Thus a 'whole-farm' approach package was adopted as a testing tool.

It was also envisaged that packages should be tailored to ecology and farm size: Dairy goats in drier ecologies and on small farms and dairy cows in wetter areas and on large farms.

When testing and/or extending a feed resource component, its success on farm will be seen through increased levels of animal products. However this increased productivity might only be realised when animals that can respond to improved feeding and management are used. At certain times this might lead to scientists going out of their way to provide for other components of the system (e.g. introduction of dairy cow, housing and better health care facilities) in order to test the viability of the technology(ies).

Figure 2: Small-scale mixed farming system showing the interplay of livestock production units, the main factors affecting them and outputs.



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EFFECT OF MANAGEMENT PRACTICES ON RHODES GRASS AND LUCERNE PASTURES WITH SPECIAL REFERENCES TO DEVELOPMENTAL STAGES AT CUTTING AND ASSOCIATED CHANGES IN NUTRITIONAL QUALITY

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ABSTRACT

Rhodes grass (Chloris gayana) fertilized at 0 or 138 kg N/ha/yr and lucerne (Medicago sativa) were grown at Kulumsa (8°N, 2200 m altitude) representing medium-highland zones of Ethiopia. Samples were taken every 10 days for about 100 days during two growing seasons (March-May and July-November) in 1986. The samples were analysed for dry matter yield, crude protein (CP), organic matter digestibility (OMD), fibres (NDF, ADF), Ash, lignin and major mineral elements.

Nitrogen fertilization increased yield, rate of growth and improved CP content and OMD during the earlier part of growth but N-fertilized Rhodes grass produced reproductive inflorescence earlier and produced forage of low CP, high fibres, low OMD, P, K, Mg and Na at the advanced stage of growth. The average rate of decline in CP due to advance in maturity was 0.14 and 0.11% /day with and without N-fertilization respectively. The corresponding decline in OMD was 0.28 and 0.19% /day respectively. Lucerne produced forage of high CP, low fibres, high OMD, K, Mg, Ca and high lignin at all stages of growth and the minimum levels of CP & OMD reached due to advance in maturity were significantly higher than those of Rhodes grass.

It was concluded that maturity stage at cutting is the most important factor which determines the quality of Rhodes grass pasture and cutting at 10-50% heading or about 50 days regrowth period can be recommended.

As to the utilisation of these and such research findings at present in Ethiopia, some issues were raised. Lack of appropriate integrated livestock/forage crops research, extension and production systems, poor research-extension linkage, less emphasis on livestock and forage extension, shortage of inputs (e.g. forage seeds) are recognised as some of the problems facing forage development in Ethiopia to date.

INTRODUCTION

Livestock production plays an important role in Ethiopian agriculture. It is an integral part of all farming systems and provides milk, meat, draught power, manure, hides and skins. Approximately 60 % (Taylor, 1984) of the total land area is utilised for raising livestock which are thus the largest single users of land resource in the country. Cattle production constitute the main component of the highland mixed farming system with small dairy herds, high traction power demand and an intensive crop and/or vegetable production. The highland is characterized by high human and livestock density leading to overgrazing, land degradation and low agricultural productivity.

The main reason for low productivity of livestock is inadequate feeds both in quantity and quality. There are few areas that can supply sufficiently good quality natural herbage for existing livestock for the whole year owing to the marked seasonality of rainfall distribution. Fodder production from improved grasses and legumes is limited to a few experimental farms due to lack of well planned crop/livestock husbandry systems, low technical expertise, restrictions relating to small farm size due to population pressure and overall low standard of agricultural production.

In recent years, the use of sown pastures has received considerable attention in areas where high producing cross-bred daily animals are owned. Rhodes grass (Chloris gayana) and lucerne (Medicago sativa) mixture is probably the most successful sown perennial grass-legume mixed pasture. Results from various experiments in low medium altitude parts of Ethiopia (Sisay 1975; Haile, 1977; Tsegahun et al, 1986; Jutzi et al 1986; FNE 1986; 1987) indicate that Rhodes grass and lucerne have a high potential as livestock feed in terms of dry matter production and nutritional value.

Rhodes grass has been a popular perennial grass in the tropics and sub-tropics of East & Southern Africa, Australia and Central America. Originating in Eastern and Southern Africa, it is valued for its (1) ability to set seed, (2) relative ease of establishment and ability to cover ground, (3) tolerance for drought, light frost, soil salinity and (4) suitability to be grown in association with many tropical legumes, clovers and lucerne. A detailed review on botanical and agronomic attributes and utilisation of Rhodes grass has been published by Bogdan (1969). Agronomic characteristics and cultivation techniques of Rhodes grass with reference to seed production in Kenya are presented in Boonman (1973) and Keftasa (1985) has presented highlights on Rhodes grass seed production in Ethiopia.

Lucerne is probably the oldest cultivated forage crop in the world and has been called the "Queen of forages". Although it originated in the Mediterranean climate of the Near East and Central Asia it is grown in almost all parts of the world. Some of its merits include tolerance to drought and low temperatures, a vigorous symbiotic relationship with Rhizobium and its high feeding value. Extensive review on lucerne have been published by Hanson (1972) and Leech (1978).

Mixed Rhodes grass-lucerne pastures have been known to be advantageous for higher yields and quality over their monocultures. A mixture of Rhodes grass benefits from the transfer of fixed nitrogen from lucerne when the nodule and/or the roots (and shoots) decay. Lucerne contains higher digestible protein and major mineral elements (Ca, P, K, Mg) than Rhodes grass but its yield is usually lower, less persistent and more difficult to harvest and cure as hay. So Rhodes grass-lucerne mixture combines the yield and quality aspects of the component monocultures and may reduce harvesting and utilisation problems.

Benefits from mixed stands of such pastures can be efficiently exploited only if proper management strategies such as optimum fertilization and accurate cutting or grazing frequencies are followed. A number of research results and literature reviews indicate that nitrogen fertilization (Howard et al, 1962; Raymond, 1966; Clatworthy, 1967; Miaki, 1968; Whitehead, 1970; Wilson and Haydock, 1971; Henzell, 1971; 1977; Minson, 1973; Binnie, 1974; Hacker & Minson, 1981) and plant maturity at cutting (Blaser, 1964; Butterworth, 1967; Milford and Minson, 1968; Stobbs, 1971; Minson, 1971b; 1972; Soneji et al 1971; 1972; Said, 1974; Rocha and Vera, 1981; Hacker & Minson 1981) is the factor which influences the nutritional value of pastures. Nitrogen frequently limits grassland productivity in the tropics. Nitrogen fertilization has been well known to increase dry matter yield and protein content of the herbage but affects herbage digestibility only slightly. Whitehead (1970), Wilson (1982) and Van Soest (1982) have reviewed published reports from different sources and concluded that the change in dry matter digestibility due to fertilizer N has been positive, negative or insignificant.

It is generally recognised that the nutritive value of tropical pasture falls as they mature due to a rise in fibre content with increasing maturity. Minson, (1971a) showed that the rate of decline in digestibility of Rhodes grass was about 0.1% /day when the overall trend of a long period is considered. In another report (Minson, 1972) showed the mean rate of fall in digestibility of Rhodes grass to be 0.25% /day between 28 and 70 days of regrowth but decreased to 0.17% /day during 70-98 days of regrowth.

Minson and Milford (1967) have shown that the digestibility of different varieties of Rhodes grass declined from 0.08 to 0.15% /day due to advanced maturity. Hacker and Minson (1981) reviewed numerous research results and concluded that after initial growth pasture plants decline in digestibility with time. They reported that the decline is more rapid in grasses than herbaceous legumes in which digestibility remain high. Raymond

(1966) reviewed reports of various authors on pattern of herbage digestibility and established a prediction formula for temperate grasses showing a steady decline in digestibility with increasing stages of maturity. A detailed work on this subject by Said (1974) shows that digestibility occurs after forage plants has headed, the reasons being increase in structural constituents (CF, cellulose and lignin) and a decrease in the non-structural constituents, mainly the soluble carbohydrates.
The common explanation for the decline has been the fall in leaf: stem ratio and rise in cell wall components coupled with increased lignification.

There are a number of interesting pieces of work done on the nutritional content of lucerne in temperate regions and Rhodes grass in East Africa and Queensland, (Australia). However, full information is lacking on the yield and quality profile of Rhodes grass-lucerne pastures relating to different cutting stages under Ethiopian conditions. The results depicated in this paper obtained from field experiments carried out to study effects of nitrogen fertilization and maturity stage on yield and quality of Rhodes grass-lucerne pastures at Kulumsa; representing the medium-highland parts of Ethiopia.

METHODOLOGY

The research site is located at an altitude of 2200 m, latitude 8^{O}N, on a clay soil with a pH of 6.2, a P content of 32 ppm, a long time when total annual rainfall of 850 mm and with mean maximum and mean minimum temperatures of 22^{o} and 10^{o}C respectively.

Rhodes grass and lucerne were sown in rows of 20 cm spacing at sowing rates of 2.5 and 8 kg/ha pure germinating seed were used. Fertilizer was applied at planting and at the rate of 100 kg/ha. DAP (18/46 N/P_2O_5) was 100 kg/ha. TSP (46%, P_2O_5) was applied every second year. Nitrogen fertilization at the rates of 0 or 138 kg N/ha/yr was superimposed on Rhodes grass at the beginning of each growing season. Herbage samples were taken at 10 days interval to determine dry matter yield, digestibility, contents of neutral detergent fibre (NDF,) acid detergent fibre (ADF), ash, lignin and contents of crude protein (CP), calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K) and sodium (Na). The samples were analysed for dry matter yield and contents of crude protein and minerals according to the specifications by Association of Official Analytical Chemists (AOAC) (1975). NDF, ADF, lignin and ash were determined with a micro fibre apparatus using the Goering and van Soest (1970) procedures. Organic matter digestibility was determined according to Lindgren (1979) and metabolizable energy content was estimated from the regression equations presented by Lindgren (1979).

Rainfall, evapotranspiration, relative sunshine hours and temperatures are shown on figures 1 and 2 respectively.

In this paper the two growing seasons are denoted as short (Feb-May) and main (June-Sept) growing seasons following the traditional terms for Ethiopia highlands.

RESULTS

As shown in Tables 1 through 4, dry-matter yields of Rhodes grass increased steadily upto 72-83 days of regrowth period and then decreased slightly or remained high. Average rates of increases in dry-matter yields during these periods were 121 and 65 kg/ha/day in the short rainy season with and without nitrogen fertilization respectively. The corresponding rates of increase in the main rainy season were 70 and 30 kg/ha/day respectively. Dry-matter yields of lucerne was generally lower than those of Rhodes grass except in few cases in non-nitrogen fertilized Rhodes grass in the earlier part of the regrowth period. Lucerne started growth faster than Rhodes grass as soon as the rains began and also declined earlier in dry-matter yield mainly due to leaf senescence and leaf diseases such as leaf spot (Pseudopeziz medicaginis).

Nitrogen fertilization increased the crude protein content of Rhodes grass by about 15% at the early stage of growth but N fertilized Rhodes grass contained less crude protein content at the advanced growth stage. The crude protein of Rhodes grass declined markedly due to advance in maturity. The rate of decline was about 0.1 and 0.08% /day in the short and the main rainy seasons respectively in non-nitrogen fertilized Rhodes grass and 0.17 and 0.14% in the short rainy seasons and the main rain seasons respectively in nitrogen fertilized Rhodes grass. Lucerne contained high crude protein in the earlier part of regrowth period but declined at the rate of 0.15% /day during 72 days of regrowth and then stagnated around 19 %.

Nitrogen fertilization improved the organic matter digestibility of Rhodes grass in the earlier part of growth period but at the advanced stage of maturity the organic matter digestibility of nitrogen fertilized Rhodes grass was inferior to the non-fertilized ones.

The organic matter digestibility of Rhodes grass increased slightly during 25 days of regrowth in the short rainy season and declined steadily at the rate of 0.36 and 0.28% /day with and without nitrogen fertilization respectively (Table 1). In the main rainy season organic matter digestibility declined steadily at the rates of 0.20 and 0.10% /day with and without nitrogen fertilization respectively. The organic matter digestibility of lucerne was almost always higher than Rhodes grass in both seasons. It declined steadily at the rate of about 0.2% /day in the main rainy season (Table 4) during the short rainy season it increased slightly in the growth period of up to 25 days and declined then after at the rate of 0.17% /day.

Figure 1. Monthly rainfall evapotraspiration and relative sunshine and hours at at Kulumsa, Ethiopia, 1986.

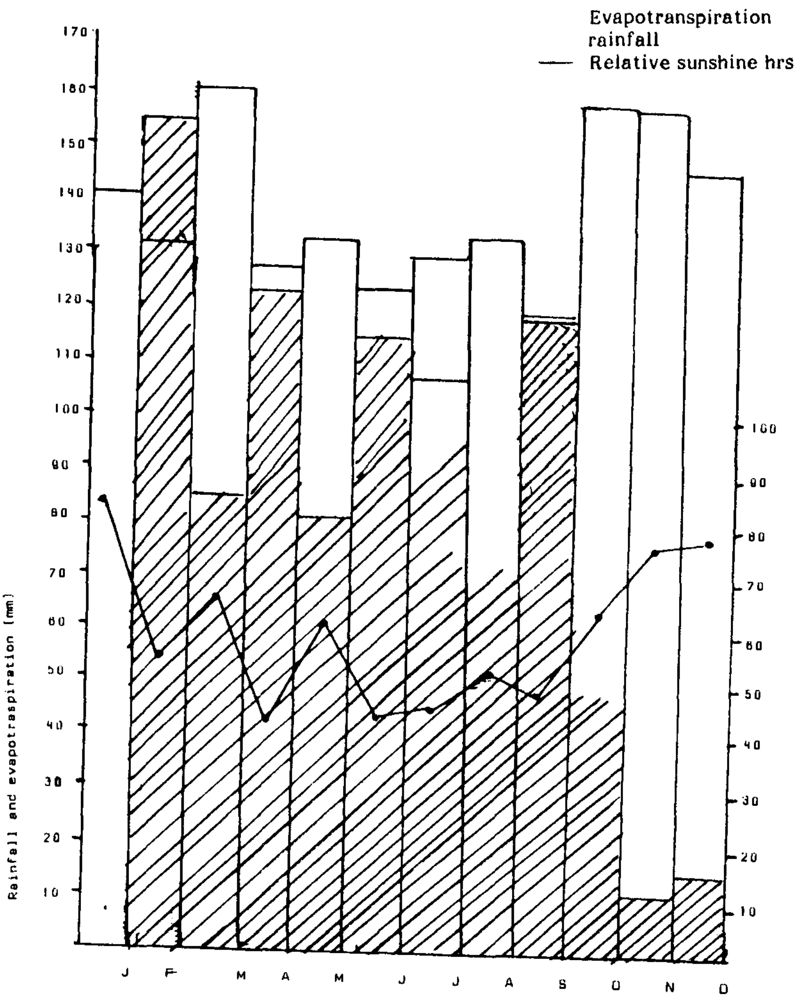

Figure 2. Mean monthly maximum and minimum temperature at Kulumsa, Ethiopia, 1988.

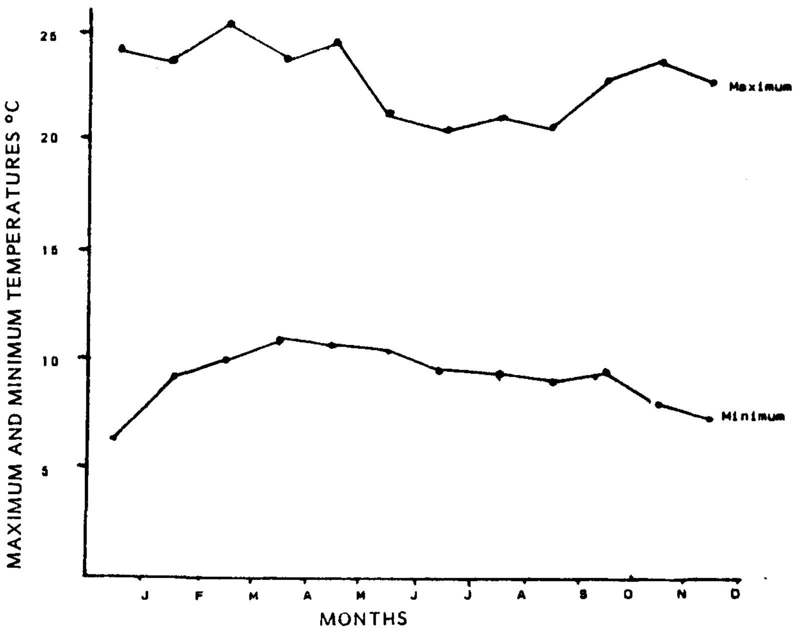

Table 1. DM yield, crude protein, organic matter digestibility and metabolizable energy contents of Rhodes grass and Lucerne at different date, with and without N-fertilization during the short rainy season, of 1986.

(N- fertilization; O=nil and + =46 kg N/ha)

Species	N-fert.	Harvesting date	Regrowth days	DM yield kg/ha	CP %	OM dig. %	Estimated ME MJ/kg OM	Botanical stage
Rhodes	0	4/3	17	1340	13.3	75	10.1	100% leafy
Rhodes	+	4/3	17	2200	18.1	76	10.3	100% leafy
Lucerne	0	4/3	17	1240	27.7	78	11.2	100% leafy
Rhodes	0	12/3	25	1740	15.0	79	10.7	95% leafy
Rhodes	+	12/3	25	3210	17.0	81	19.1	95% leafy
Lucerne	0	12/3	25	2150	32.1	81	11.5	100% leafy
Rhodes	0	21/5	34	1880	12.3	74	9.9	90% leafy
Rhodes	+	21/3	34	3790	15.1	79	10.7	90% leafy
Lucerne	0	21/3	34	2470	26.8	81	11.5	100% leafy
Rhodes	0	31/3	44	3000	8.2	69	9.1	75% leafy
Rhodes	+	31/3	44	6680	11.9	73	9.8	75% leafy
Lucerne	0	31/3	44	3600	25.5	77	11.1	100% leafy
Rhodes	0	9/4	53	3760	9.3	70	9.3	50% headed
Rhodes	+	9/4	53	7430	8.8	67	8.8	50% headed
Lucerne	0	9/4	53	3640	22.9	74	10.8	10% flowering
Rhodes	0	28/4	72	4410	6.6	66	8.7	75% headed
Rhodes	+	28/4	72	8900	8.9	62	8.0	75% headed
Lucerne	0	28/4	72	4520	19.1	69	10.2	10% flowering

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Table 1. DM yield, crude protein, organic matter digestibility and metabolizable energy contents of Rhodes grass and Lucerne at different date, with and without N-fertilization during the short rainy season, of 1986.
(N- fertilization; O=nil and + =46 kg N/ha)

Species	N-fert.	Harvesting date	Regrowth days	DM yield kg/ha	CP %	OM dig. %	Estimated ME MJ/kg OM	Botanical stage
Rhodes	0	7/5	81	5640	5.3	61	7.9	80% headed
Rhodes	+	7/5	81	8150	4.8	60	7.7	Fuel heading
Lucerne	0	7/5	81	3320	20.3	72	10.6	15% flowering
Rhodes	0	17/5	91	5530	5.1	53	6.6	Full heading
Rhodes	+	17/5	91	7640	4.0	55	6.9	anthesis
Lucerne	0	17/5	91	2600	19.8	71	10.5	20% flowering
Rhodes	0	27/5	101	5670	5.1	57	7.2	Seed maturity
Rhodes	+	27/5	101	7290	4.4	50	6.1	Seed maturity
Lucerne	0	27/5	101	2240	19.9	71	10.5	20% flowering
Mean ± standard deviation (SD)								
Rhodes N_o				3663 ± 1757	8.9 ± 3.8	67 ± 8.7	8.8 ± 1.4	
Rhodes N_+				6143 ± 2419	10.3 ± 5.5	67 ± 11.0	8.7 ± 1.6	
Lucerne N_o				2864 ± 991	23.8 ± 4.5	75 ± 4.5	10.9 ±0.5	

As shown in Tables 2 and 5 both the NDF increased with advance in maturity. It appears that both NDF and ADF were lower in nitrogen fertilized Rhodes grass if cut early but higher if cut late (advanced maturity). This feature of NDF and ADF contents followed the pattern of crude protein content and organic matter digestibility. Lucerne contained less NDF and ADF than Rhodes grass at all stages of cutting and their contents increased at slower rate than that of Rhodes grass. The ADF ash of Rhodes grass was found to be quite high as compared to lucerne indicating the presence of large amount of silica which could severely interfere with digestibility. It appears higher in nitrogen fertilized Rhodes grass and its trend of increase with maturity is not consistent. The ADF ash content of lucerne was somewhat higher in the earlier part of growth and was not detectable in most of the cases in the latter part of growth. The lignin content of both Rhodes grass and lucerne increased with maturity. Lucerne contained more lignin than Rhodes grass and there were no marked differences in lignin contents of Rhodes grass due to nitrogen fertilization.

As shown in Tables 3 and 6, generally the total ash content of both species declined as the maturity advanced but some increases were also observed in non-nitrogen fertilized Rhodes grass. It was observed that the P, K, Mg and Na contents declined due to advance in maturity in both species but the Ca content was fluctuating and the trend was not consistent. This higher content of Ca in the middle (about 50 days regrowth) and at the latter growth stage might be due to the role of Ca in the plant as a structural element. Lucerne contained more K, Ca, Mg and Na than Rhodes grass in almost all of the cases. The P contents of Rhodes grass and Lucerne were not distinctly different but it appears that Rhodes grass contained higher P than lucerne at early part of the cutting stages but less in the later part. Ca:P ration increased with maturity, the peak being around 50 days growth period and the magnitude is higher in lucerne than Rhodes grass.

The crude protein content, organic matter digestibility and mineral contents of Rhodes grass reported in this paper are comparable to the earlier findings in Ethiopia (Evaldson, 1969), Uganda (Soneji et al, 1971; 1972) and Kenya (Said 1974; Abate et al, 1981). This work indicates that stage of maturity at cutting is the most important aspect to determine feeding value. Both yield and quality varied according to growing season. That the short rainy season produced forage of high yield and quality in this particular study may be due to higher maximum and minimum temperatures (Figure 2) more irradiation and sufficient rainfall condition (Figure 1). Work is going on at Kulumsa (Keftasa, unpublished) to demonstrate the practical application of these findings to adopt more frequent cutting systems in a year than the conventional single-cut in the main growing season.

Table 2. Neutral detergent fibre (NDF), Acid detergent fibre (ADF) ADF ash and Lignin contents of Rhodes grass and Lucerne at different cutting dates, wtih and without N-fertilization during the short rainy of season 1986.

N-fertilization 0=nil, +=46 kg/ha

Species	N-fert.	Harvesting date	Regrowth days	NDF	ADF	ADF ash	Lignin
				% DM			
Rhodes	0	4/3	17	62.7	33.0	7.6	3.8
Rhodes	+	4/3	17	58.3	30.4	7.8	4.0
Lucerne	0	4/3	17	31.1	27.2	0.6	5.1
Rhodes	0	12/3	25	61.1	30.6	6.7	3.7
Rhodes	+	12/3	25	61.0	30.9	6.0	3.6
Lucerne	0	12/3	25	30.9	28.8	ND	7.0
Rhodes	0	21/3	34	65.5	34.1	6.2	4.9
Rhodes	+	21/3	34	62.4	32.4	5.2	3.6
Lucerne	0	21/3	34	31.8	26.8	0.3	5.3
Rhodes	0	31/3	44	67.0	35.3	5.4	4.5
Rhodes	+	31/3	44	65.3	36.2	5.4	4.1
Lucerne	0	31/3	44	34.9	27.5	ND	5.3
Rhodes	0	9/4	53	70.6	36.7	4.5	4.4
Rhodes	+	9/4	53	69.1	38.1	5.7	5.0

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Table 2. Neutral detergent fibre (NDF), Acid detergent fibre (ADF) ADF ash and Lignin contents of Rhodes grass and Lucerne at different cutting dates, wtih and without N-fertilization during the short rainy of season 1986.

N-fertilization 0=nil, +=46 kg/ha

Species	N-fert.	Harvesting date	Regrowth days	NDF	ADF	ADF ash	Lignin
				% DM			
Lucerne	0	9/4	53	38.5	31.0	0.5	6.5
Rhodes	0	28/4	72	72.9	40.5	4.4	4.7
Rhodes	+	28/4	72	68.2	39.0	6.2	5.9
Lucerne	0	28/4	72	41.6	31.9	ND	7.1
Rhodes	0	7/5	81	17.8	41.2	5.0	5.6
Rhodes	+	7/5	81	72.0	40.9	4.4	5.2
Lucerene	0	7/5	81	41.5	31.6	0.5	7.4
Rhodes	0	17/5	91	71.7	41.1	3.9	4.8
Rhodes	+	17/5	91	73.6	4.26	4.0	5.5
Lucerene	0	17/5	91	41.4	31.3	ND	7.4
Rhodes	0	27/5	101	74.3	40.4	5.1	5.9
Rhodes	+	27/5	101	75.9	42.3	5.2	5.6
Lucerne	0	27/5	101	43.4	32.3	0.2	7.7

Table 3. Total ash, Phosphorus, Calsium, Potassium Magnesium and Sodium contents of Rhodes grass and lucerne at different cutting dates, with and without N-fertilizations during the short rainy season of 1986.

N-fertilization 0=nil +=46 kg N/ha

Species	N-fert	Harvesting date	Regrowth day	Ash	P	Ca	K	Mg	Na ppm
				% of DM					
Rhodes	0	4/3	17	18.0	.55	.54	2.82	.20	128.6
Rhodes	+			16.7	.45	.59	3.60	.22	141.1
Lucerne	0			13.2	.44	1.53	4.15	.25	127.0
Rhodes	0	12/3	25	15.8	.48	.55	3.32	.18	102.1
Rhodes	+			14.5	.40	.43	3.72	.19	87.4
Lucerne	0			15.2	.42	1.08	4.71	.25	117.8
Rhodes	0	21/3	44	14.3	.43	.41	3.21	.16	112.6
Rhodes	+			15.2	.28	.60	3.72	.19	93.5
Lucerne	0			12.3	.28	1.19	4.31	.22	110.8
Rhodes	0	31/3	53	12.4	.40	.51	1.38	.13	75.1
Rhodes	+			13.8	.22	.58	3.49	.17	86.1
Lucerne	0			12.4	.25	2.19	3.54	.22	113.0
Rhodes	0	94/4	62	11.6	.23	.50	2.49	.14	93.9
Rhodes	+			13.1	.25	.55	2.54	.19	77.2

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Table 3. Total ash, Phosphorus, Calsium, Potassium Magnesium and Sodium contents of Rhodes grass and lucerne at different cutting dates, with and without N-fertilizations during the short rainy season of 1986.

N-fertilization 0=nil +=46 kg N/ha

Species	N-fert	Harvesting date	Regrowth day	Ash	P	Ca	K	Mg	Na ppm
				% of DM					
Lucerne	0			12.2	.23	1.66	2.90	.19	103.8
Rhodes	0	28/4	72	10.8	.34	0.40	2.20	.11	72.2
Rhodes	+			12.6	.31	.50	2.06	.12	62.4
Lucerne	0			11.3	.25	2.07	2.74	.20	71.1
Rhodes	0	7/5	81	10.7	.28	.36	2.14	.11	58.8
Rhodes	+			10.6	.28	.31	2.21	.11	56.6
Lucerne	0			11.6	.25	1.52	2.65	.18	99.2
Rhodes	0			9.9	.18	.37	2.09	.10	72.0
Rhodes	+			9.8	.15	.34	2.17	.10	49.5
Lucerne	0			10.9	.21	1.56	2.64	.21	124.5
Rhodes	0	27/5	101	10.4	.21	.34	1.52	.10	70.1
Rhodes	+			9.7	.15	.37	1.55	.10	59.3
Lucerne	0			10.3	.24	1.40	2.56	.19	48.30
		Means ± SD							
Rhodes No				12.6±2.8	0.35±0.13	0.44±0.08	2.46±0.57	0.14±0.04	87.3±13.3
Rhodes N_+				12.9±2.5	0.28±0.10	0.47±0.11	2.78±0.85	0.15±0.04	79.2±27.9
Lucerne N_o				11.9±0.9	0.29±0.08	1.58±0.36	3.35±0.84	0.21±0.03	101.7±26.0

Table 4. DM yield, crude protein content, organic matter digestibility and metabolizable energy contents of Rhode grass and lucerne at different cutting dates with and without N-fertilization during the, main rainy season, of 1986.
N-fertilization 0=nil; + = 92 kg N/ha)

Species	N-fert.	Harvesting date	Regrowth days	DM yield kg/ha	CP %	OM dig %	Estimated ME MJ kg Om	Botanical stage
Lucerne	0	29/7	14	1280	30.1	82	11.6	100% leafy
Lucerne	0	8/8	24	1650	30.8	78	11.2	100% leafy
Rhodes	0	18/8	34	1200	8.8	69	9.7	100% leafy
Rhodes	+	18/8	34	2140	10.0	74	9.9	100% leafy
Lucerne	0	18/8	34	2100	22.7	76	11.0	100% leafy
Rhodes	0	6/9	43	1860	6.7	65	8.5	10% heading
Rhodes	+	6/9	43	3460	8.0	68	9.0	10% heading
Lucerne	0	6/9	43	2223	21.3	74	10.8	20% flowering
Rhodes	0	16/9	53	1980	6.5	62	8.0	15% heading
Rhodes	+	16/9	53	3840	6.9	68	9.0	15% heading
Lucerne	0	16/9	53	2471	22.2	73	10.7	30% flowering
Rhodes	0	26/9	63	2150	5.1	65	8.5	50% heading
Rhodes	+	26/9	63	4220	6.6	66	8.7	50% heading
Lucerne	0	26/9	63	2250	22.6	74	10.8	40% flowering
Rhodes	0	6/10	72	2260	5.3	65	8.5	90% heading
Rhodes	+	6/10	72	5680	6.0	68	8.2	90% heading
Lucerne	0	6/10	72	2500	18.8	68	10.1	40% flowering

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Table 4. DM yield, crude protein content, organic matter digestibility and metabolizable energy contents of Rhode grass and lucerne at different cutting dates with and without N-fertilization during the, main rainy season, of 1986.

N-fertilization 0=nil; + = 92 kg N/ha)

Species	N-fert.	Harvesting date	Regrowth days	DM yield kg/ha	CP %	OM dig %	Estimated ME MJ kg Om	Botanical stage
Rhodes	0	17/10	83	2400	4.5	61	7.9	Anthesis
Rhodes	+	17/10	83	5880	5.9	65	8.5	Anthesis
Lucerne	0	17/10	83	1420	18.8	67	10.0	50% flowering
Rhodes	0	28/10	94	1760	4.1	66	8.7	Seed maturity
Rhodes	+	28/10	94	4900	3.7	57	7.2	Seed maturity
Rhodes	0	10/11	107	1800	4.3	61	7.9	Seed maturity
Rhodes	+	10/11	107	4970	3.0	58	7.4	Seed maturity

Mean ± SD				
Rhodes N_o	1936±368	5.7±1.6	64±2.8	7.4±0.43
Rhodes N_+	4386±1239	6.3±2.2	65±5.6	8.5±0.89
Rhodes N_o	2112±433	23.4±4.6	73±6.3	10.8±0.53

Table 5: Neutral detergent fibre (NDF), Acid detergent fibre (ADF) ADF ash and lignin contents of Rhodes grass and lucerne at different cutting dates, with and without N-fertilization during the main rainy season, of 1986.

Species	N-fert.	Harvesting date	Regrowth days	NDF	ADF	ADF ash	Lignin
				% of DM			
Lucerne	0	29/7	14	32.9	28.9	0.24	4.8
Lucerne	0	8/8	24	35.5	28.3	0.22	5.4
Rhodes	0	18/8	34	68.9	39.1	6.6	4.5
Rhodes	+	18/8		65.3	37.4	3.5	4.5
Lucerne	0	18/8		37.2	31.6	ND	5.9
Rhodes	0	6/9	43	69.1	38.5	8.2	4.1
Rhodes	+			68.4	37.5	5.0	4.1
Lucerne	0			36.4	29.3	0.29	5.9
Rhodes	0	16/9	53	69.2	27.6	7.6	4.2
Rhodes	+			70.4	37.7	3.6	3.7
Lucerne	0			39.8	31.2	ND	7.2
Rhodes	0	26/9	63	70.0	37.4	7.0	4.3
Rhodes	+			71.2	37.7	4.3	4.1
Lucerne	0			40.8	31.4	ND	7.0
Rhodes	0	6/10	72	70.4	37.7	7.0	4.2
Rhodes	+			72.7	39.4	5.2	4.9
Lucerne	0			45.2	31.4	ND	7.6
Rhodes	0	17/10	83	68.3	37.7	8.5	4.8

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Table 5: Neutral detergent fibre (NDF), Acid detergent fibre (ADF) ADF ash and lignin contents of Rhodes grass and lucerne at different cutting dates, with and without N-fertilization during the main rainy season, of 1986.

Species	N-fert.	Harvesting date	Regrowth days	NDF	ADF	ADF ash	Lignin
							% of DM
Rhodes	0			59.9	39.7	4.6	5.1
Lucerne	-			46.6	37.9	ND	8.0
Rhodes	0	28/10	94	65.5	36.3	8.6	4.4
Rhodes	+			72.5	43.2	4.9	5.7
Rhodes	0	10/11	107	67.0	37.9	8.6	5.0
Rhodes	+			71.6	41.3	6.0	5.5
Mean $\pm$ SD							
Rhodes N_o				68.6$\pm$1.6	37.8$\pm$0.8	7.8$\pm$0.8	4.4$\pm$0.3
Rhodes N_+				70.3$\pm$2.4	39.2$\pm$2.1	4.6$\pm$0.8	4.7$\pm$0.7
Lucerne No				39.3$\pm$4.76	31.3$\pm$3.0	-	6.5$\pm$1.1

Table 6. Total ash phosphorus calcium, potassium, magnesium and sodium contents of Rhodes grass and lucerne at different cutting dates with and without N-fertilization during the main rainy season of 1986.

Species	N-fert.	Harvesting	Regrowth	Ash	P	Ca	K	Mg	Na
		date	days			% of DM		ppm	
Lucerne	0	29/7	14	12.9	.64	1.47	5.16	.27	89.4
Lucerne	0	8/8	24	12.6	.48	1.71	4.80	0.26	98.1
Rhodes	0	18/8	34	13.5	.51	.54	2.02	.13	31.3
Rhodes	+	18/8		12.9	.50	.48	3.26	.19	64.5
Lucerne	0	18/8		11.4	.33	2.25	3.75	.23	136.9
Rhodes	0	6/9	43	12.9	.55	.51	1.88	.13	49.4
Rhodes	+	6/9		10.8	.45	.50	2.78	.14	52.1
Lucerne	0	6/9		11.6	.23	2.75	3.05	0.21	133.0
Rhodes	0	16/9	53	14.2	.54	.51	1.57	.13	34.4
Rhodes	+	16/9		10.6	.45	.44	2.62	.12	50.4
Lucerne	0	16/9		11.3	.28	2.47	2.62	.22	122.3
Rhodes	0	26/9	63	13.2	.52	.51	1.81	.13	48.9
Rhodes	+	26/9		10.6	.35	.47	2.15	.13	49.3
Lucerne	0	26/9		9.9	.32	2.17	2.50	.21	95.0
Rhodes	0	6/10	72	12.4	.42	.51	1.68	.10	8.1
Rhodes	+	6/10		10.9	.33	.50	2.03	.11	31.1
Lucerne	0	6/10		9.0	.26	1.93	2.35	.19	43.3
Rhodes	0	17/10	83	14.1	.45	.61	1.63	.14	13.8

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Table 6. Total ash phosphorus calcium, potassium, magnesium and sodium contents of Rhodes grass and lucerne at different cutting dates with and without N-fertilization during the main rainy season of 1986.

Species	N-fert.	Harvesting	Regrowth	Ash	P	Ca	K	Mg	Na
		date	days	% of DM				ppm	
Rhodes	+	17/10		11.0	.30	.54	2.42	.12	36.2
Lucerne	0	17/10		8.5	.28	1.61	2.70	.19	151.9
Rhodes	0	28/10	94	15.4	.47	.58	1.77	.15	13.1
Rhodes	+			10.1	.29	.42	1.84	.12	22.2
Rhodes	0	10/11	107	15.3	.30	.61	1.55	.15	11.9
Rhodes	+	10/11		11.0	.29	.54	1.79	.12	27.0
Means ± SD-Rhodes N_o				13.88±1.08	0.47±0.08	0.55±0.05	1.73±0.13	0.13±0.02	26.4±16.9
Rhodes N_+				10.99±0.83	.37±0.08	0.49±0.04	2.34±0.50	0.13±0.03	43.7±14.5
Lucerne N_o				10.90±1.61	0.35±0.14	2.05±0.44	3.37±1.09	0.21±0.04	108.7±34.6

DISCUSSION

Various field studies and laboratory analyses concluded that the existing feedstuffs in Ethiopia, native pastures and crop residues, are poor in quality thus providing inadequate protein, energy, vitamins and minerals. In certain areas where improved forage crops are introduced farmers fail to utilise them at the optimum developmental stage when the herbage is high in quality to satisfy livestock needs and support production. One reason for this failure is lack of strong extension support in adopting the recommended practices.

In Ethiopia the Institute of Agricultural Research (IAR) with the began research on crops, livestock and forages began in 1966. IAR's broad objective was the formulation of a national policy for agricultural research which should be within the framework of the country's central plan. This national policy for agricultural research should then be to implement through co-ordinated programmes of applied research. Soon after the establishment of IAR, the Chilalo Agricultural Development Unit (CADU), the first comprehensive pilot project, was established in Arsi region in 1967 under the Ministry of Agriculture (MOA). CADU undertook various research programmes in cattle cross-breeding of cattle and forage evaluation in addition to the extension programme. As a result of the effort of these two major institutions in forage research, it has been possible to recommend a number of forage species and their cultural practices for different ecological zones of Ethiopia (Lulseged Gebre-Hiwot and Tadesse, 1985).

Agricultural extension was initiated since the 1950s. The Ministry of Agriculture has been the main organisation responsible for organising, giving advice and assistance as well as services to the peasant sub-sector. Within the Ministry today, departments for animal breeding and feed resources development are directly concerned with introduction and utilisation of improved forage crops.

The Animal Breeding and Feed Resources Development Department through its various projects (e.g. Fourth Livestock Development Project, FLDP) promotes forage development, introduction of improved forages crops and management techniques, forage seed production on farmers fields (on contract basis), adaptive research and training of farmers and development agents. The Soil Conservation Development Department multiplies seeds of grasses and multipurpose forage shrubs on nursery sites and undertakes plantations on catchment sites. The two departments work in close co-operation.

At the field level the linkage between research and extension has been weak in general and worse in the fields of livestock and forage development. To promote the research extension linkage certain measures have been taken in crop production, such as IAR/MOA joint research programmes, farming system research (on-farm trials) and research-extension liaison committees of which none is involved in livestock/forage fields. Although there are development agents on over 2000 centres (FAO, 1985), quite a small propotion (in terms of time or resource allocation is working in this field) indicates that there is less emphasis on livestock and forage development. The current research and extension systems focus mainly on improving of major cash crops (cereals, pulses, oil crops, cotton and coffee) with little integration with the livestock subsystem in such areas as forage legume-based crop rotation, alley cropping, etc.

There is an acute shortage of forage seeds in the country. There is still no agency responsible for production and certification of forage seeds. There are some forage seed production programmes within the MOA at the South-Eastern Zonal Office for Agricultural Development (ex CADU), FLDP and soil conservation nurseries. However, production has been much below the requirements. There is considerable demand for forage seeds for planting at state-owned cattle breeding stations dairy development and beef production enterprises as well as dairy co-operatives and individual smallholders who own upgraded dairy cows. Utilisation of improved forage crops at the smallholder level has not been successful due to low return to local zebu cattle and competition for scarce land and labour. At present the use of fertilizers on pasture lands remains to be questionable due to limited availability, low level of credit services and capital investment. FAO (1985) reported that only 14% of Ethiopia farmers used fertilizers (8.76 kg/farmer) but that only 2% use improved seeds (food crops). In Arsi region where research and extension programmes have been relatively more effective, the corresponding figures were 47% (31.75 kg farmer) and 21% fertilizers and improved seeds respectively.

Experience in Arsi region shows that small-scale farmers and farmers' co-operatives who own cross-bred dairy cows adopted favourably forage production. Oats/vetch mixtures, fodder beet and Rhodes grass are planted about 600 ha of land every year with dry matter production/ha comparable to state-owned dairy and cattle breeding farms. Any recommended package related to improved forage crops may need to be accompanied by improvement of the existing low producing animals otherwise the package may not be economical.

The introduction of the training and visit extension system is expected to improve the currently weak research-extension linkages through regular training of development agents who visit farmers frequently and regularly to pass on relevant technical messages and also bring back farmers' problems to researchers. The integration of forage development with soil conservation is expected to reduce competition for arable land and help to develop a good landuse system. Emphasis should be placed on forage legumes for a sound integration of forage production in cereal crop rotation systems requiring minimum inorganic fertilizer input particularly at smallholder level. The success of forage production in Ethiopia would be measured through its incorporation into dairy and beef production programme.

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PASTURE RESEARCH CONDUCTED IN NIARI VALLEY RANCHES

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ABSTRACT

Almost thirty years ago the government of the Congo established five large ranches covering a total area of 80,364 ha in the Niari valley. In December, 1986 the estimated livestock population was 32,200 head constituting 45% of the total cattle population in the Peoples Republic of the Congo. Over the past few years changes in the vegetation cover of the ranches, probably due to mineral deficiencies, have been observed. Consequently, tests were conducted on the vegetation cover of the ranches between 1975 and 1987 to collect scientific data with a view to improving the management of these important forage resources and increasing animal growth.

The tests revealed that - the mean above-ground biomass was 20 kg/DM0.01 ha (2000 kg DM/ha) during the month of December. It increased rapidly between January and May, reaching a maximum yield in June-July.

- Optimum mean above-ground biomass yield varied between 80 and 135 kg DM0.01 ha (8000 and 13500 kg DM/ha) . There was a significant difference between the mean biomass yield of Louboula ranch ($P<0.001$) and the other four ranches at Massangui, Louamba, Lolila and Dihesse.

- the relation between volume (x) and biomass (y) is expressed by the equation.

$$y = 0.51x + 25.19 \quad (r = 0.56,\ P<0.05)$$

These results were particularly useful in the production of forage potential maps to be used by ranch managers.

Tests conducted on mineral nutrient contents of forages, mineral block licks, and maize bran in the valley showed that:

- the iron and management contents, of forages were satisfactory and the cobalt contents were within the desired limits. Copper and zinc contents however, were well below the desired limits.

- the copper, zinc and manganese contents of the maize bran were high. Consequently the distribution of maize bran and mineral block licks as remedial measures against copper and zinc deficiencies was recommended.

There was a need, identified, that micro-elements contents of the blood plasma and hair of animals should be tested.

INTRODUCTION

Environment

The Niari valley, located on Scisto calcareous rock outcrops is part of the Niari river basin, which covers some 15,000 km^2 extending from 12^{o}30' and 14^{o}00'E longitude and 2^{o}30' and 4^{o}30'S latitude (Figure 1). The valley receives 1100 to 1400mm rainfall between October and May and experiences a marked drop in the amount of rainfall in January and February. Between May and October, there is a long dry season.

Mean annual temperature is 24^{o}C and mean relative humidity is 83%. Using the French soil classification system, soils of the study areas may be classified as:

- ferralitic soils
- poorly evolved mineral soils;
- hydromorphic mineral soils.

Soil analytical tests done on these soils in the study ranches revealed, a soil texture ranging from fine to very fine, organic matter content of 3.5%, and mean pH of 5.0.

The vegetation consists of intermediate forest (Koechlin, 1961) but savanna grasses, Hyparrhenia diplandra, Schizachyrium platyphyllum and Annona arenaria are predominant species.

Research conducted

Changes in the vegetation cover were observed and mineral deficiencies in the cattle herds were observed for several years. Consequently, tests were conducted on the herbaceous cover during the 1975 and 1987 period to collect basic data with a view to monitoring these forage resources, ensuring more efficient management, diagnosing mineral deficiencies and identifying ways of alleviating these deficiencies. The tests focussed on:-

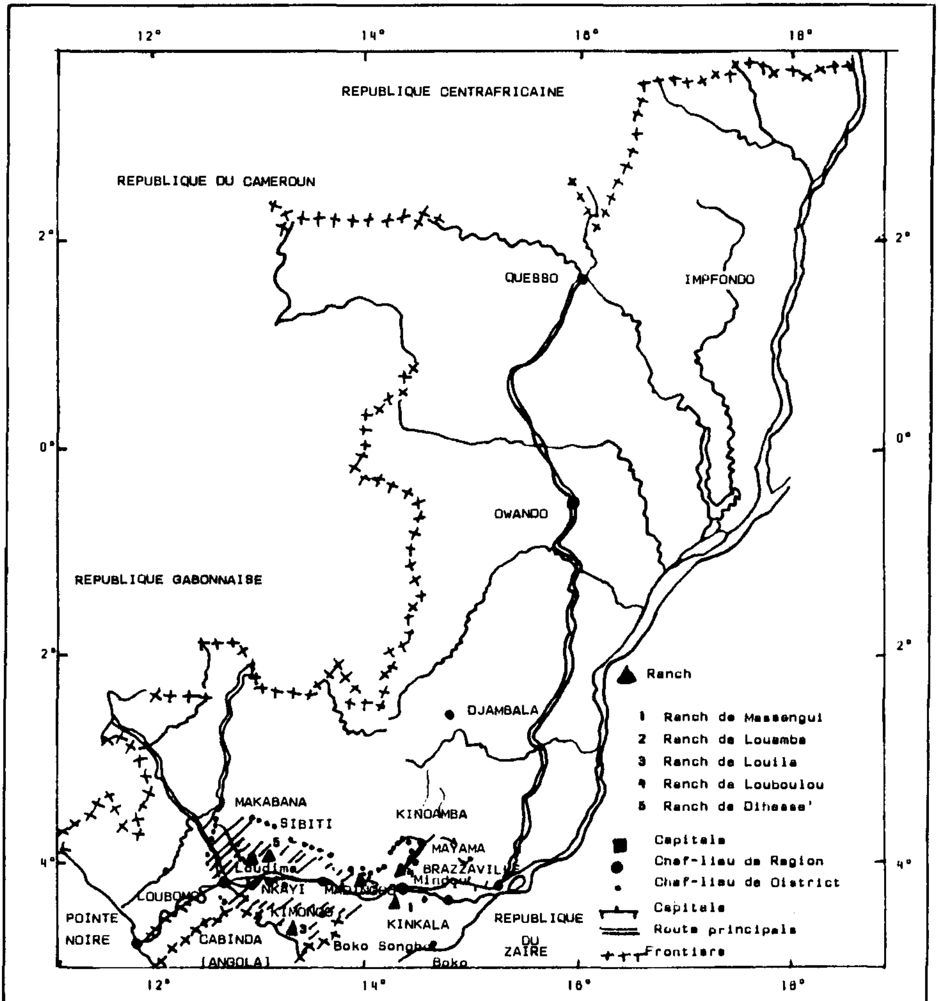
- herbage above ground biomass and volume
- micro-element contents of forages, mineral block licks and maize bran produced in the region

STUDY METHODOLOGY

Estimation of dry matter yield

Biomass is the weight of living organisms per unit area (Touffet, 1982). Estimates of biomass were made on 406 stations covering the five ranches (Massangui, Louamba, Louboulou and Dihesse). The study was preceeded by observations of above ground biomass variation in several stations.

Figure 1: Location of the ranches in the Niari Valley



Echelle: 1/5.000.000

0 250 500 km

The above-ground biomass of the grass cover was measured using the cut-and-carry method (Faye et al, 1986). Dry matter vegetation was harvested from two 1m^2 quadrats and samples were cut at a 2.5cm stubble height. Fresh weight was recorded and dry weights, after oven-drying at 85^{o}C for 24 hrs were also recorded. A mean biomass (in kilograms of dry matter) per hectare for each station was then calculated.

Estimation of volume

Volume was expressed as the product of size of biomass in m^3/ha for each station. Forage samples were obtained from three topographical locations in the Dihesse ranch (slope, depression, flat terrain). Samples of mineral salt (block licks) were obtained from Dihesse ranch and from stocks of the Direction General de Office du Gros Betail (OGB) in Brazzaville.

Analyses of soil samples were carried out at the ORSTOM Centre in Brazzaville. The macro-elements contents were determined by the Soils and Vegetation Laboratoire of the Centre de Cooperation International en Recherche Agronomic pour le Development (CIRAD) in Montpellier, France. Determinations of micro-elements contents of forages, mineral block licks and maize bran samples were done at the Institut d'Elevage et de Medecine Veterinaire des pays Tropicaux (IEMVT) in Maison Alfort, France.

Statistical analyses of biomass and volume data were done on the Apple Microcomputer with softwares developed by Professor Cusset of the laboratoire de Phytologie Quantitative, at the Pierre and Marie Curie University in Paris. Correlations between biomass and volume were calculated on the Boss microcomputer with softwares developed by Moukoko and Dimi of Mathematics Department of Marven Ngouabi University, Brazzaville.

RESULTS AND DISCUSSION

Figure 2 shows the growth cycle of forages at Dihesse ranch. The mean December biomass was estimated at 20 kg DM/0.01 or 2000 kg DM/ha and rapidly increased between January and May. It reached a maximum growth in June-July when mean biomass ranged between 80 to 95 kg DM/0.01ha depending on the year. Although not shown in this graph, it was observed that biomass decreased considerably from the latter half of July. Consequently, it appeared that the optimal biomass correspond with the flowering/fruiting periods of the dominant perennial grass species.

Optimum biomass for all the ranches are given in Table 1. A comparison of the means using the poisson test (Table 2) shows a significant difference between above-ground biomass of the grass cover at Louboulou ranch and biomass of the other four ranches. Based on these data it is clear that the optimum biomass differences could be used for estimating the carrying capacities of the ranches (Boudet, 1978). The carrying capacity of a unit area of pasture is the maximum stocking rate possible which the unit can support without irreversible deterioration. Within the framework of management and rotational utilisation of pastoral resources this definition of capacity is of real practical interest. Consequently, with the assistance of the Institut d'Elevage et de Medecine Veterinaire de pays Tropicaux potential maps of each ranch were produced (Diamouangana, 1988; Diamouangana and Kiyidou, 1983; Diamouangana et al 1984). If allowance is made of biomass losses during the dry season, due to trampling and the need to maintain some ground cover to protect soil from various agents of erosion, it could be estimated that about one-third of the palatable above-ground biomass is consumed annually. Also if we adopt the tropical livestock unit (TLU) of 250 kg at maintenance with a daily consumption rate of 6.25 kg of dry matter, then the carrying capacity estimates vary between 1 and 2 TLU/ha. So far estimates of carrying capacity have been theoretical and several tests will have to be done. Boudet (1978) suggested that these tests should focus on the condition of the herds which should not suffer excessive weight losses during the dry season and should have the capacity for rapid compensatory weight gain once the rainy season starts.

Figure 2. Above-ground herbaceous biomass over time for 20 samples in the Dihesse Ranch during 1975 and 1976-7

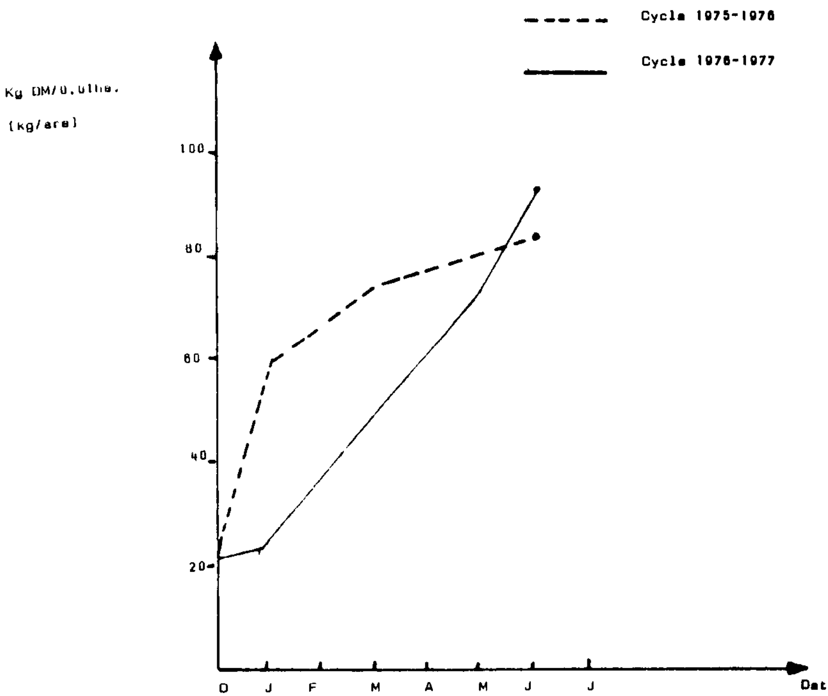


Table 1. Analysis of variance in dry matter yields (kg DM/ha) of the grass cover of the ranches

Ranches	Massangui	Louamba	Louila	Louboulou	Dihesse
No of stations	69	80	80	79	94
Mean yield	93.7	89.0	80.0	134.8	94.9
Variance	1543.9	1206.6	513.0	2168.3	1488.8
Standard deviation	32.29	34.73	22.65	46.56	38.58
Confidence interval	95%	+77.0	+44.39	+91.25	+75.61
	99%	+101.36	+58.44	+120.12	+99.63

Table 2. Comparison of mean dry matter yields in kg DM/ha of the herbage in the ranches (Polssons test)

Ranches	Massangui	Louamba	Louila	Louboulou	Dihesse
Massangui	1.00	0.77NS	2.55*	5.82***	0.19NS
Louamba	0.77 ns	1.00	1.94 NS	7.02***	1.19NS
Louila	2.55*	1.94 NS	1.00	2.55*	3.16**
Louboulou	5.82***	7.02***	9.42***	1.00	6.06***
Dihesse	0.19NS	1.19NS	3.16**	6.06***	1.00

Descoing (1976) noted that volume, the function of area covered by mass could be calculated quite easily in the field, and that the major constraint in its calculation was inadequate knowledge of the vegetation. By establishing coefficients of correlation between volume and biomass, the biomass can be correlation between volume and biomass, the biomass can be calculated from the volume which is more easily obtained. Figures 3 gives the line of regression of volume and standing biomass and the coefficients of correlation. The relation between volume and biomass was studied by trying out various permitations of simple mathematical models. The linear function, by its very simplicity proved to be most appropriate.

Mineral composition of forages

The mean mineral contents of forages at Dihesse ranch are given in Table 2. Several authors (Faye and Grillet, 1984; Faye et al, 1986; Lamand, 1972; Lamand, 1979) have considered such analyses of forages to be correct. The deficiency limits for forages and other fodder crops were established by Conrad et al (1985), Faye and Grillet (1984), Faye et al (1986) and Lamand (1972, 1979) as follows:

Cobalt	:	0.07 ppm of DM
Copper	:	7.00 ppm of DM
Zinc	:	45.00 ppm of DM
Manganese	:	45.00 ppm of DM
Iron	:	50.00 ppm of DM

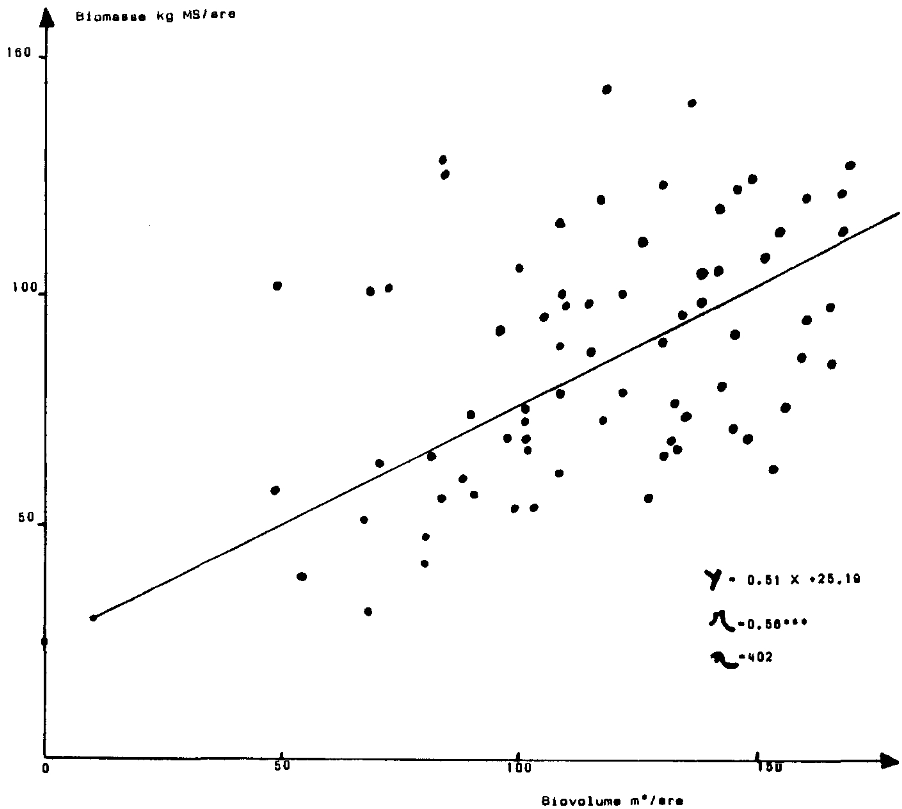
The iron and manganese contents in the current study were satisfactory. The cobalt contents were within the accepted deficiency limits but those of copper and zinc were well below the deficiency limits.

Chemical composition of mineral block licks

Block licks distributed in the Niari valley ranches were in the form of rock salts obtained from the Tchitondi (House) potash deposits (Table 3). The sodium content of both samples was between 30% and 40% of dry matter. They were extremely deficient in calcium, potassium, magnesium and phosphorus. The iron contents were satisfactory, but cobalt, copper, zinc and manganese contents were well below the deficiency limits.

Figure 3. Relationship between volume and above-ground herbaceous biomass.

***: Highly significant at P>0.001
n: Number of samples
(Data in kgDm/0.001)



able 3. Cobalt, copper, manganese and iron contents of forages in Dihese ranch during the 1977-78 vegetation cycle in ppm (Serre, 16.17).

Sample locations	Cobalt	Copper	Zinc	Manganese	Zinc
1	0.04	3.5	22.5	179.4	96.4
2	0.11	3.7	20.1	181.5	101.8
3	0.03	3.6	19.7	258.3	68.7
Mean and					
standard deviation	0.06	3.6	20.7	206.4	88.9
	+0.04	+0.39	+1.51	+44.95	+17.75
In depression					
1	0.04	2.7	19.7	169.9	54.9
2	0.03	2.7	20.6	191.6	62.7
3	0.10	2.1	47.7	211.6	96.7
Mean and	0.056	2.5	29.3	191	71.4
standard deviation	+0.03	+0.34	+15.91	+20.86	+22.22
On flat terrain					
1	0.08	3.6	23.1	185.7	324.7
2	0.15	3.3	23.4	213.8	468.0
3	0.06	2.4	15.8	167.0	149.5
Mean and	0.09	3.1	20.7	188.8	314.0
standard deviation	+0.05	+0.62		+23.55	+159.51
Instory laterit zone					
1	0.09	3.5	25.8	134.2	443.4
2	0.07	3.5	23.0	201.0	290.0
3	0.06	3.7	19.5	374.9	294.0
Mean and	0.07	3.6	22.7	236.7	443.4
standard deviation	+0.01	+0.12	+3.15	+124.25	+87.43

The mineral composition of maize bran produced by the Nyaki cattle feeds mill and popularly used in the Niari valley ranches is shown in Table 4. These compositions can be considered as satisfactory for calcium, phosphorus, magnesium, potassium, copper, zinc, manganese and iron. The content of cobalt was unsatisfactory.

Table 4. Chemical composition of maize bran produced by the Nkayi catte feed mill

Elements on % DM basis	Fine maize bran	Remulled maize bran
% of dry matter		
Organic matter	93.77	94.33
Total protein content (N x 6.25)	18.98	17.64
Row cellulose	11.88	11.51
Fat content (ether exitract)	3.56	2.59
Nitrogen free extracts	59.35	62.59
Total mineral matter (ashes)	6.23	5.67
Insoluble hydrogen chloride	0.07	0.07
Calcium	0.13	0.12
Phosphorous	1.39	1.24
Magnesium	0.45	0.38
Potassium	1.38	1.24
Trace-elements (zn ppm)	11.70	12.10
Copper	0.03	0.03
Cobalt	90.50	86.10
Zinc	65.40	65.40
Iron	101.00	

Table 5. Chemical composition of block licks

Elements on % DM basis	Sample 1	Sample 2
% 100 dry matter		
organic matter	-(*)	0.76
Minerals (Ashes)	-(*)	99.24
Insoluble hydrogen chlorides	-(*)	0.03
Calcium	0.11	0.02
Phosphorus	0.00	0.06
Magnesium	0.04	36.91
Potassium	0.11	
Sodium	39.00	
Trace-elements (in ppm)		
Cobalt	-(*)	0.02
Copper	1.50	11.80
Zinc	1.30	3.50
Manganese	13.80	5.90
Iron	69.00	211.00

GENERAL CONCLUSIONS

The above ground biomass of forages in the ranches varied between 80 and 135 kg DM/0.01 ha, which production is comparable to that of the savanna grassland of Lamto in the Ivory Coast (Cesar, 1981; Fournier, 1987). The theory of correlation between volume and biomass may be considered proven and biomass can therefore be estimated using the equation derived.

$$Y = 0.51x + 25.19$$

where y is biomass (kg DM/ha)
and x is volume (M^3 DM/ha)

Tests on micro-elements contents of forages in the Niari valley although in their early stages show that cobalt, copper and zinc contents are below the desired limits. Research on trace element deficiencies should be more comprehensive and involve the animal itself by evaluating the amount of micro-elements such as molybedenum and selemium in the blood plasma an hair. This study is relevant in identifying problems in forages and feed resources in real world animal production systems.

The chemical composition of the mineral block licks from the Tchitondi region was considerably varied and appeared to be extremely deficient in cobalt, copper, zinc and manganese. The macro-element contents (Calcium, phosphorus, magnesium and potassium) and micro-element contents (Copper, zinc and manganese) of the maize bran produced by the cattle feeds mill were extremely high. This makes maize bran as a mineral supplement product of major importance to livestock production in the Peoples Republic of the Congo.

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SOME CONSTRAINTS TO ADOPTION OF AGRO-BYPRODUCTS RESEARCH RESULTS BY THE COMMUNAL FARMERS OF ZIMBABWE

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ABSTRACT

Livestock in communal areas of Zimbabwe are dependent on natural veld during the rainy season and on crop by-products during the dry winter months. The main types of stovers available are from maize and sorghum, whilst groundnut hay is the main legume stover. However, the quantities produced, vis-a-vis the livestock numbers, are inadequate and thus need to be used judiciously. Adoption of technologies that would improve the utilisation of these feeds would benefit farmers communal areas. Very few of the farmers have adopted these technologies. Reasons for this lack of adoption include restricted flow of information, lack of cash to buy inputs, lack of appropriate processing equipment, low quantities of complementary crop residues and multiple roles of livestock. It is necessary that there is a great need for on-farm research and for researchers to interact directly with farmers to better appreciate their problems and resources.

INTRODUCTION

Communal area farmers are found mainly in natural regions 4 and 5 (Clatworthy, 1987). These areas are characterised by low and eratic rainfall (less than 500 mm per annum on average) and can have long spells of dry periods within the rainy season. In addition, the soils are poor and fragile. Livestock in these areas is mainly dependent on natural veld during the winter months (Sibanda, 1986). However, because of the soil types and rainfall patterns the amount and type of cropping varies greatly and so does the availability of crop residues. The main types of cereal stovers found in the areas are from maize and sorghum, whilst groundnut hay is the main legume stover found. The quantities of the stovers available can be estimated from grain production by assuming that the grain yields are equivalent to the stover yield. In 1987 the residues obtained in communal areas are reported as follows:

maize 2 million tonnes,
sorghum 80,000 tonnes,
soya beanstalks 2000 tonnes,
groundnut hay 70,000 tonnes,
Source: CSD, 1988

The livestock population in the communal areas, estimated by the Department of Veterinary Services, Ministry of Lands, Agriculture and Rural Resettlement, indicates that in 1987 there were about 3 million cattle, 1.6 million goats and about 260,000 sheep. As all this population would have to depend on crop residues for about 2-3 months of the year, it is apparent that the crop residues are inadequate and need to be utilised judiciously to achieve even a modicum of livestock production.

Crop residues are generally of low nutritive value to ruminant livestock because of high fibre and low nitrogen content and, consequently, low degradabilities in the rumen. There are notable exceptions like groundnut hay tops, sweet potato leaves and cottonseed hulls, to name a few. With some treatment, chemical or physical, the nutritive value of the residues can be improved (Mason and Owen, 1986). Supplementation with energy and/or protein sources without treatment has also been found to improve the nutritive value of stovers (Dixon, 1985; Ndlovu and Buchanan-Smith, 1985). In Zimbabwe several experiments on improving utilisation of crop by-products through physical treatment, chemical treatment and supplementation (Reynolds, 1984; Smith et al, 1987, Ndlovu and Manyame, 1987) have been done on station. The results from these trials have not yet been adopted by the farmers. Sibanda (1986) noted that even though the majority of farmers in communal areas now harvest stovers, very few supplement the stovers on feeding.

This paper aims to discuss some of the reasons that contribute to this anomalous situation where technology exists but is not utilised by the group most likely to benefit from it.

THE CONSTRAINTS

Restricted flow of information

Research in Zimbabwe is mainly carried out at research stations or the University, even though aimed at solving communal area problems. The flow of information from the researchers to the farmers is infinitely slow. Very few researchers report their results in publications anyway. Field days organised to show the public research in progress usually attract commercial farmers only. Thus there is a need for the researchers to communicate with the farmers, not necessarily through extension personnel.

Lack of cash to buy inputs

The resources available to the communal area farmers are limited and cash for livestock inputs is scarce. Urea, ammonia and other alkalis that can be used to treat crop residues are expensive. The probability of them being extensively used in communal areas without financial aid of one form or another is remote. Using ureas as a supplement at feeding would require smaller amounts and thus be cheaper than other forms of nitrogen supplementation. However, there is a real danger of poisoning the animals through excess urea. Hydration (Ndlovu and Manyame, 1987), even though inexpensive, can only be done in areas with abundant water supplies. Very few communal areas enjoy adequate water supplies.

Lack of appropriate processing equipment

Pre-feeding processing such as chopping and milling are known to improve the utilisation of crop residues. However, communal area farmers cannot afford to purchase and run power-driven machines. Production of hand and animal driven machines such as chaff-cutters would be beneficial. Presently these machines are not available.

Low quantities of complementary crop residues

Supplementation of cereal crop residues with legume hays would be an effective, simple and cheap way of improving the use of crop residues. However, this is constrained by the small quantities of legume hay produced in communal areas due to inadequate rainfall and poor soil types.

Multiple role of communal area livestock

Lastly, the aims of the communal area farmer vis-a-vis his livestock may not be conducive to adopting technologies that require extra input. Researchers, therefore, need to link technologies to improved crop production (and milk production) rather than improve animal *per se*. In Zimbabwe, most communal area farmers keep cattle primarily for draught and manure (Scoones and Wilson, 1988). Therefore, appealing to the farmers' own objectives would enable scientists to sell their technology.

CONCLUSION

It is concluded that restricted flow of information from scientists to farmers, the unsuitability of the technologies proposed and the nature of the message reaching the farmer are serious constraints to adoption of research results. There is a need for on-farm research and researchers serving as extensionists.

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IMPROVEMENT OF NITROGEN LEVEL IN RUMINANT'S DIET THE PROBLEM OF DISSEMINATION OF RESEARCH RESULTS ON UTILISATION OF UREA AND BROWSES AS NITROGEN SOURCES IN SAHELIAN FEEDING SYSTEMS

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ABSTRACT

The problem of protein supply for livestock traditionally-raised in the Sahel and the constraints to using urea and browse plants at the farmer's level has been highlighted.

In the case of utilising urea either as non-protein nitrogen source or as a reagent for low quality roughage treatment, the constraints involve its unavailability in rural areas, difficulty in handling this potentially toxic compound, water shortage and the low educational level of farmers in the Sahel.

The main constraints to browse utilisation are in relation to optimal range management and environment preservation. Some technical points such as selection of species, their secondary productivity and toxicity, remain to be clarified by more research.

The education of farmers is of major importance in the introduction of the new feeding techniques.

INTRODUCTION

Bioclimatic constraints are still the main limiting factor to availability of feeds for ruminants in the Sahel.

The dissemination of available research results which propose well-adapted solutions to these constraints is of particular urgency.

Cereals and high energy nitrogen concentrates remain costly not to mention problems of transport and of competition for livestock with alternative usages. Some agro-industrial by-products with high nutritive value are exported consequently making their availability scarce.

In Sahelian countries, therefore, ruminant feeding systems are naturally based on natural pastures and low quality roughages like cereal straws which are good sources of cellulose but low in digestible nitrogen (see Table 1). Chemical and/or physical treatment including nitrogen, energy and mineral supplementation are indispensable for optimal utilisation of low quality roughages.

Among nutritional constraints, protein deficiency appears to be one of the most important. Protein sources are expensive and some proposed solutions involving utilisation of oil meals and cereal brans seem to have poor applicability for large-scale extensive livestock production. Therefore urea and browse plants could be used as locally available and cheaper nitrogen sources.

For more than 50 years, research work on protein in the nutrition of ruminants has identified urea as the most promising chemical for cereal straw quality improvement and non-protein nitrogen supplementation (Jackson, 1979; Sundstol, 1984). However the dissemination of research results concerning African traditional livestock have been poor.

Browse plants are other readily available sources of protein in pastures. During the dry season, browse plants could constitute as high as 50% of the diet of cattle. In the case of small ruminants browse plants could constitute around 80% of their diet (Guerin et al, 1985) when grazing. The available information describes the nutritive value of trees and shrubs; their high protein content and aptitude to enhance nitrogen level of the diet of ruminants is emphasised (Le Houerou, 1980; Kone, 1987; Fall, 1988). Urea supplementation and browses can therefore be used to reduce nitrogen deficiencies and improve livestock productivity in the Sahel.

My objectives are to (1) highlight several considerations linked with practical dissemination of research results, (2) identify constraints and (3) propose some solutions for making nitrogen supplementation to low quality fodder using urea and browse plants possible at the farmer's level and finally (4) to indicate priority areas in making such on-farm research investigation.

CONSTRAINTS TO ON-FARM UREA UTILISATION IN SAHELIAN COUNTRIES

Urea for nitrogen supplementation in the ruminant's diet. Urea availability (Table 2).

In most of the Sahelian countries urea is not locally produced. This chemical is imported and widely used as fertilizer. In Senegal, around 10,000 t/year are imported and manufactured for fertilizer production. This quantity is below the national requirement for soil improvement and urea usage in livestock feeding could increase the deficit.

The Government's subsidy is decreasing from year to year; the objective being to encourage private initiative but resulting in a decrease in urea distribution, availability and cost of urea are major constraints to popularisation of urea production. Both livestock and the soil need greater quantities of urea for their improvement.

The question is whether urea supplementation is feasible and profitable for extensive livestock production. On-farm trials coupled with economics studies are needed.

Table 1. Urea availability and cost in Senegal (Tons)

	1986	1987	1988
Total requirement for soil improvement (tons)	-	17000	17000
Imported quantities (tons)	-	10000	8000
Price (tax free) CFA* kg	60	60	60
Government contribution CFA* kg	24	16	8
Dakar price CFA/kg	70	70	70
Rural market price CFA*/kg	75	70	75
Requirement for ruminants supplementation	-	-	171550

* 298 CFA = 1 US$ (1988)

Source: Ministry of Rural Development (personal communication)
Our estimation: 20 g/head (small ruminant)
200 g/head (cattle).

Urea (ammonia) dosage toxicity and ruminants digestive peculiarities.

Microorganisms in the ruminant's stomach have the capacity to use non-protein nitrogen in order to synthesise their own body protein which is absorbed by the animal host.

In the rumen urea is attacked by micro-organisms, ammonia release occurs rapidly which could be toxic depending upon the amount of urea intake. The content of urea in a ration should not exceed 2-3% on a dry basis. In practical conditions given quantities are 150 to 200 g/TLU or 15 to 20 g/sheep. Gradually offered over the day, urea can improve forage digestibility and nitrogen supply for the ruminant. An overdose leads to a rapid ammonia poisoning. So the daily dose appears to be a constraint on-farm. Farmers must be aware of the potential toxicity of ammonia when using urea. The sale of urea should therefore be in units whose dosage has been prepared separately for the small ruminant and cattle respectively.

Table 2. Nutritive value of cereal straws

Chemical composition digestibility and intake	Rice straw (N)	Maize straw (N=1)	Millet Straw (N)	Sorghum straw (N=3)
Organic matter *	827 ± 19 (29)	751	886 ± 43(5)	914 ± 29
Crude protein *	25 ± 13 (29)	36	60 ± 15(5)	39 ± 9
Crude fiber *	360 ± 34 (29)	251	397 ± 55(5)	344 ± 31
NDF *	555 (1)	618	814 ± 83(3)	708 ± 36
ADF *	428 (2)	316	518 ± 57(3)	708 ± 36
Lignin *	62 (2)	55	96 ± 19 (3	438 ± 26
Silica *	-	107	43 ± 41 (4)	32 ± 13
Calcium *	1.9 (2)	1.1	3.1 ± 2.2(5)	2.7 ± 0.2
Phosphorus *	0.7 (2)	0.5	1.8 ± 1.1(5)	0.46 ± 0.12
Magnesium *	-	0.9	4.1 ± 0.1	3 ± 0.4
Potassium *	-	0.4	93 ± 98(3)	8.2 ± 3.1

Cont'd

Cont'd

Table 2. Nutritive value of cereal straws

Chemical composition digestibility and intake	Rice straw (N)	Maize straw (N=1)	Millet Straw (N)	Sorghum straw (N=3)
Cobalt ppm	-	0.76	0.6 ± 0.1	0.34 ± 0.07
Copper ppm	-	17.9	6.5 ± 1.7	3.1 ± 0.6
Zinc ppm	-	76.5	29.4 ± 5.0	18.1 ± 7.5
Manganese ppm	-	50.3	107.8 ± 13.3	195 ± 27
Sodium ppm	-	2525	575 ± 414	757 ± 307
Dry-matter digestibility (sheep) p100	49+3 (15)	48(1)	37(10)	44
Organic matter digestibility (sheep) p100	58	39	38	46
Intake g/kg				
sheep	48	-	34	39
cattle	74	-	-	-

* g/kg dry matter

Source: Fall et al (1987)

The same attention should be given to urea storage so as to prevent a fasted ruminant animal from helping itself. The farmer should keep it in an out-of-reach box.

Characteristic of urea-added diets. To optimise urea's digestive capacity, a good supply of energy, true proteins and minerals are needed. Easily digestible sources of energy are molasses and cereals. The first is available in sugar-cane producing areas while the second is difficult to obtain on account of nutritional needs by humans and other monogastric animals.

Urea mixture in the diet should be as homogeneous as possible to ensure progressive consumption by the ruminant. This aspect involving diet preparation may be a constraint to the farmer since urea is sold in a pellet form. It has to be dissolved in water before it is mixed with the other components of the diet. This implies that a good water supply, a blendor or a hand-mixer (like fork) to impregnate forage with urea solution are needed.

Concerning the addition of true proteins for a well-balanced ration, NRC (1976) estimates that urea level should not exceed 30-40% the protein requirement of the animal. This goes to show that urea cannot solve the whole problem of nitrogen requirement in protein deficient diets.

Minerals, especially calcium and phosphorus but also sulphur and cobalt, are required for optimal activity of rumen microbes, the true users of urea. Availability of such mineral supplements in traditional livestock production systems must be adequately addressed.

Availability of water in the Sahel is the most important constraint to urea utilisation. Animals on a urea diet should be watered as regularly as possible. It is advisable to give water *ad libitum* which is almost impossible in the Sahel.

Temporary water points dry-up early in the dry season. The maintenance of drilled wells is a major problem: as such wells do not work often and the distance between them in the Ferlo area in

Senegal is too far (See Figure 2). Hence herds are watered once every two days which is not adequate to satisfy ruminant requirements. These conditions evidently do not allow urea introduction.

Establishment of beef fattening schemes in areas where water supply is adequate offers the best condition for a successful dissemination of results involving urea usage in the diet of ruminants.

Poor palatability of urea-added diets may be a constraint to its acceptance by ruminants. The addition of molasses and/or common salts to urea-added diets significantly improves palatability.

Farmers therefore need to be aware of those characteristics of urea-based diets in order to ensure good absorption and prevent ammonia intoxication.

Improving the nutritive value of low quality roughages by urea processing

Urea processing

Comparison of urea with other chemical and physical methods for improving straw quality.

A major limiting factor to straw utilisation is its bulkiness and low concentration in digestible nutrient. The low nitrogen content of straw has a negative effect upon its digestibility.

Several physical and chemical methods have been used to improve the intake and digestibility of straws although both methods have their drawbacks.

Physical treatment by chopping or milling straws consumes energy and needs equipment and hence is costly. However rice straw is less rough and does not need to be chopped on farm. Hand cutting sorghum with a chopper and milling straw help in making them more easily edible.

For chemical treatment of low quality roughages, several alkaline or acid reagents are proposed. Among these, ammoniation by urea offers greater promise because of its feasibility and because it supplies non protein nitrogen (Jackson, 1979; Sundstol, 1984; Fall et al, 1987). Also it is more accessible to the farmer compared to other chemicals. Urea is three times cheaper than sodium hydroxide which is not available in rural areas in Senegal, for example. Unfortunately, urea too has its constraint.

Technical constraints to dissemination of urea treatment of cereal straws

In addition to the availability of urea and the potential toxicity of ammonia, there is a need to make urea-treatment of cereal straws adaptable to tropical conditions. According to Jackson (1979) one method of treating straw with urea is to mix straw with 5% urea. The dry procedure method involves injecting urea in the straw using high pressure. The resultant temperature rise seems to give the best forage quality. Unfortunately, the cost and unavailability of the needed equipment makes that technology out of reach for Sahelian farmers on a large scale.

The second method involves a small quantity of water where a 5% urea solution is sprinkled over the straw at the rate of 1 litre of solution per kilogram of straw to make it reasonably damp (Fall et al, 1987). The urea-straw mixture is kept in a silo and left for incubation for two (in tropical climate) or six weeks (in cool climate). This latter method is recommended for drought conditions in the Sahel. Needless to say, it also protects the environment from pollution.

Urea-ensiling helps to improve intake, digestibility and nitrogen content of poor quality roughages (Table 3). However its proportion in the diet of the ruminant should be limited so as to avoid risk of ammonia toxicity for beef cattle or transmission of toxic compounds in milk for dairy cattle (Preston and Leng, 1987). In north Europe treated straw is usually around

30% of the diet (Preston and Leng, 1987). More research work is needed to evaluate accurately the daily optimal consumption of urea-treated straws for sheep and cattle in Africa.

The urea-ensiling method seems to be easily applicable. What it needs is to be made adaptable to rural conditions. In view of the non-availability of suitable equipment in rural areas where livestock are raised, the use of locally available tools is a must to popularise straw ammoniation by urea treatment.

Physical treatment of straw

Before urea-ensiling takes place, long cereal straws are chopped in order to make them easy to handle and to enable the reagent to reach the cell wall. Rice straw is less rough and does not need a reduction of length. As most of the choppers are more or less sophisticated and electric-operated which may not be available in rural areas, the chopping process may be carried out by hand with a hatchet.

Tools of treatment

Urea solution can be sprinkled by watering cans instead of straw being urea-ensiled in big metal containers as is done in northern Europe. The process can be carried out in a silo hollowed out of soil laid over with cement or clay.

A mixture of urea solution with straw takes place, the silo can be covered with a polythene tarpaulin which might not be readily available in which case banana or palm tree leaves can be used just as well. Complete sealing is essential as some ammonia gas can escape. All necessary precautions should be taken to counteract the loss of ammonia through the silo.

Ensiling time

Although treated straw may be conserved for a long period from a technical point of view, ensiling time may be a constraint for small-scale farmers who may not have the capacity to treat a great quantity of straw at once. They prefer to treat the required amount each week. The reported optimum ensiling time is from 10 days (in warm climate) to six weeks (in temperate countries). Research should be carried out to find out influence of decreasing ensiling time on straw quality improvement.

Cost of urea treatment of straw

As discussed earlier, the cost and non-availability of urea in rural areas make it a major constraint to its utilisation. It is estimated that treatment cost in rice producing areas is three times that of its cost price; i.e. treatment cost is 45 CFA/kg while its cost price is 15 CFA/kg.

Very few studies have been made in Sahelian countries about the costs involved to produce milk or liveweight gains made of urea-ensiled straw. Economics of straw ammoniation by urea should be a major on-farm research work in order to be precise about the costs and profits involved and to convince farmers to adopt technology.

CONCLUSION

The ability of urea to enhance the nitrogen level of ruminant's diet either as supplement or as chemical reagent for improving low quality roughages has been proved for many years.

In Sahelian countries the dissemination of available research results is limited by a) lack of suitable equipment b) scarcity of urea in rural areas, c) its high price, and d) potential toxicity by quick ammonia intra-ruminal release.

More on-farm research could solve technical constraints and find ways and means of making feasible adaptations in rural areas. Needless to say, farmers' training is pre requisite for introducing urea in Sahelian feeding systems.

Table 3. Effect of urea treatment on straws nutritive value

		Crude protein g/kg DM	Dry-matter digestibility p100	Dry-matter intake $g/kgW^{0.75}$
Rice straw				
	Urea 5% ensiled	79	54 ± 4 (N=6)	61 ± 10 (N=6)
	Control	45	43 ± 4 (N=6)	48 ± 3 (N=5)
Maize stover				
	Urea 5% ensiled	149	57 ± 5 (N=6)	53 ± 10 (N=6)
	Control	39	49 ± 2 (N=6)	40 ± 5 (N=5)
Millet stover				
	Urea 5% ensiled	141	49 ± 6 (N=5)	31 ± 7 (N=4)
	Control	84	39 ± 6 (=5)	31 ± 7 (N=4)
Sorghum stover				
	Urea 5% ensiled	146	65 ± 3 (N=6)	68 ± 3 (N=6)
	Control	42	47 ± 5 (=2)	50 ± 6 (N=5)

(source Fall et al, 1987).

CONSTRAINT TO UTILISATION OF BROWSE PLANTS IN THE DIET OF RUMINANTS IN THE SAHEL

Recent results have shown the importance of trees and shrubs in ruminant feeding in Africa (Le Houerou, 1980). In natural pasture they can reach 70 to 80% of sheep and goat's diet during the dry season (Guerin et al, 1985). Leaves, flowers and fruits of browses are well known for their high level of nitrogen which improves the ruminant's protein supply (Le Houerou, 1980; Kone, 1987; Fall, 1988).

Some 100 browse species are consumed according to Le Houerou (1980). In the Sahelian Ferlo area of Senegal, the main genus are *Acacia*, *Balanites*, *Calotropics*, *Guiera*, *Boscia*, *Zyziphus* and *Combretum*.

Nutritive value, harvesting and management constraints can be a limiting factor to browse usage at the farmer's level.

Nutritive value of browse plants

Chemical composition

Chemical composition of browses may be a limiting factor to their digestibility. High maturity contributes to high proportion of cell wall which plays a negative role upon digestibility. Part of the proteins may be imprisoned in lignocellulose and cannot be reached by protein microbes (Guerin et al, 1988). So the total protein may not be available. It depends on the degree of lignification, the age and part of the plant.

Occurrence of tannins in browses has been mentioned by McLeod (1974), Diagayete (1981) and Reed et al (1985). These antiquality factors have a negative effect, specially upon digestibility and protein metabolism.

Research should be undertaken to identify the best period of harvesting according to its stage of development and which nutrient can be available in what part of the plant.

Intake and toxicity

Limiting factors to browse intake are in relation to the chemical composition of the browse plant. Some species can be rich in digestible nutrient but are unplatable.

Tannins and other toxic compounds contribute to the unpalatability of trees and shrubs. Most of them remain to be identified, their toxicity and seasonal variations studied. However, browse intake varies according to the season and year. During a drought period when food is scarce, ruminants are known to accept unpalatable species.

A long adaptation period seems to improve the intake of browses.

Digestibility and intra-ruminal degradation.

A high proportion of cell wall and lignin fraction contribute to lower digestibility of browses. The poor intra-ruminal solubility in a short incubation period explains, in part, the low intake of some species (Fall, 1988). Research should be undertaken to find out a feasible method of browse ensiling to cut back this negative effect of the cell wall.

On-Farm utilisation of trees and shrubs

Browse harvesting

Most of the Sahelian countries do not have any legislation regarding the utilisation of natural pastures. They should enact such legislation to enable the farmer to be involved in range management. Such legislation would facilitate an orderly use of pasture so that it would not be disrupted by movement of herds looking for water and food. Currently ruminants use browse plants freely in pasture. Some browse species are over-grazed while others are not touched. Stocking rates are often too high and bush fire is still destroying a great part of pasture land.

Therefore, to make the best use of available feed resources, farmers should cut and save trees and shrubs for the worst part of the dry season.

Piot (1980) has made a review of some exploitation techniques. The review describes the haphazard cutting down of trees, not helping in their regeneration and/or the protection of the environment. According to the review only the upper leaves of trees should be cut to allow regeneration to take place.

Storage of trees and shrubs

In the Sahel storage of browse plants for fodder reserves is a necessity. While the usual practice in West Africa is to sun-dry most of the harvested Acacia fruits this procedure may affect the nutritive value of some species.

Hentgen (1985) says Azadirachta indica leaves are stored by ensiling with salt, a method which method offers promise. However proper training of farmers must precede introduction of that technology.

Supplementation of ruminants

Browse supplementation (to ruminants) calls for more investigation on the resultant weight gain and on milk production. This is necessary so that sound recommendation can be made on their use.

Browse management in pasture

A whole methodology of browse exploitation has to be defined. It would include a time table of browse harvesting methods, species to be protected, storage and distribution to ruminants as supplement. Direct utilisation of browse in pasture needs more research work to be able to control the optimal stocking rate.

Browse management must therefore take into account all technical and particularly social constraints constraints.

Harvesting: In addition to the problem of methodology, utilisation of browse plants has to be seen in light of collection of species and an optimal period for harvesting.

It is not easy to define harvesting methodology applicable to all genera. Variations in phenological behaviour justify a particular study of each genus or species. The goal is to exploit and allow browses to regenerate. Cutting leaves and small branches seems to be a good method of harvesting (Piot. 1980).

Some species are high in nutritive value while others are practically useless as ruminant fodder. An association of chemical and secondary production criteria should allow a given number/type of species to be protected or introduced in pasture.

The choice of browse harvesting period is of major importance. One must bear in mind that cutting too early can break the process of development of reproductive parts (flowers and fruits) while cutting too late can lead to an excess of lignification and a decrease in the nutritive value of trees and shrubs. Species variation in development cycle suggests adoption of different periods of harvesting according to their phenology.

Storage of harvested browses: A good storage of leaves or fruits of trees and shrubs can overcome bioclimatic hazards like fire, drought, and wind as well as pests such as insects or birds. They can contribute to limit undernutrition and mortality of ruminants in the Sahel.

The depressive effect of sun-drying upon nutritive value suggests that ensiling should be tested with local tools.

Direct utilisation in pasture: The free choice method does not help to improve management in the present situation in the Sahel where there is a large movement of herds of Sahelian livestock during the dry season. The free choice method would result in a disordered exploitation of natural pasture. The survival of some browse species may be threatened due to overgrazing, consequently encouraging useless species to develop.

The determination and control of adequate stocking rates could minimise the constraints to direct utilisation of browses in pasture situation.

CONCLUSION

Some browses have a high digestible protein level and are available in the Sahel where livestock are raised traditionally.

Constraints to the optimal utilisation of browse plants at the farmer's level involve variation in nutritive value, range management as well as the educational level of the farmer himself.

Research on browse plants need to be intensified in order to answer questions involving choice of species and collection including their secondary productivity.

GENERAL CONCLUSION

Undernutrition of protein is the main constraint to livestock production in the Sahel.

Because the usual protein sources, like oil meals or seeds, and by-product of animal origin, are either expensive and not available in livestock grazing areas of the Sahel, research workers must now think in terms of practical on-farm utilisation of low cost protein sources like browses or urea. The ability of urea to improve the nitrogen content of the diet of ruminants is now an established fact. The adoption of this technology, i.e. the use of urea, in the developing countries of the Sahel by farmers could help in supplying more protein and improving low quality roughages. Unfortunately, these research results are not that well-known amongst Sahelian farmers. Constraints to the introduction of that new feed technology in traditional livestock growing areas involve risks of toxicity, water shortage, cost and availability of urea in rural areas, lack of equipment as well as low educational level of farmers. There is need for basic education in the management of appropriate feeding methods for maximising the profit of urea-supplemented diets.

Research needs to be carried out on-farm to be able to recommend which local tools to use, the best urea-straw ensiling time and the economics of on-farm urea utilisation as a new feeding technology in rural areas.

Optimal utilisation of browses requires a better knowledge of their nutritive value, the techniques of harvesting and secondary productivity. In addition to technical constraints, the problem of range management needs to be investigated. On-farm research efforts should include education of the farmer in environment preservation.

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Figure 1: Area of cereal production in Senegal.

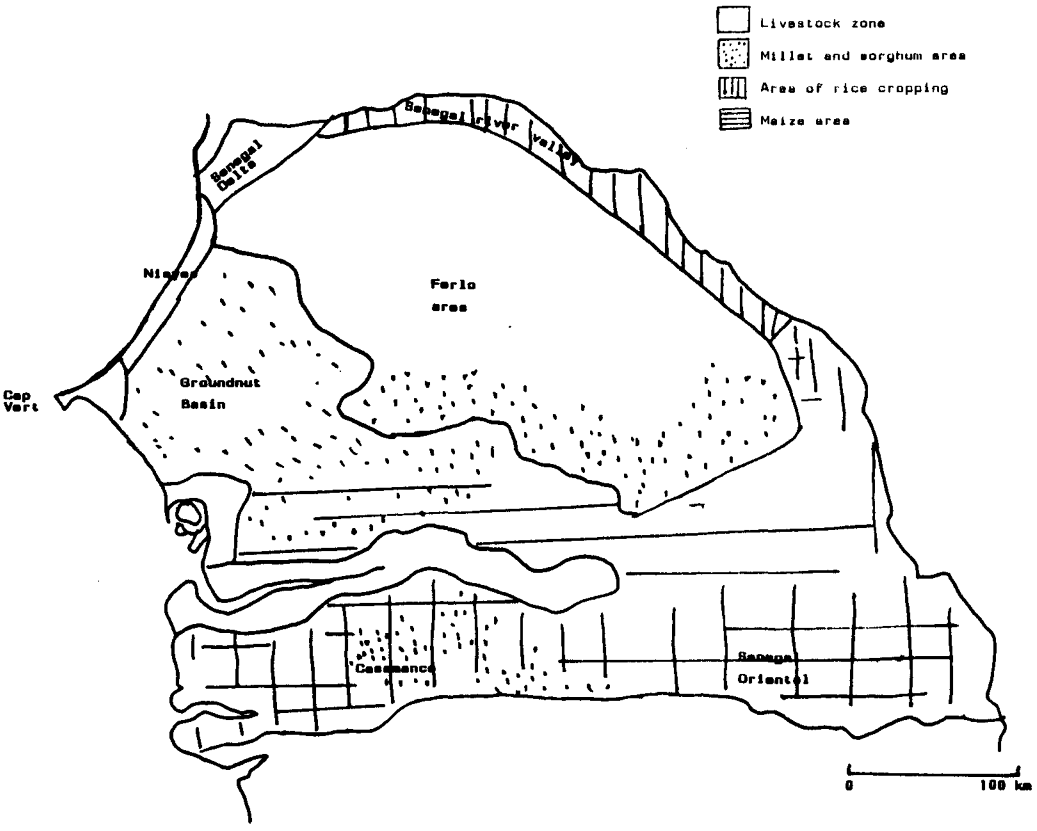


Figure 1: Area of cereal production in Senegal.

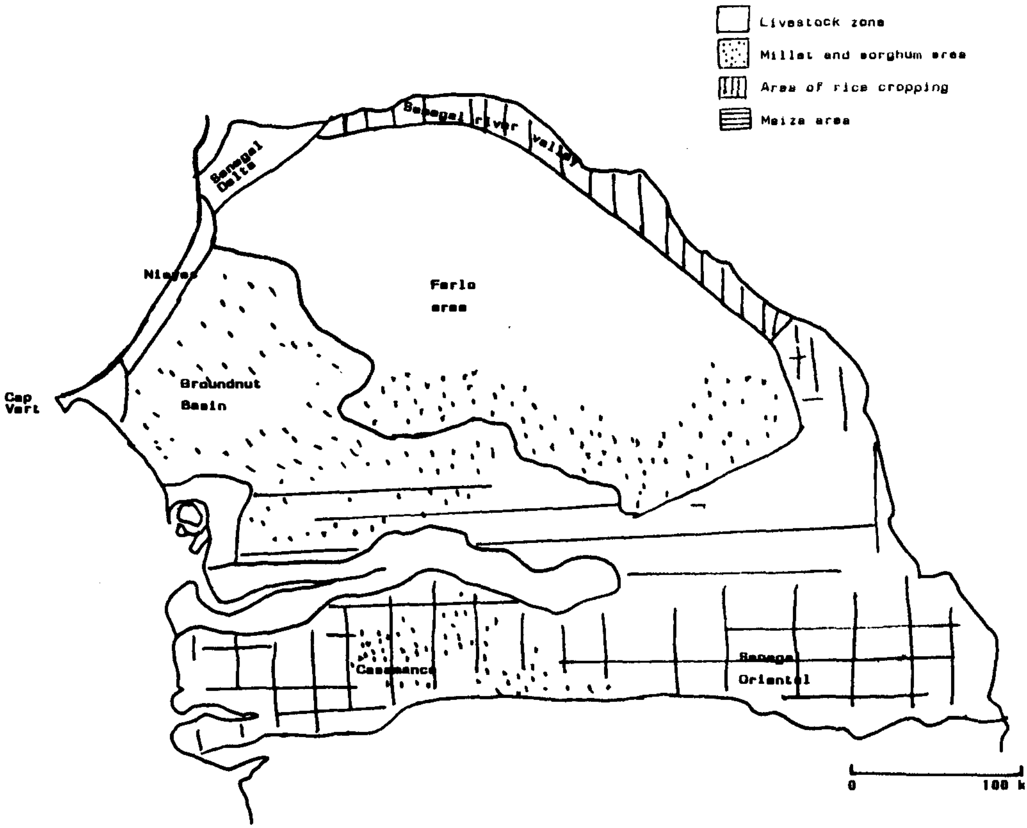


Figure 1: Area of cereal production in Senegal.

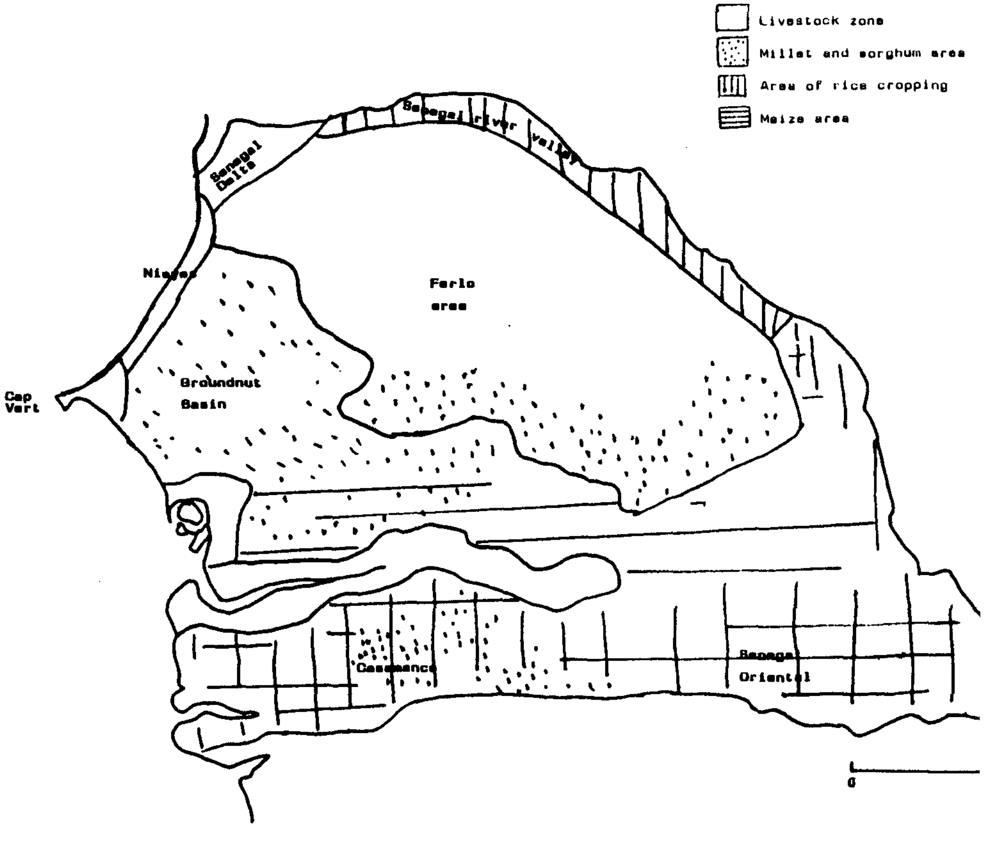


Figure 1: Area of cereal production in Senegal.

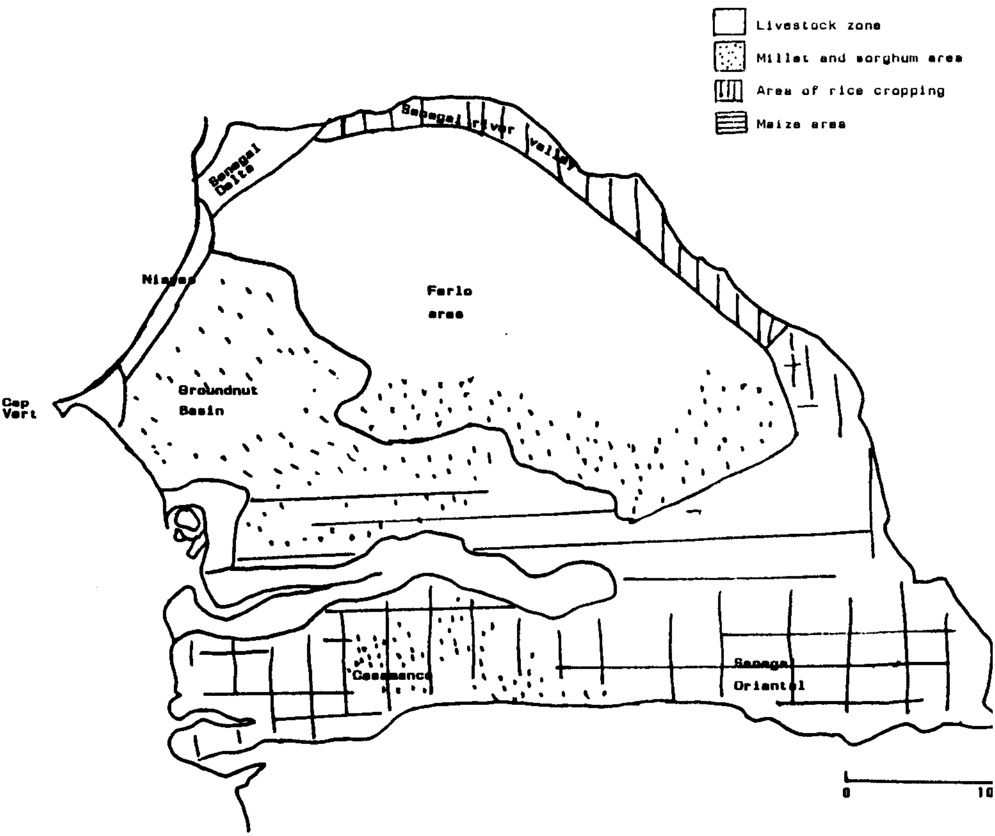
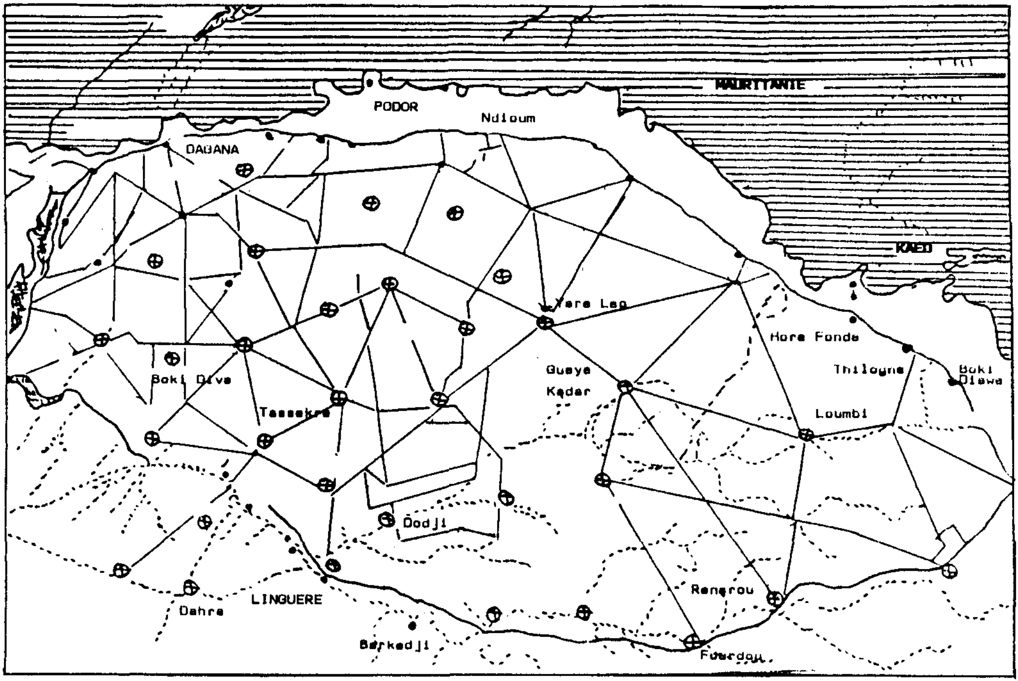
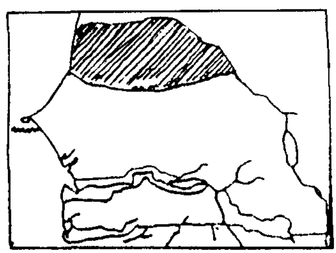


Figure 2. Sahelian Ferlo area: drilling distribution in Senegal



⊕ drilling

Source: Gaston (1987).



ADOPTION OF THE RHIZOBIUM INOCULATION TECHNOLOGY FOR PASTURE IMPROVEMENT IN SUB-SAHARAN AFRICA

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ABSTRACT

The production of high quality livestock and livestock products depends on adequate and nutritious pastures. Such good pastures need to be cheaply produced by incorporation of legumes instead of using large quantities of expensive nitrogen fertilizers. In most sub-Saharan Africa the potential of such pastures is high. However, for proper establishment legumes should be inoculated with an appropriate *Rhizobium* inoculant. A major constraint to exploiting the *Rhizobium* inoculation technology is that most farmers are not aware of the technology and its benefits. Efforts should be made to increase farmer awareness and appreciation of the technology through a multi-disciplinary team approach.

INTRODUCTION

In most countries of sub-Saharan Africa food and cash crops such as maize, groundnuts, cassava, cotton and tobacco are among the major crops dominating agricultural production. However, the cropping system under most smallholder conditions in this region includes livestock production.

Livestock production relies upon pastures which need to be both highly productive and nutritive. In order to produce high yields of high quality dry matter, large amounts of nitrogen fertilizers are needed. Nitrogen fertilizers are available in most countries of sub-Saharan Africa. However, the cost of such fertilizers is very pohibitive to most smallholder farmers. For example in Malawi, over the past ten years, the price of the three most commonly used nitrogen fertilizers: compound 20-20-0, calcium ammonium nitrate, and sulphate of ammonia has increased by 253%, 255% and 391% respectively. On the other hand, prices of livestock products at the farm gate have not changed equally to warrant use of expensive nitrogen inputs on pastures. Consequently, very few farmers use nitrogen fertilizers on their pastures.

An alternative to the expensive inorganic nitrogen fertilizers is to incorporate legumes and apply the nitrogen fixing bacterium Rhizobium spp. This technology is not a new concept in sub-Saharan Africa (Haque and Jutzi, 1984; Haque et al, 1988; Savory, 1972; Thomas, 1973; Thomas and Addy, 1977).

To successfully adopt use of Rhizobium inoculants in pasture improvement, it is essential that legume varieties suitable for the target ecological zone be identified and matched with appropriate Rhizobia for optimum nitrogen fixation. The inoculation technology itself need to be simple enough both in scope and means of application.

Undoubtedly the use of pasture legumes is not at the same level nor uniform all over sub-Saharan Africa. Consequently any attempt to describe in detail the situation in each country in a paper of this nature would be futile. Therefore this paper mainly describes the Rhizobium inoculation technology in Malawi as an example of exploiting the Rhizobium-legume symbiosis in pasture improvement in sub-Saharan Africa. Wherever possible, examples from other countries in the region are also given. Prospects and constraints to adoption of the inoculant technology and possible solutions are discussed.

RATIONALE FOR USING RHIZOBIUM INOCULANTS

Biological nitrogen fixation is a natural process whereby atmospheric nitrogen is reduced to ammonia. In legume, this system operates in the root nodules formed by the nitrogen fixing Rhizobium spp. In most natural ecosystems, heavy losses of nitrogen occur due to crop uptake, leaching, erosion, denitrification etc. However, significant replenishment of nitrogen occurs in most soils mainly due to biological nitrogen fixation (Hardarson et al, 1987).

Nitrogen provided in this form is not only cheap but also does not impart other undesirable aspects such as pollution hazards due to heavy use of inorganic nitrogen fertilizers. In addition, inoculation of seeds, plants and soil with Rhizobium is even simpler than applying correct doses of inorganic nitrogen fertilizers such as urea or diammonium phosphate.

The inoculation of legume seeds with Rhizobium has been practiced in agriculture for several decades. The mixture of Rhizobium cells and a carrier e.g. peat, filter-mud, bagasse etc is what constitutes the Rhizobium inoculant (Okon and Hardy, 1983). If inoculants are properly used, significant amounts of nitrogen could be fixed. Due to problems in measuring exact quantities of nitrogen fixed, only estimates could be made. The validity of such estimates strongly depends on the method used to estimate nitrogen fixation. Table 1 shows some estimates of nitrogen fixed by some grain and forage legumes. It can be noted that forage legumes fix larger amounts than grain legumes. This is probably a reflection of the duration of the crop: most grain legumes are annuals while most forage legumes are perennials. Comparable data for nitrogen fixation by forage legumes in sub-Saharan Africa are shown in Table 2. With such high amounts of nitrogen provided in a cheap way, it is imperative that exploitation of this natural system be encouraged.

Pasture improvement offers an excellent opportunity for exploiting biological nitrogen fixation in sub-Saharan Africa. Many pasture legumes in addition to providing their own nitrogen for good growth are also rich in protein and highly nutritious to livestock (Sprague, 1975). Use of nitrogen fertilizers on pastures faces strong competition from the demand of nitrogen fertilizers by cereals which provide the bulk of staple food for most people in sub-Saharan Africa. As such, any advocation of applying nitrogen fertilizers to pastures is already a skeptical idea to the smallholder farmer. Thus promotion of using inoculants on pasture legumes in both pure and mixed legume-grass swards seems logical.

Table 1. Estimates of nitrogen fixation by grain and forage legumes.

Legume species	Maximum fixation (kg/ha/year)
A. Grain legumes	
Arachis hypogaea	124
Cajanus cajan	280
Canavalia ensirforis	49
Cyanopsis tetragonoloba	220
Glycine max	180
Lupinus spp.	208
Phaseolus aureus (green gram)	342
P. aureus (mung bean)	61
P. vulgaris	64
Pisum sativum	85
Vicia faba	552
Vigna sinensis	354
B. Forage legumes:	
Calapogonium muconoides	450
Centrosema pubescens	395
*Desmodium unicnatum***	178
Lespedeza spp	193
*Leucaena leucocephala**	580
Lotus corniculatus	116
Medicago sativa	463
Melilotus alba	183
Stylosanthes spp	220
Trifolium spp	673
Vicia villosa	184

Source: Adapted from Hardason et al (1987)
* Data reported by Guevarra (1976) quoted by Sanginga
** Data reported by Haque and Jutzi (1984)

Table 2. Some values of Nitrogen fixation in sub-Saharan Africa

Region	Rainfall (mm)	Legume	Nitrogen fixed (kg/ha)
Nigeria (rainforest)	1,143	Centrosema pubescens	280
Nigeria (savanna)	1,085	Stylosanthes guyanensis)	84
Uganda (tropical, subhumid)	>1,143	Centrosema pubescens Stylosanthes guyanensis	161
Kenya (W. Province)	1,111	Desmodium uncinatum	178
Zimbabwe (high rainfall sandveld)	908	Lotononis bainesii	62
Tanzania*	ND	Leucaena leucocephala	110
Malawi*	ND	Stylosanthes guianenses	

Source: Adapted from Thomas (1975)
* Data from Haque and Jutzi (1984)
ND = No data presented

BENEFITS FROM INOCULATION WITH RHIZOBIUM SPP

Inoculation is a cheap insurance that the legumes will have adequate nitrogen for its growth. In most soils of sub-Saharan Africa, Rhizobium spp of the 'cowpea' miscellany occur freely. As such most pasture legumes nodulate naturally. For example Thomas (1973) reported that Aeschynomene americana, Calapogonium muconoides, Centrosema pubescens, Desmodium intortum, Desmodium uncinatum, Indigofera hirsuta, Neonotonia wightii, Pueraria phaseoloides and Stylosanthes spp nodulate very well in Malawi without inoculation. According to Thomas (1973), similar responses have been reported for Centrosema pubescens, Pueraria phaseoloides and Stylosanthes guianensis and S. erecta in Tanzania, Stylosanthes guianensis and Desmodium intortum in Uganda, Desmodium spp in Kenya and Zimbabwe.

However for such legumes, it is essential that the amount of nitrogen fixed be quantified because the Rhizobium spp forming the nodules may not be effective. If ineffective nodulation is the case, then inoculation with a highly effective and efficient strain would ensure large amounts of nitrogen to be fixed.

Such improvements in nodulation of legumes which nodulate freely with local Rhizobia have been achieved in groundnuts in India (Nambiar, 1985). According to Nambiar (1985), out of 15 cultivar x Rhizobium strain combinations the average increase in pod yield of inoculated over the uninoculated plots was 16%. It is significant to note that such responses were obtained in fields where the uninoculated plots had 200-600 nodules per plant. Similar responses could be obtained in pastures if legume varieties are properly matched with efficient Rhizobia.

However, some legumes like Leucaena leucocephala are strain specific (Trinick, 1968). Leucaena has been imported into most countries in Sub-Saharan Africa and its Rhizobium strain does not occur naturally in such countries. As such, inoculation of leucaena is beneficial. Sanginga (unpublished data) reported good responses of leucaena to inoculation at two sites in Nigeria (Table 3). The effect of inoculating with an effective strain was equivalent to the application of 150 kg N/ha.

In Malawi inoculation of leucaena has always improved the establishment of this forage legume. (Savory, 1979; Davis, 1982). Responses, however, are influenced by the legume variety, Rhizobium strain and site where the crop is grown.

Similar responses of Stylosanthes guianensis cv Cook have been obtained in Malawi and inoculation mainly enhances establishment (Table 4) (Davis, 1982).

IMPORTANCE OF EFFECTIVELY NODULATED PASTURE LEGUMES

In terms of livestock production higher content of nitrogen in inoculated forage legume (Table 5), implies higher plant protein for livestock and therefore increased liveweight gains.

Thomas and Addy (1977) have demonstrated that legume-based pastures can contribute substantial liveweight gains in both wet and dry seasons (Table 6). More recently, Dzowela (1985) has reported that *Stylosanthes guyanensis* cv Cook can be effectively used to improve natural grasslands and liveweight gains. Similar improvements in liveweight gains from stylo-based grasslands have also been realised in Swaziland (Ogwang, 1986). In Malawi, unfertilized *Chloris gayana* - *Desmodium uncinatum* pasture gave significantly higher average daily liveweight gains than the grass pasture alone (Dzowela, 1986).

It is evident from the above examples that effectively nodulated pasture legumes could contribute significant dividends to the development of livestock industry at the smallholder level of production in sub-Saharan Africa. The major impact of such legume-based pastures is in reducing the cost of producing high quality livestock.

RHIZOBIUM INOCULANT DEMAND

Despite the realisation of the benefits of inoculating legumes for pasture improvement, there are relatively few data to indicate use of *Rhizobium* inoculants in sub-Saharan Africa.

Table 3. Effect of urea fertilizer and inoculation with *Rhizobium* on nodulation, growth and nitrogen fixation leucaena at IITA and Fashola, Nigeria, at 24 weeks after planing.

Treatment	Nodules (number/ plant)[a]	Nolduels from inoculant strains %	Nodule dry wt.a (mg/ plant)	Shoot dry (g/	Shoot N (kg/ha)	Nfixed (kg/ha)
Fashola						
Uninoculated	36	69	179	26	82	ND[b]
150 kg N/ha	36	69	87	72	232	ND
Rhizobium IRc1050	40	78	485	79	228	ND
Rhizobium IRc1045	15	94	174	68	209	ND
IITA						
Uninoculated	0	0	0	51	174	0
150 kg N/ha	0	0	0	130	445	0
Rhizobium IRc1050	17	100	187	103	398	224
Rhizobium IRc1045	34	100	277	121	448	274
LSD (5%)						
Fashola	11	ND	23	12	53	ND
IITA	12	ND	25	22	66	ND

[a] At 12 weeks after planting.
[b] Not determined

Source: Sanginga (unpublished data)

In Malawi, inoculants for several legumes are produced and sold at a modest cost of MK1.50 (USD 0.55) per 50 g packet (Table 7). Sales have increased slowly from 448 x 50 g packets in 1976/77 to 1775 x 50 g packets in 1987/88 (Table 8). The number of inoculant buyers has fluctuated greatly. However the number of buyers does not necessarily reflect the number of inoculant users. The current system in Malawi is that the Agricultural Development Divisions purchase the inoculant in bulk and then distribute it to the respective smallholder farmers. Use of inoculants in pastures is shown in Table 9. As it can be seen from this table, more inoculant use is in grain legume. This is a reflection of emphasis on growing grain legume such that pastures are unfortunately, considered secondary. In Kenya total inoculant sales have increased from 630 packets in 1981 to 5206 packets in 1985 (Nairobi MIRCEN, 1986). The increase in sales is attributed to effective demonstrations at annual agricultural shows.

Table 4. Response of *Stylosanthes guyanensis* cv Cook to field inoculation with *Rhizobium*

Rhizobium Treatment	Site	Dzalanyama	Mbawa
MG 5013		11467a	8546
R 3861		10753ab	8730
R 3943		10340abc	9514
R 3811		9711abc	8203
R 3884		9259bc	9789
R 3837		9026bc	9988
R 3871		8662c	9582
Uninoculated		8468c	8716
Mean		9711	9133
SE±		631.1*	475.8NS
CV%		15.2	18.1

Data followed by the same letter in a column are not significantly different from each other according to Duncan's Multiple Range Test at P = 0.05.

* = Significantly different P = 0.05

NS = Not significant

Source: Davis (1982)

Table 5. Response of *Stylosanthes guianensis* cv Cook to field inoculation with *Rhizobium*

% Nitrogen in legume (Data of single harvest only) May 1977.

Rhizobium Treatment	Site	Dzalanyama	Mbawa
MG 5013		1.68a	1.61a
R 3861		1.66ab	1.55ab
R 3943		1.66ab	1.50bc
R 3811		1.65ab	1.49bc
R 3884		1.62abc	1.46bc
R 3837		1.47bc	1.43c
R 3871		1.32cd	1.42c
Uninoculated		1.24d	1.40c
Mean		1.54	1.48
SE±		0.059***	0.035**
CV%		9.4	5.7

Data followed by the same letter are not significantly different (P = 0.05).

* significantly different at P = 0.01.
*** significantly different at P = 0.005.

Source: Davis (1982).

Table 6a. Total cattle liveweight gain (kg) during the wet season.

	Malawi zebu	Friesian x MZ	Grade Fr	Mean
Rhodes grass	72.7	80.4	67.0	73.4
Rhodes grass + legume	78.7	90.5	74.8	81.4
Response to legume	+6.1	+10.1	+7.8	+8.0
Grazing period (days)	163	163	125	

Table 6b. Liveweight changes (kg) during the wet season. Cattle grazing Rhodes grass forage with or without cottonseed cake (protein) supplement and Rhodes grass - legume.

	Malawi zebu	Friesian x MZ	Mean	Response to protein
Rhodes grass	-3.2	+0.7	-1.3	-
Rhodes grass + legume	+19.0	+300	+24.5	+25.8
Rhodes grass + supplement	+18.0	+286	+23.4	+24.7

Source: Thomas and Addy (1977).

Table 7. Rhizobium inoculants available in Malawi.

Code Number	Legume species	Weight of seed treated by one 50 g packet
CWP	Cowpea (Vigna unguiculata)	25 kg
	Axillaris (Macrotyloma axillare)	10 kg
	Glycine (Neonotonia wightii)	10 kg
	Siratro (Macroptilium atropurpureum)	10 kg
	Joint vetch (Aeschnomene americana)	5 kg
	Stylo (Stylosanthes guianensis)	5 kg
DES (MG 500)	Silverleaf (Desmodium uncinatum)	10 kg
	Greenleaf (Desmodium intortum)	5 kg
LOT (MG 5007)	Lotononis (Lotononis bainesii)	2 kg
LEU (MG 707)	Leucaena (Leucaena leucocephala)	10 kg
CEN (MG 512)	Centro (Centrosema pubescens)	10 kg
BNS (MG 336)	Beans (Phaseolus vulgaris)	25 kg
SOY (MG 614)	Soyabean: all varieties (Glycine max	25 kg
LUC (MG 400)	Lucerne (Medicago sativa	10 kg
GNT (TAL 1000)	Groundnut (Arachis hypogaea)	25 kg
GUA (MG 5017)	Guar (Cyamopsis tetragonoloba)	25 kg

Inoculants for most other legumes are available by special request from.

Microbiology Section
Chitedze Agricultural Research Station
P. O. Box 158
Lilongwe
Malawi. Phone: 767 222

Table 8. Total Rhizobium inoculant sales in Malawi, 1976-1988.

Growing season	Number of buyers	Number of 50 g packets sold	Total cost (Kwacha)*
1976/77	ND	448	224.00
1977/78	ND	616	308.00
1978/79	14	1089	544.50
1979/80	20	872	436.00
1980/81	22	1179	520.00
1981/82	23	3481	1741.00
1982/83	11	1741	1384.25
1983/84	18	975	731.25
1984/85	20	1296	972.00
1985/86	16	1145	858.75
1986/87	38	1767	1325.25
1987/88	ND	1775	1221.25

ND = No data.
* = The cost of inoculant was 50 tambala per 50 g packet in 1976/77.
- In 1982/83 the price was raised to 75 tambala.
- Present price since 1988/89 season in MK 1.50 (1US$ = MK 2.65)

Table 9. Types of inoculants distributed in Malawi during 1986/87 and 1987/88 seasons.

Inoculum type	Legume species	Number of packets distributed	
		1986/87	1987/88
CWP	General	38	63
DWS	Desmodium spp	32	33
LOT	Lotononis	0	0
LEU	Leucaena	148	62
CEN	Centrosema	12	5
BNS	Common beans	141	1275
SBG & SBH	Soyabeans	1176	0
LUC	Lucerne/alfalfa	10	6
GNT	Groundnuts	8	0
GUA	Guar beans	200	400
PEU	Peuraria	2	0
Total		1767	1869

Source: Microbiology section, (Unpublished data).

CONSTRAINTS TO ADOPTING INOCULANTS FOR PASTURE IMPROVEMENT

Several reasons limit farmer adoption of the rhizobium inoculant technology. The most fundamental one is that the majority of smallholder farmers are not well informed of the technology. In sub-Saharan Africa, very few demonstrations have been established to show farmers the beneficial effects of inoculating pasture legume seed.

In Malawi, a recent in-service course on use of inoculants involved 90 participants from both research and extension establishment. The presentations by the participants revealed surprising data. Almost three-quarters of the participants did not know the value of inoculants in agriculture. Less than half had actually seen inoculants and only about a quarter had used inoculants. Most of those that had used inoculants had used them as supplements to high levels of nitrogen fertilizers. Obviously the smallholder farmer in such an environment will not realise the benefits of inoculation readily.

Munthali and Dzowela (1987) have given three other constraints to pasture improvement in Malawi. Communal grazing, high pasture establishment costs and small size of holdings in addition to competition with other crops for labour etc. Similar problems have been reported from Zimbabwe (Clatworthy et al, 1986) and Nigeria (Mohammed-Saleem, 1986). In Gambia (Russo, 1986) and in Swaziland (Ogwang, 1986) land tenure systems are prohibitive to improvement.

Probably a significant constraint is that farmers do not want to take any risks. The inoculation technology has not been demonstrated clearly that it will improve pasture production and thus livestock.

In Malawi, an additional constraint is the adverse publicity that the inoculants advocated require refrigeration. In an experiment comparing the thickness of inoculant packaging material (DAvis (1982) had categorically shown that the inoculants produced in Malawi remain viable for up to 12 weeks at 26^{o}C. The optimum planting period in the rainy season in Malawi is 4 weeks. Meteorological data indicate that during the period November to January, average room temperature in Malawi should be between 18^{o}C and 25^{o}C. Under smallholder grass-thatched house conditions, temperature should be about 20 - 26^{o}C or even lower. Considering all the above data, it is recommended that the inoculants produced in Malawi can be stored at room temperature for up to six weeks. However, most research and extension staff immediately think of refrigeration and are reluctant to have inoculants in remote areas until refrigerators are provided.

This is similar to problems encountered in advocating leucaena for rotational grazing in Australia due to the adverse publicity on the extreme effects of mimosine toxicity (Wildin, 1983).

In countries where credit systems are operational e.g. Malawi, credit packages are oriented towards food/cash crops. No component to include pasture seeds and inoculants is included. Farmers are thus inclined to grow crops with readily available inputs. This season (1988-89), South-Mzimba Agricultural Project in Malawi is including inoculants in the credit package (Gwembere, personal communication).

In addition to the above constraints, the recommendations for establishing pasture legumes under smallholder conditions might be prohibitive to adoption. For example, advocating undersowing pastures in maize appears to be in conflict with the other recommendations that the farmer should keep the crop free of weeds, and, in most regions of sub-Saharan Africa, the cropping system is mostly mixed intercropping. In this situation the farmer needs to be advised properly that the legume/grass pasture is an important crop to his enterprise that has a dairy cattle component in it. Without proper advise, adverse results may be obtained. Mwafulirwa (unpublished data) gives an example from Malawi: two farmers had to experiment further on the establishment of Rhodes grass under maize until they realised no maize grain yield reduction.

Undersowing of pastures in maize is not a new introduction in sub-Saharan Africa (Thomas, 1975). However, in Malawi the technology has not been widely adopted because of lack of institutional support in/form of follow-up extension effort and provision of a credit package (E.S. Mwafulirwa, unpublished data).

Further to the above statements, the legume species being promoted for incorporation in the current cropping systems may be inappropriate for smallholders. For example, the need to inoculate them with Rhizobia might be too demanding on the farmers. In addition the nature of some legume e.g. silverleaf Desmodium adhering to clothes, legs etc makes such legumes unattractive to include in an undersowing enterprise since the farmer experiences discomfort during field visits and maize harvest. The review by Nnadi and Haque (1986) shows that more work is needed on forage legume cereal mixtures in sub-Saharan Africa in order to fit this technology in the traditional farming systems of the region.

Baker et al (1986) discussed some factors for non-adoption of a technology. They further stated that people farm for different reasons and therefore the technology should meet producer goals. Mwafulirwa (unpublished data) has examples to this effect: one farmer had established a beautiful Rhodes grass pasture by undersowing in maize. However in the second year he ploughed the pasture and planted sweet potatoes. Another farmer also had a good pasture which he harvested and cured but left it in the field until it got rotten. This farmer, however, had feed problems but never fed the hay to his livestock. A number of lessons can be learnt from these examples e.g. farmers' priority setting, labour requirement and probably the farmers do not regard livestock as an integral part of their farming system needing more attention.

Finally, the distribution of Rhizobium inoculant and pasture legume seeds is in itself a limiting factor. In most of sub-Saharan Africa inoculants and legume seeds are not readily available at the usual retail outlets for farm inputs. Thus, despite the recommendations, farmers have no access to the inputs. In malawi, Rhizobium inoculants are produced at Chitedze Agricultural Research Station in Lilongwe. Inoculants are sent to various parts of Malawi only upon request. Some pasture legume seed is available at the National Seed Company of Malawi but the seed might be very expensive for most smallholders to purchase.

CONCLUSIONS AND RECOMMENDATIONS

The Rhizobium inoculation technology can have great dividends to livestock production. However, for the technology to be adopted, more work is needed. A multi-disciplinary team of specialists in agronomy, animal science, farm management and local leaders should work together to provide a package of recommendations for specific areas.

A farming systems approach is required to bring research workers in close co-operation with local extension staff and farmers. This, probably, would streamline the transfer of the technology.

In order to increase awareness, numerous demonstrations at easily accessible sites and highly visible locations representing production areas need to be set up. All available forms of the media should be used to inform farmers of the benefits of inoculating legumes, source of inoculants and legumes seeds and locations where additional information could be obtained.

Finally inorder for technology transfer to be successful, the following are the essential elements that need consideration (Baker et al, 1981).

1. Goals and procedures need to be clearly defined.
2. Competent staff need to be involved.
3. Appropriate disciplines to be involved to farmer's needs.
4. There should be mutual confidence between the farmer and field staff.
5. There should be total community involvement.
6. Adequate funds should be available inorder to execute the programmes.
7. Administrative support should be provided to the technology transfer teams and their programmes.
8. Staff continuity should be guaranteed.
9. Suitable support staff in addition to the component staff should be available.
10. There should be adequate time allowed for the technology transfer since changes occur slowly as farmers do not want to take risks.

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PROBLEMS AND UTILISATION POTENTIAL OF SEASONALLY WATERLOGGED LANDS IN ZIMBABWE: A BRIEF REVIEW

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INTRODUCTION

Overstocking has been identified in most agricultural literature in Zimbabwe as the main factor that has led to degradation, reduced grass growth, and the replacement of decreaser grass species by increasers and/or invaders. The latter are mostly unpalatable to livestock. Invader grass species although prevalent in degraded dryland grazing areas are also found in "dambos". Problems of dambo utilisation hinge on the ability of dambos to support large livestock numbers during the dry months of the year when grass elsewhere in the grazing area is low in nutritive value and quantities are also low. That livestock numbers have either been maintained or decreased during drought years, and increased during years of copious rainfall raises the question of whether overstocking is the cause of the problem. It may be argued that dambos have formed a buffer between starvation and death, and therefore their management, development and utilisation is the key to increased livestock production rather than reduced livestock numbers as suggested by proponents of overstocking as the cause of the problem.

This paper highlights the soil types, the extent of dambo distribution in Zimbabwe, problem of definition, morphology, vegetation and significance of dambos in peasant agriculture.

At the end of the paper, preliminary data to show trends in dambo herbage production is presented.

SOILS

There are many different soil types in Zimbabwe. There are soils derived from granite (most common rock), predominantly that named sandveld (with little clay content) which drains well, dries quickly and has low organic matter (OM) and phosphorus (P); then there is paragneiss - a soil which is a result of the weathering of an unusual rock type reformed from granite (brown, slightly red sandy loams) (Bishop, 1975).

Black turf soils (very fertile, heavy clay, hard when dry, very sticky when wet) are derived from a less common rock, basalt. Dolorite weathers to rich red clay soils scattered throughout Zimbabwe. Kalahari sandstone weathers to Kalahari sands (very fine grained soils of low fertility found in the drier regions of the west of the country. Serpentine, the most common rock on the "Great Dyke", weathers to shallow greyish brown sand loam soils unsuitable for crop production because of presence of nickel and chromium salts that are harmful to plant growth. Norite is a rock found in some sections of the Great Dyke and forms clay soils more like black turf soils (north and south of Selous).

Mopani soils are found in dry areas, are composed of heavy clay and are very alkaline. Two main types of dambo soils occur in Zimbabwe (Whitlow, 1985) and have been characterised thus;

a. Calcic hydromorphic soils comprise dark grey or black clays with a high base status. The dominant clay is montmorillonite, hence these soils resemble vertisols in their behaviour with respect to expansion and contraction during wetting and drying phases. Whitlow (1985) further stated that carbonate concretions sometimes occur in subsoils within zones of fluctuating water table. Calcic hydromorphic soils occur in broad depressions on mafic rocks in areas receiving over 600 mm rainfall per year. The mafic rocks comprise dark humic soils overlying light coloured sandy or sandy clay soils which generally have a low base status, with kaolinite being the prevalent clay mineral. Whitlow (1985) found that mottling and iron concretions are common in subsoils within dambo margins.
b. Non-calcic hydromophic soils originate from siliceous parent materials and are the most extensive of the dambo soils in Zimbabwe covering in excess of one million hectares of dambo land (Whitlow, 1984a).

Peaty dambo soils, comparable to those found in parts of Zambia (Brammer, 1973) are quoted by Whitlow (1985) as representing a third type of hydromorphic soil. Three main pedological process occur in the non-calcic hydromorphic soils:

i) organic matter accumulation
ii) gleying and
iii) clay translocation

It should be noted here that organic matter accumulation is an advantage to the establishment of pasture legumes on dambo sites. This is reinforced by further findings (Whitlow, 1985) that dambo soils are characterised by well defined organic surface horizons which increase in depth from dambo margins to wetter sites, and that the OM is generally well decomposed on drier areas (margins) but becomes progressively more fibrous and peaty towards low-lying waterlogged sites. The latter fact supports the idea of introducing pasture legumes on the periphery of dambos with a view to improvement of the quality of forage.

Gleying effects relate to both permanently and periodically saturated soil horizons. The permanently wet horizons are typically pale grey to white in colour due to a decrease in free iron content from the dambo margin to its eye where a reduction of iron compounds into a ferrous state occurs (Whitlow, 1985). Microbial activity is limited by the acid, waterlogged conditions (Whitlow, 1985) but Purves (1976) points out that microbial activity under anaerobic conditions assists in the process of iron reduction thereby enabling its removal by lateral drainage. Removal of iron and production of bleached or pallid subsoils is a process regarded as ferrolysis (Brinkman, 1985) and would seem to occur in some dambos in Zambia as well as in Zimbabwe (Whitlow, 1985). Waston (1964) described ferricrete formation at a depth of 2.5 metres within a dambo near Harare and explained that, that marked the lower limits of the dry season water table level. This observation suggests that the soil above 1.5 metre depth should be moist enough to support both grass and pasture legume growth during the dry periods of the year and is part of the basis of the hypothesis.

TOWARDS A DEFINATION OF VIEWS

Locally known as "vleis" in Zimbabwe, and dambos in central and southern Africa, these seasonally wet areas are not adequately defined. The problem of dambo definitions in Zimbabwe has been alluded to by Rattray et al. (1953), Thompson (1972) and Whitlow (1980, 1984b). The definition given by Ivy (1981) is accepted officially for the purposes of legislation in the Natural Resources Act.

Definitions

Author and year		Definition
Ivy	1981	Land that is saturated to within 15 cm of the surface for the major part of a rainfall season of average or above average rainfall and which may exhibit one or more of the following characteristics: i. the presence of mottles or rust-like stains in root channels within 15 cm of the surface. ii. a black topsoil horizon very rich in OM overlying pale leached sands; iii. a dark grey or black heavy clay showing considerable surface cracking when dry.
Thompson	1972	A vlei is a depression at the head of, or flanking, a water course in which the soils are saturated during the rainy season, and which remains saturated to within 50 cm or less from the surface for some considerable period thereafter.
Rattray et al	1953	A low-lying, gently sloping, treeless tract of country which is seasonally waterlogged by seepage from the surrounding high ground assisted by rainfall, and which contains the natural drainage channel for the removal of excess run-off from this surrounding ground.

All of these definitions do not account for those areas that are waterlogged throughout the year with visible fluctuations in the water level as seasons change into the driest part of the year. All three definitions recognise seasonal waterlogging during the rainy season but do not indicate when this water logging ceases during the year. This raises my contention that, if to a great extent these lands are waterlogged during the rainy season, this is so because their use at that time is not necessary as grazing elsewhere on topland would be at its best. It is during the dry periods of the year that these waterlogged lands play their role as fodder banks (not grazed or sparingly grazed during the rainy season, and fully utilised during the dry months).

DAMBO DISTRIBUTION AND MORPHOLOGY

Dambos cover an area of about 1.228 million hectares or 3.6% of the total land area in Zimbabwe (35.6 million hectares) (Whitlow, 1984a) (Table 1). Over one million hectares or nearly 90% of dambos in Zimbabwe occur on gneisses or intrusive granites. The former are mainly tonalitic in composition, with sodic feldspars being common, and the latter are dominated by adamellites with potash feldspars being common (Whitlow, 1979). Dambos are confined mainly to the headwater regions of rivers draining the central plateau of Zimbabwe, and account for up to 30% of the land areas of granitic terrain (Whitlow, 1980).

Morphologically, they vary from broad, lobate depressions through to narrow linear features extending several kilometres down valleys. They also vary greatly in their materials. Whitlow (1985) sound a warning that this variable character of dambos makes it difficult and dangerous to generalise about the effects of human activities on dambos (each situation is unique in some way). As earlier noted, some dambos are wetter and for longer periods than others and it is this feature which should be used to advantage for pasture legume introduction into dambo vegetation. The wetness is an advantage in that it provides abundant moisture for plants; ensuring a reasonable harvest even during the drought seasons (Mazambani, 1982). The disadvantage is that waterlogged soils are typically badly aerated necessitating removal of excess water to enable proper root development (Whitlow, 1983). Butzer (1976) noted that vleis in Africa are best developed on plateaux where for about five months rainfall ranges from 800 to 1300 mm per annum. Bond (1963, 1967) advances the idea that dambo processes may have definite climatic limits. In Zimbabwe, dambos certainly are prone to drying out during the long dry season, perhaps more so than those in higher rainfall areas of between 700 to 1000 mm per annum, and are certainly prone to drying out during the long dry season, perhaps more so than those in higher rainfall regions in Zambia (1000 mm per annum) and Malawi (Whitlow, 1985). Butzer (1976) suggested that some dambos are inactive in Zimbabwe but did not indicate how he reached that conclusion. However, Goudie (1983) explained that there is likelihood that, with changing environmental conditions during the late Quaternary period, rainfall regimes have at some stage been more favourable for dambo development than those which now prevail. In general, one might regard climatic conditions in Zimbabwe as being more marginal for the development and maintenance of dambos than elsewhere in south-central Africa (Whitlow, 1985).

Table 1. Dambo distribution according to variation in average slope in Zimbabwe.

Slope under 2^{o}	2^{o} to 4^{o}	Over 4^{o}	Total area
38.4% (492,334 ha)	45.6% (584,646 ha)	16.0% (205,139 ha)	100% (1,228,120 ha)

Source: Whitlow, (1984b)

Most dambos (84% of total dambo area) occur in land areas with slopes of 4^{o} or less. This derives from the fact that 60% of land in Zimbabwe has average slopes of 4^{o} or less (Table 1). The 84% of total dambo area (1,076,980 ha) is land that has potential for intensive pasture development. Cormack (1972) has argued that the dambo water should be put to more productive use in growing crops or improved pastures within dambos, providing there is no damage to soils or stream flow, but to the contrary Whitlow (1985) argued that some farmers in Zimbabwe have undertaken maize production and introduction of legumes in dambos with seemingly little effect on stream flow. The most extensive dambos occur on the relatively flat terrain of the central watershed areas above 1200 m above sea level.

They occur in a rather irregular arc varying in width from about 20 to over 80 km and around 300 km long. Localised islands of dambos occur on plateau remnants outside this main arc (Whitlow, 1985). The distribution of dambos in Zimbabwe as elsewhere in south-central Africa is influenced by factors such as relative relief, regolith (bedrock) characteristics, and climatic conditions (Mackel, 1974; Whitlow, 1984b). To date, no detailed analysis of the relationships between dambos and these environmental factors has been carried out. However, Whitlow (1985) pointed out that low relief and gentle rivers with increasing distance from central watershed results in dambos becoming more localised. Eventually, in the lower reaches of the main river systems below 900 m altitude, the dambos are unable to persist. My view is that these dambos that are unable to persist should be the areas with sufficient residual moisture for sustenance of pasture legumes introduced into the dambo vegetation after the rainy season has terminated. The more complex a plant community in terms of species diversity, the more likely that ecosystem stability is achieved.

DAMBO VEGETATION

Henkel (1931) was the first to describe and classify dambos in Zimbabwe as valley grasslands, and Whitlow (1985) noted that sedges and herbs are common and locally dominant constituents. The absence of trees and shrubs in Zimbabwe dambos was attributed to the inhibiting effects of seasonal waterlogging, periodic frosts, and occasional but intensive fires (Rattray, 1957). However, in many respects vegetation in Zimbabwe dambos is comparable to that of dambos elsewhere in central Africa

(Fanshawe, 1969; Werger and Coetzee, 1978). The vegetation generally comprises a mosaic of plant communities which changes in character from the margins to the central portions of the dambo dependant upon the degree and duration of waterlogging (Whitlow, 1985). This pattern of vegetation as described above has prompted my hypothesis that there must be different moisture levels supporting the growth of the different communities forming the mosaic, the moisture levels decreasing progressively away from the centre of the dambo and in effect allowing plants of different moisture requirements to grow within the limits of their tolerance to waterlogging. For this reason, a screening trial of forage legume species for selection of the best-bet types has been proposed on seasonally waterlogged lands. This is validated by the realisation by many researchers that these seasonally waterlogged lands are key grazing resources for livestock during the dry part of the year (June to October) (Whitlow, 1983; Scoones, 1987; Rattray, 1957). It is the availability of these key grazing resources (vleis browse, river banks, and drainage lines) and the facility of flexible utilisation that has sustained high livestock populations in the communal areas for a long period (Scoones, 1987).

In view of the foregoing, it becomes apparent that research aimed at improvement and development of dambo pasture is long overdue. If the carrying capacity is to be increased the key resources mentioned above are the components that research should focuss on, as they directly determine carrying capacity levels. Improvements in the extensive grazing land, although beneficial, will have less direct effect on carrying capacity and, because this is a far larger area than the key total land resource area, any attempts at intervention will be financially and operationally more difficult than a focussed approach (Scoones, 1987). With draught power provision being a primary objective for communal area livestock, development oriented research on key resource areas that provide dry season fodder is vital. Selective use of the key resources opens up the possibilities for selective feeding of priority stock (draught oxen; milking cows), reserved dry season grazing and their development as fodder banks.

SIGNIFICANCE OF DAMBOS IN PEASANT FARMING COMMUNITIES

The moist conditions which prevail in dambos for most of the year provide a favourable environment for plant growth. However, there appears to have been a preoccupation with the hazards of soil erosion and drying out of dambos in Zimbabwe (Jennings, 1923; Rattray et al; 1953) such that legal restrictions have prevented realization of the potential of these seasonally waterlogged lands through various prohibitive measures enshrined in the legislature.

The most common form of dambo utilisation is for livestock grazing. In commercial farms the dambos are burned from late August to October. The residual soil moisture is adequate to support new growth of herbaceous cover, providing valuable grazing at a time when other sources of feed are at a low level (Whitlow, 1985). In peasant farming areas dambos are used as part of the communal grazing lands. Dambo cultivation has required drainage of excess water. A traditional method developed by peasant farmers is to use ridges and furrows trending down the slope. This system is ideally suited to small-scale hoe cultivation but did not meet the needs of mechanical farming on commercial scale (Whitlow, 1983).

The prevalence of dambo cultivation with rice and tsenza (*Cleus esculentus*) being important crops amongst peasant farmers was reported nearly a century ago (Bishop, 1975; Whitlow, 1985). Remnants of ancient ridges and furrows occur in many dambos in the wetter parts of Zimbabwe and may date back some 250 to 300 years (Whitlow, 1983). Dambo cultivation is a well established tradition amongst peasant communities in Zimbabwe as elsewhere in central Africa (Walker, 1966; Russell, 1971). Dambo gardens provide a good regular supply of crops for home consumption and for sale in urban centres. They are especially important during drought years when dryland crops are poor, but wet conditions in dambos are still adequate to yield reasonable harvests (Mazambani, 1982). Only one detailed study on the importance of dambos in the agrarian economics of the peasant farming sector of Zimbabwe has been carried out (Thiessen, 1975). This confirmed that there was a positive relationship between the area of dambo cultivated by individual families and their socioeconomic well-being.

The legislative restrictions on dambo cultivation have retarded implementation of organisational reforms and have contributed to the deterioration of man-land relationships in these areas (Whitlow, 1979). Whitlow's (1985) view is that there is a need to reassess the role of dambos in peasant farming particularly since overgrazing and trampling by livestock have probably caused more serious erosion than cultivation. I also find it important that research into improvement of dambo management, pasture development and utilisation has to be carried out with the aim of improving and sustaining livestock condition through the dry part of the year, and improvement of quality of forage at that time.

Studies have been initiated aimed at quantifying grazing management effects on dambo resources (Tables 2 and 3).

Table 2. Seasonal changes in dry matter (DM) yields of vlei sites compared to adjacent top land in Zimbabwe (1987/88). Preliminary Data.

Grazing schemes: Kowoyo A. Province: Mashonaland East (1987/88)

Rainfall: 800 mm$^+$/annum.

Pad.	Sampling site locations	kgDM/ha Dec '87	Feb '88	May '88	Change in DM yield Dec-May
A	Vlei margin	550 G	466 R	1099 R	549
B	Vlei stream bank	834 G	364 G	742 G	-92
C	Vlei stream bank	158 G	440 G	749 G	591
D	Vlei topland	229 G	229 G	631 G	401

G = Grazed R= Rested at time of sampling
Source: Mupangwa and Nyathi, 1988.

Observations:- There was a decline in DM yield in Pad A (15%) and B (56%) from early to mid-season due to stock concentration in these two paddocks during that period (records of stock movement). The vlei stream bank sites had higher dry matter yields than topland sites at the end of season (May) despite having been continuously grazed throughout (December 1987 to May 1988), attributed to higher moisture levels in the former than the latter. The vlei margins (Pad A) had a partial rest from mid (Feb) to end of season (May) resulting in increased DM production, almost twice as much as the vlei stream bank, and the wooded topland site. Continuous grazing of the vlei stream bank (Pad B) throughout the summer season seems to have negative effects on grass growth and herbage production (-92 kg/ha by May).

Table 3. Seasonal changes in dry matter (DM) yields of vlei sites compared to adjacent top land in Zimbabwe (1987/88). Preliminary data.

Grazing yields: Chikowore. Province: Mashonaland Central
Rainfall: 800mm^{+}/annum

Pad	Number/location	Dec '88	Feb '88	May '88	Change in DM yield Dec-May
1	Topland-Mt slope thick bush	196 G	577 R	668	472
2	Previously cult-ivated Mt slope	142 G	613 R	823	681
3	Vlei stream bank	137 G	615 R	941	804
4	Mountain foot sparse tree distribution	177 R	995 G	338	161

G = Grazed; R = Rested at sampling time
Source: Nyathi, 1987; 1988

Observation: In all sites change in DM yield is greater between Dec-Feb than Feb-May due to vigorous grass growth and higher rainfall in the early summer season period than the late season. The vlei stream bank site seems to produce higher DM yields than the previously cultivated Mt. slope and topland when all three sites had mid-season rest while the mountain foot area was grazed.

CONCLUSION

Dambo utilisation is seemingly hampered by waterlogged conditions which prevent normal microbial activity, root development, and organic matter degradation. This should not be so prohibitive since indications from the literature alluded to in the text are that dambos have gradations of moisture resulting the vegetation zonation according to decreasing moisture levels away from the eye of the dambo (wettest spot). Furthermore, the pattern of organic matter accumulation and degradation follows the same trend with higher levels of undecomposed organic matter in the centre of the dambo (eye) than in the dambo margin (drier part). Soil depth increases towards the dambo centre. At the dambo margin, however, conditions appear to be ideal for crop production and the peasant farmer has evolved ridges and furrows over the years for production of rice and other crops.

An area of 1.2 million hectares occupied by dambos in Zimbabwe is indeed large enough to warrant investigations into its proper management, utilisation and development for sustained livestock production. Preliminary results of comparisons of dambo herbage production with topland sites seem to show that dambos are consistent sources of forage. With the overwhelming evidence that dambos are used for livestock grazing both by the large-scale commercial farmer and the communal small-scale farmer, it becomes imperative for agricultural scientists to start development-oriented agricultural research programmes that will help to reveal the productive potential of dambos.

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WORKSHOP SUMMARY AND RECOMMENDATIONS

The workshop was attended by nearly 90 delegates from twenty-two countries of East, North, Southern, Central and West Africa with 52 papers presented in four sessions. The content of these sessions was somewhat varied ranging from specifically forage to specifically agricultural by-products but the majority of papers addressed both forages and by-products together. This makes it difficult to draw a line of distinction between the people and subject matter with respect to their affiliation with either PANESA or ARNAB networks.

In relation to by-products, there appeared from this meeting that there was a move away from such treatments as alkali/ammonification as being very unrealistic from a smallholder farmer's point of view to conserving to reduce trampling spoilage and earlier harvesting of residues to reduce spoilage by exposure. There is evidence of a growing realisation that forage materials, particularly legumes, have a very important supplementary role to play.

It is apparent from the number of presentations and from the field trip to visit a smallholder rural dairy project outside Lilongwe city, that grass forages play a very significant role in meeting the nutritional demands of upgraded livestock for milk production. Napier grass (Pennisetum purpureum) was perhaps the most important resource in this respect though Rhodes grass (Chloris gayana) was also widely used on fallow lands. The questions of long-term maintenance of soil fertility was not squarely addressed. However, there is the danger of running into competition for the fertility inputs which come largely from manure, between the demands of crops and forages. In many cases this was not being considered, except in one paper on the transfer of technology related to Rhizobium and legume-nitrogen economy, to the likely detriment of productivity and longevity of the fodder resource and possibly also crop production.

While grass forages clearly have a role to play in their capacity to produce bulk, which is often in short supply during the wet season because of the intensity of land use for crop production, there is the need for an overall strategy of quality forage production using legumes to help maintain soil fertility and during the dry season to supplement the quality of the otherwise low-quality crop residues and agro-industrial by-products.

Then there was the question of lack of or minimal adoption of research results due to socio-economic and poor research-extension-farmer linkage.

The resolutions derived from the four working group sessions on the last day of the workshop were:-

1. Despite the long history of research in both pasture and agricultural by-products there has been little impact to the small-scale farming systems. There are two possible reasons for this: some of this research might have been inappropriate; where research has been appropriate the resultant technology had not been transferred to the farmers, mainly due to weak extension service.

2. There is a need for continued monitoring and evaluation of the relevancy and effectiveness of research programmes if we are to deliver the goods to the farmers.

3. The extension services need to be strengthened if progress is to be made in farmer adoption of research results. This may be done through *inter alia*, improved linkages between researchers and extension worker (through joint research), involvement of networks in training extension staff and improved university training in extension.
4. Land tenure systems in most countries militate against improved pasture and animal management. There is, therefore, a need to involve and advise the policy makers. The workshop also highlighted the need for studies on ecosystems, grazing studies and degradation of the environment, and integration of soil conservation and forage production if sustainable land-use systems are to be designed.

5. The availability of pasture seed was identified as a constraint. This problem could be alleviated by importation of seed in the short term, but ideally efforts should be made to produce seed locally and at affordable prices. It will be necessary to train farmers in seed production.

6. The important role of networks in co-ordinating research programmes within and between our countries was acknowledged. This may be facilitated by increased publication of Network Newsletters collaborative research and manpower development programmes.

7. There is a need for the authorities to provide conducive pricing policies and credit facilities in form of inputs in order to facilitate adoption of improved technologies by farmers.

8. It is imperative that the nutritive characteristics of available crop residues, by-products and pasture forages are measured and information placed in data banks for use by all interested parties. An inventory of the products and their accessibility is necessary. The need for standardization of terminology in describing food resources was also highlighted.

9. There is a need to develop appropriate experimental methodologies for on-farm research so that both the scientific merit and application of research results can be accommodated.

10. Economic appraisal should form an integral part of all research programmes.

11. Studies on feed resource budgeting and allocation should be encouraged in order to facilitate design of correct feeding strategies.

12. Reviews on topical subjects should be commissioned by the Steering Committee of the two networks in order to improve access to information which may be scattered in numerous publications.

13. Commercial feed manufacturers should be encouraged to produce stockfeeds from crop residues and agricultural by-products at prices which are affordable to the small-scale farmers. It may, however, be necessary to first investigate the suitability of machinery.

14. There is a need to training in oral presentation of research results by scientists, for instance, this may be offered as part of training programmes put by Networks or ILCA.

15. Recommendations from previous workshops should be referred to as most remain topical.

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