# ACCOMPLISHMENTS OF PARTICIPATORY RESEARCH FOR SYSTEMS IMPROVEMENT IN IGANGA DISTRICT, UGANDA 1993 TO 1997

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# PREFACE

This volume, the twenty-seventh in a working document series that serves research on common bean (*Phaseolus vulgaris* L.) in Africa, reports on systems research with a community-based participatory research approach conducted as an activity of the Eastern and Central Africa Bean Research Network (ECABREN). Research was initiated by the National Agricultural Research Organization (NARO) and CIAT research staff with farmers in 1992 in the Ikulwe area of Iganga District of eastern Uganda. Much information has been gained on technical alternatives for improving the farmers' production systems through integration of superior crop varieties with improved options for crop, soil and pest management. Lessons learned on collaboration with farmers in research are of value to systems researchers in other countries. Besides Uganda, other countries of ECABREN are Burundi, D.R. Congo, Ethiopia, Kenya, Madagascar, Rwanda, Sudan and Tanzania.

The Pan-Africa Bean Research Alliance (PABRA) serves to stimulate, focus and coordinate research efforts on common bean. PABRA is organized by CIAT in collaboration with two interdependent sub-regional networks of national programs: the Eastern and Central Africa Bean Research Network (ECABREN) and the SADC Bean Research Network (SABRN) for southern Africa.

Working documents include bibliographies, research reports and bean network discussion papers. These publications are intended to complement two associated series of Workshop Proceedings and Reprints.

Further information on bean research in Africa is available from:

Pan-Africa Coordinator, CIAT, P.O. Box 6247, Kampala, Uganda.

Regional Coordinator, Eastern and Central Africa Bean Research Network, P.O. Box 2704, Arusha, Tanzania.

Regional Coordinator, SADC Bean Research Network, P.O. Box 2704, Arusha, Tanzania.

# ACKNOWLEDGEMENTS

Many farmers in the Ikulwe area participated in the research and in disseminating the information to other farmers. Brian Tibenkana from the Ikulwe District Farmers Institute played an important role in the initiation of the participatory research. Numerous researchers of NARO and the international agricultural research centers have contributed to the work with input from: Forestry Research Institute for alley cropping, Namulonge Agriculture and Animal Research Institute for beans, soybeans, cassava, sweet potato, rice and groundnuts; Kawanda Agricultural Research Institute for soils, horticulture, beans and post-harvest; the International Institute of Tropical Agriculture for banana integrated pest management research; and Namalere Appropriate Technology Institute for Agro-mechanization.

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# TABLE OF CONTENTS

# ACCOMPLISHMENTS OF PARTICIPATORY RESEARCH FOR SYSTEMS IMPROVEMENT IN IGANGA DISTRICT 1993 TO 1997

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## SUMMARY

Researchers of NARO and CIAT began collaborative research with farmers in Iganga with participatory exercises for characterization and diagnosis (C&D) in 1992. This was followed by participatory research to improve their systems which has been on-going until present. Some highlights of research findings follow.

- Farm sizes were commonly of 1.8 to 2.0 ha. Large livestock units were absent from most farms, with few on other farms. The farming systems were biologically and agronomically diverse with farmers relying on numerous commodities for food and income.
- Soils generally were sandy loams with moderate levels of organic carbon, soil pH and bases, but very low in phosphorus. Farmers grouped the soils as upland (*elyomutala*) and valley (*elyakibali*) soils. The most important type was an upland soil called *emyufu*.
- The problem solving research responded to needs identified with farmers as active participants in the research.
- Cassava varieties were tested in response to the severe cassava mosaic virus which increased from low to very high importance during this period. Nanse 2 and SS4 were identified as promising and are being multiplied by farmers.
- Numerous bean varieties were tested for good performance under low input conditions and acceptability, and several were subsequently adopted, multiplied and supplied to other farmers.
- Botanical materials were tested for control of maize and bean storage pests, but the results were not conclusive.
- Hot water treatment of pared corms of banana proved successful as a component of IPM for banana weevil and nematodes.
- Soybean responded well to inoculation of seed with *Brady rhizobium* with marginal rates of return exceeding 400%.
- Bean responded to inoculation with rhizobia only when P was applied. P application resulted in increased N-fixation and productivity, but P plus inoculation resulted in the most N-fixation (about 30 kg $ha^{-1}$) and the heaviest yield.

- Root (mole) rats were successfully cleared from fields by planting tephrosia, a leguminous species which appears to derive about 50% of its N from the atmosphere.
- Farmers, most of whom had no cows, found strategic use of vetiver grass as living barriers appropriate for soil erosion control.
- Much work was done with green manure/cover crop species. Production through intercropping with a food crop was especially appropriate with crotalaria (maize and bean) and canavalia (maize, bean, sweet potato). Improving fallow with crotalaria was superior to a weedy fallow. Mucuna was especially preferred by farmers when noxious weeds were a problem. Lablab was most preferred for fodder. Crotalaria, although agronomically superior in improving productivity of subsequent crops, was relatively laborious to produce and was least adopted.
- The green manure research stimulated much experimentation by farmers on ways of integrating these species into their production systems. A decision guide to the use of four species was developed.
- Alley-cropping using hedgerows of calliandra did not result in improved crop yields over the eight seasons of evaluation.
- Residual effects of P on bean yield were significant.
- Nutrient fluxes and balances were determined at the crop, land use type and farm levels. Farmyard manure and crop residues were generally well used. There was much nutrient transfer to banana which had positive balances, while macro-nutrient balances for annual crop land use type were negative (-60, -7, and -60 kg $ha^{-1}$ for N, P and K, respectively).
- Farmers who participated in the research have done much to facilitate technology transfer including multiplication and sale of seed of improved bean varieties and green manure species, hosting groups of visiting farmers, organizing workshops to inform other farmers, use of the media and attendance at national agricultural shows and various meetings.
- The participatory research continues with emphasis on crop variety evaluation and soil management. Work has been initiated on grain storage.
- Lessons have been drawn from experiences gained in planning and designing research with farmers, and in evaluation of results from farmer experimentation.

## INTRODUCTION

Participatory research to improve the farming systems in the sub-humid, traditionally 'banana-coffee based' farming systems of eastern and central Uganda was initiated in 1992 with characterization and diagnosis (C&D) using participatory rural appraisal approaches. Additional C&D exercises and a planning meeting followed in 1993; C&D has subsequently been on-going. Implementation of field activities followed and continued until the present time. Beginning in 1996, dissemination of newly gained information to farmers in other communities of the agro-ecological zone became a major activity.

The participatory research, was done with farmers from the communities around Ikulwe DFI in Iganga District ($0^o$ 26’ N, $33^o$ 28’ E, 1170 m asl). Many farmers have participated over the years, typically with 25-30 active at any one time, and 12-15 who have remained active throughout.

## CHARACTERIZATION AND DIAGNOSIS

### *Rainfall distribution*

Rainfall distribution was essentially bimodal, with peaks in April and again in October and November (Fig.1), with an annual mean of 1250 mm. Farmers' perception of the pattern of distribution was very similar to the pattern established from 25 years of measured rainfall, but farmers tended to underestimate rainfall during the drier months of January, February, June and July, and to over-estimate April and August rainfall. Water deficits often are a major constraint to crop performance, and need to be considered in interpretation of research results.

### *Labor demand*

Farmers estimated the demand for labor to be greatest in March, April, September and October (Fig. 2). These periods coincided with sowing and weeding times. The results suggest that technical alternatives that require much labor during these periods of peak demand are not likely to be well adopted unless labor saving alternatives could be adopted. For at least five months of the year, the labor capacity of the farmers appeared to be very much under-utilized, presumably offering opportunities for increased productive activity.

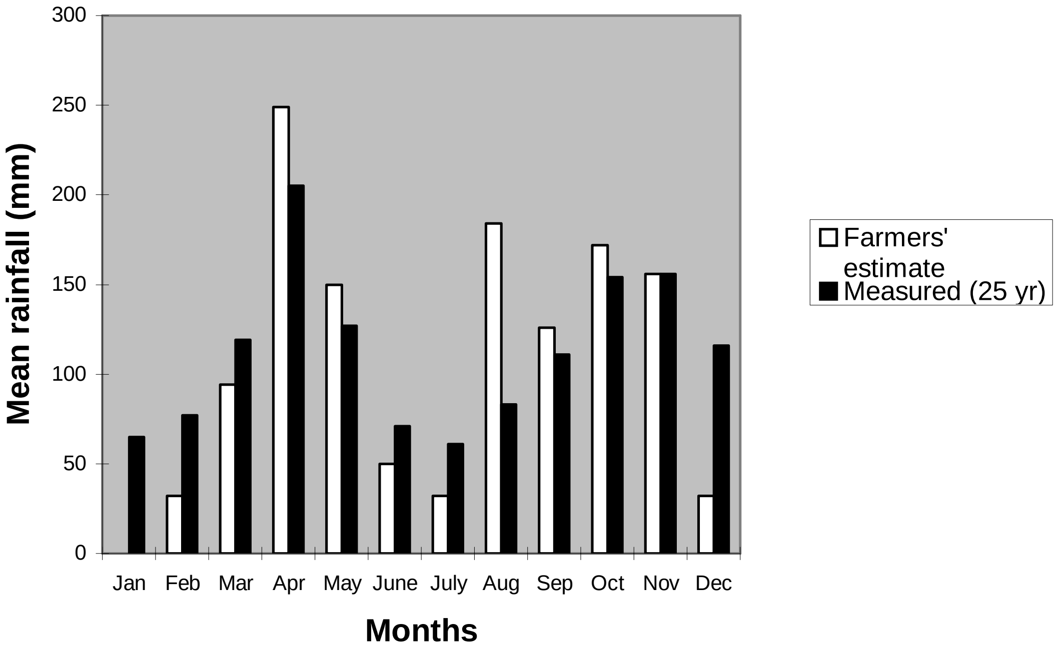


Figure 1. Rainfall distribution in Ikulwe according to long term monthly means and farmers' perceptions.

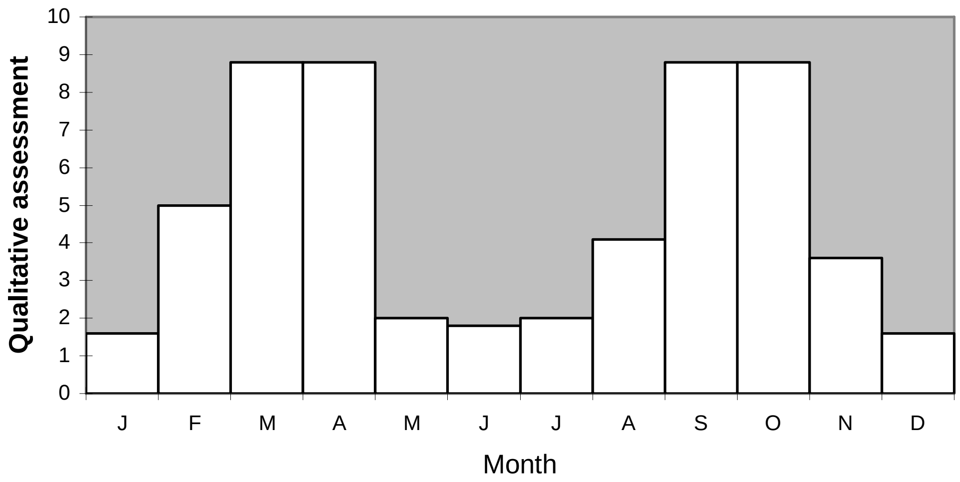


Figure 2. Monthly distribution of labor demand in Ikulwe as perceived by farmers.

Farmers estimated that they invested more labor in banana than in other crops, though labor demand for banana was spread throughout the year (Fig. 3). They also estimated that they invest much labor in cassava, which was often intercropped with beans and groundnuts. Less labor was apparently invested in other crops although information on seasonality of demand was inadequate.

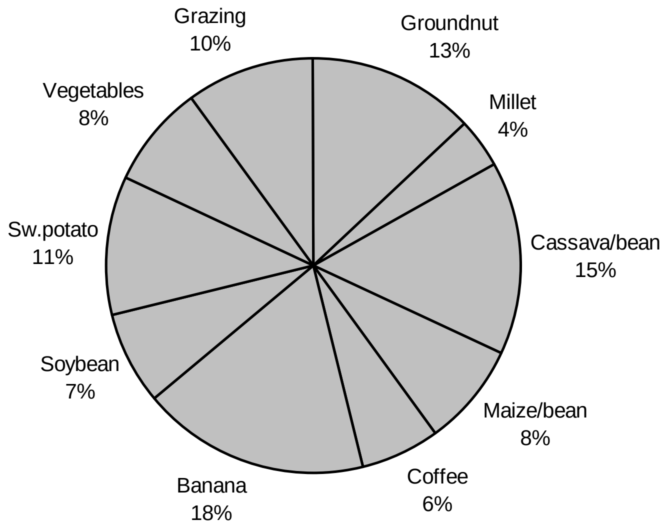


Figure 3. Relative labor investment for different crops in Ikulwe as perceived by farmers.

The amount of work for different farm operations performed by men and women differed (Table 1), and the perceptions of women sometimes differed from those expressed by a mixed-gender group which was dominated by men. Clearing bush and marketing of dry and uncooked produce were responsibilities of men, while women did most of the planting, and much of the weeding, harvest of fresh produce, marketing of cooked produce, and winnowing. Men and women were similarly responsible for most other operations. The all-women group estimated the role of women to be greater than perceived by the mixed-gender group, particularly in planting and weeding of annual crops, and winnowing and drying of beans.

Table 1. Labour distribution between sexes for different crop operations as indicated by farmers from Ikulwe (‘X’ for the mixed-gender, ‘x’ where an all-women group suggested modification).

| Crop operation | Man | Woman |
|---|---|---|
| **Maize** | | |
| Slashing | XXXXXXXXXX | |
| Tilling | XXXXX | XXXXX |
| Planting | XXXXX | XXXXX |
| | xx | xxxxxxxx |
| Weeding | XXXXX | XXXXX |
| | xx | xxxxxxxx |
| Harvesting | XXXXX | XXXXX |
| Drying | XXXXX | XXXXX |
| Selling | | |
| uncooked | XXXXXXXXXX | |
| cooked | | XXXXXXXXXX |
| **Bean** | | |
| Tilling | XXXXX | XXXXX |
| Planting | | |
| chop and plant | | XXXXX |
| line planting | XXXXX | XXXXX |
| | xxx | xxxxxxx |
| Weeding | XXXXX | XXXXX |
| | xx | xxxxxxxx |
| Harvest | | |
| dry | XXXXX | XXXXX |
| fresh | | XXXXXXXXXX |
| Threshing | XXXXX | XXXXX |
| | xx | xxxxxxxx |
| Winnowing | | XXXXXXXXXX |
| Drying | XXXXX | XXXXX |
| | xx | xxxxxxxx |
| Selling | XXXXXXXXXX | |
| **Groundnut** | | |
| Tilling | XXXXX | XXXXX |
| Planting | XXXXX | XXXXX |
| | xx | xxxxxxxxxx |
| Weeding | XXXXX | XXXXX |
| | xx | xxxxxxxx |
| Harvesting | XXXXX | XXXXX |
| Selling | XXXXXXXXXX | |

***Land use***

Farm sizes were commonly of 1.8 to 2.0 ha.  Many farms had no livestock other than chickens.  The mean numbers were 1.5 local cows, 0.2 improved cows, 1.7 goats or sheep, 0.9 pigs and 12.0 chickens per farm.  The farming systems were found to be biologically and agronomically diverse with small but numerous parcels (the mean was 14 parcels/farm) having varying crop associations, planting dates, etc..  The parcels were generally contiguous, however, and part of one or two land units.  Most of the cultivated land was on hillsides, which had the greatest concentration of banana, but the hill crests and foot-slopes were often cultivated as well.  Crop and agronomic diversity was high with six or more food crops, usually with two or more cultivars, occupying at least 2% of the land (the indicators of diversity in Table 2 consider species but not cultivars).

Farmers indicated that more land was used for banana production than for any other crop (Fig. 4).  Much land was also planted to maize, cassava and fruits.  Bean, sweet potato and grazing accounted for smaller proportions of land use.  Other information, however, indicates that farmers under-estimated the importance of cassava (Table 2).

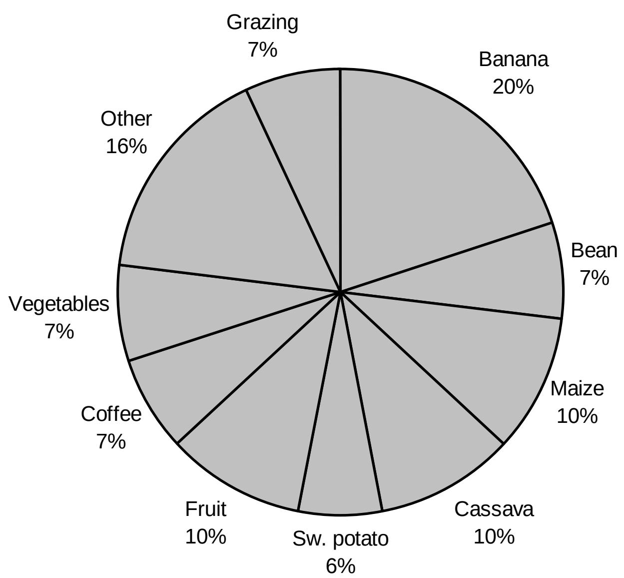


Figure 4.  Land use for different crops in Ikulwe as perceived by farmers.

Table 2. Allocation of land in the 1995b season.

| Crop association | Area, % | Crop association | Area,% |
|---|---|---|---|
| Banana, sole crop | 5.6 | Maize/groundnut | 2.3 |
| Banana/coffee | 2.3 | Bean sole crop | 0.3 |
| Banana/maize | -- | Cassava sole crop | 9.1 |
| Banana/bean | 2.9 | Cassava/maize | 12.3 |
| Banana/groundnut | 1.5 | Sweet potato sole crop | 3.1 |
| Coffee, sole crop | 8.0 | Soybean sole crop | 1.4 |
| Maize sole crop | 1.3 | Vegetable/fruit | 0.3 |
| Maize/bean | 5.4 | Fallow | 4.1 |
| Maize/soyabean | 2.0 | Pasture | 5.9 |

| | Indicators of crop and agronomic diversity | |
|---|---|---|
| | Crop species | Crop associations |
| Species/association number (S) | 12 | 26 |
| Shannon diversity index (H') | 2.13 | 2.45 |
| Shannon evenness index (E) | 0.86 | 0.75 |
| Berger-Parker diversity index (d) | 0.23 | 0.13 |

S was the number of crop species or crop associations indicating richness of diversity;
H' combines richness and evenness to give proportional abundance;
E gives evenness of diversity; and
d indicates relative dominance of the most abundant type.

Source: Wortmann and Kaizzi, in press.

***Seasonal food availability***

Food availability varied throughout the year as did the relative importance of different foods (Table 3). Cassava and vegetables were of major importance year around. Banana and sweet potato were also of importance throughout the year but less available in some months. Maize, beans, pumpkin and groundnuts were important food crops but their availability varied greatly throughout the year with supplies generally depleted well before the first harvest of a season.

***Biotic constraints to crop production***

Web blight, angular leaf spot and common bacterial blight were all occasionally important as constraints to bean production. Bean stem maggot has caused much damage to bean seedlings in late sown bean.

Groundnut rosette occurred commonly as a constraint to groundnut production. Maize streak was occasionally devastating to susceptible varieties. Banana production apparently has declined due to low productivity caused by a complex of weevils, nematodes, foliar diseases and plant nutrition problems. Sweet potato weevil caused significant yield loss. Root rats (commonly called mole rats) damaged several crops, but especially root crops, including sweet potato and cassava. Termites caused much damage to maize during dry periods.

Table 3. Food availability calendar as perceived by farmers in Ikulwe.

| *Crops* | *Jan* | *Feb* | *Mar* | *Apr* | *May* | *Jun* | *Jul* | *Aug* | *Sep* | *Oct* | *Nov* | *Dec* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize | XXX | x | | | x | XXX | XXX | XXX | XXX | Xx | X | XXX |
| Bean | | | | xxx | XXX | XXX | xxx | | | Xxx | XXX | XXX |
| Banana | XXX | xxx | xxx | xxx | xxx | XXX | XXX | XXX | xxx | Xxx | Xxx | XXX |
| F. Millet | | | | | xxx | XXX | XXX | | | | | |
| Sorghum | | | | | xxx | XXX | XXX | | | | | |
| Soybean | | XXX | | | | | | XXX | | | | |
| Simsim | XXX | | | | | | | XXX | | | | |
| Cassava | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| Vegetable | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| Bambara | | | | | | | XXX | XXX | | | | |
| Pea/gram | | | | | | XXX | XXX | | | | | |
| Rice | | | | | | | | | XXX | XXX | | |
| Groundnut | XXX | | | | | XXX | XXX | | | | | XXX |
| Sw. potato | Xxx | xxx | xxx | xxx | xxx | xxx | XXX | XXX | XXX | xxx | xxx | xxx |
| Pumpkin | | | | xxx | xxx | XXX | XXX | XXX | xxx | | | |
| Citrus | Xxx | xxx | xxx | xxx | xxx | XXX | XXX | XXX | xxx | xxx | xxx | xxx |
| Sugarcane | | | | | | | xxx | Xxx | XXX | XXX | xxx | xxx |

'X' and 'x' indicate moderate to high importance and low to moderate importance, respectively, during three periods of the month.

Severe cassava mosaic virus has emerged as a major constraint to cassava production since the participatory research was initiated. Cassava mealy bug was a priority problem initially but is no longer considered important, probably because of effective biological control introduced to Uganda in the 1980's.

### ***Soil types***

#### *Farmers' classification of soils*

Farmers consider color, texture and topographic position in classifying their soils (Tables 4 & 5), and evaluated their soils for water holding capacity, tilth, nutrient supply and water infiltration rate (Table 6). They differentiated between one to four soil types on their own farms. Soils differed significantly for organic matter, P and Ca, but not for pH and K (Table 7). The soils could be grouped into upland (*elyomutala*) and valley (*elyekibali*) soils. Most production occurred on the upland soils but valley soils can be more productive. The valley soils were used for dry season production, but few farmers had access to these. *Elyekibali* soils were higher in OM than the other types. *Elilugavu* and *elyekibali* were highest in P and Ca which confirms the farmer perception that these were fertile soils; poor drainage was limiting to crop production on *elyekibali* soils

#### *Upland (elyomutala) soils*

*Emyufu* was the most important soil in terms of area as well as crop production. These were typically red-brown in color and considered by farmers to be relatively fertile, although P was generally low (Table 4 and 6). These soils were found on the hillsides

Table 4. Farmers' soil classification and characteristics of soils at Ikulwe

| Soil type | Translation | Occurrence | | Soil color | Soil depth (cm) | | | Topsoil pH ($H_2O$) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Total | % of Farms | | Top soil Range | Mean | Subsoil Range | Range | Mean |
| Elyolubalebale | gravelly/ stoney | 22 | 62.9 | brown/dark reddish brown | 10-30 | 21 | 20->90 | 5.1-6.7 | 5.6 |
| Lusenyhosenyho | Sandy | 14 | 40.0 | brown/greyish brown | 25-40 | 29 | 45->90 | 4.5-6.0 | 5.2 |
| Emyufu | red(dish) | 12 | 34.3 | (dark) reddish brown | 15-40 | 29 | 30->90 | 5.2-6.3 | 5.7 |
| Eliirugavu | black/dark soil | 10 | 28.6 | black/dark reddish/brown/ greyish black | 25-55 | 37 | >90 | 5.3-6.7 | 5.9 |
| Elyekibali[1)] | swamp soil | 8 | 22.9 | black | 13-55 | 29 | 40->90 | 5.1-6.3 | 5.7 |
| Elyomutala[1)] | crest soil | 7 | 20.0 | (dark) reddish brown/greyish brown | 25-30 | 29 | 70->90 | 5.5-6.0 | 5.9 |
| Kikusikusi | brown(ish) | 5 | 14.3 | (dark) reddish brown | 20-30 | 27 | >90 | 5.0-5.9 | 5.7 |
| Elyeitosi | clay/muddy | 1 | 2.9 | greyish black | 20 | -- | >90 | ---- | |
| Kigoola | Unproductive/ grazing land | 1 | 2.9 | black (?) | 30 | -- | 75 | ---- | |
| Lumosi(mosi) | clay/black | 1 | 2.9 | black | 25 | -- | >90 | ---- | |
| Gamugamu | sticky | 1 | 2.9 | greyish brown | 30 | -- | >90 | 5.5 | |

[1)] *Elyekibali* and *Elyomutala* refer to valley and upland soils generally, and each includes several soil types.

Table 5. Farmers soil classification in Ikulwe (Iganga District) and Matugga (Mpigi District)

| Soil name (vernacular) | | Physiography | Description | Land management / crops |
|---|---|---|---|---|
| Ikulwe (Lusoga) | Matugga (Luganda) | | | |
| Eliirugavu | Lidugavu | Occurs on hilltop and foothill | Black/dark soil, deep, easily eroded; does not stick to cloth or skin and easy to brush or wash off | High crop potential (same as Imyufu); especially suitable for bananas; soybeans have too much vegetative vigour and produce few seeds |
| Elyolubalebale | Luyinjayinja | Occurs on crest and hillslopes | Gravelly/stony soil including a subgroup: murram type with small breakable stones cemented together ("Ekisirikoko") | Poor soil, crops easily wilt during dry spells; cassava gives a fair crop, not suitable for sweet potato, beans and banana |
| Lubale | Lwazi | Occurs on hill-slopes and eroded surfaces | Rocky, mostly laterite, too hard to dig | No cultivation |
| Emyufu Luondo) | Limyufu(myufu) | Mostly found on crest (Lyamutala) | Deep soil with good water-holding capacity; low erodibility; sticks to the hoes when wet and can not easily be brushed off from clothes; crops splashed with soil during rains; good for making bricks | Very productive soil, most crops grow well; soybean only yields well after the soil has lost some of its fertility |
| Kikusi(kusi) | Lukusi(kusi) | Mostly found on crest (Lyamutala) | In Busoga it was used as a synonym to Imyufu but referring more to the subsoil of Emyufu | As for Emyufu |
| Lusenyhosenyho (Luchangachanga) | Lusenyusenyu | Occurs on crest and hillslopes | Deep "light" soil, sandy; easily wettened, good infiltration; easily eroded, fine material washed away, coarse material remaining. Therefore the soil was becoming more sandy; easy to dig; termite was a common problem | Fertility medium to low, suitable for cassava, sweet potato, beans millet, banana |
| Musenyho | Omusenyu | Mostly found on foothills | Very sandy soil with low water-holding capacity | Unproductive, sometimes cassava |
| Elyeitosi | Lubumbabumba | Occurs in swamps (Lyekibali), small areas, flat | Clay/sandy clay; muddy when wet, cracks when dry; sticks to the hoe | Especially suitable for rice |
| Elyeibumba (Lumanto, Itosi) | Bumba (Tosi) | Occurs in the swamps; covers large areas | Almost pure clay used for making pottery | Not cultivated |
| Lumosi(mosi) | | Occurs in valleys | Clay soil, sticky (=gamugamu), waterlogged when wet | Suitable for rice |
| Kiyolera | | Occurs in small patches (less than 1 acre) on crests | Mostly shallow soils underlain with rock; low water-holding capacity. All crops perform poorly but causes were not known | Unproductive |
| Elyolunyu | Lunyu | Occurs in patches, mostly found on hilltops | Literal translation: salty. Identified as a very infertile soil; has been associated with manganese toxicity. | Unproductive, grazing area, no cultivation |
| | Zibugo | Occurs on hilltops and upper slopes | Lit. translation: dead, kills crops. Very infertile soil. Problem not clearly identified. | Poor growth of all crops. Grazing. |
| Kigoola | | Flat land, vast open plains | Mostly shallow underlain with laterite; waterlogged during rains but dries quickly during dry spells | Unproductive, mainly used for grazing |
| Lyekibali | | Swamp soils | Refers more to location than to a particular soil type; all Itosi, Lutositosi and some of the Lumosi soils belong to this group | Too wet for banana |
| Mutalatala | | Crest soils | Refers more to location than to a particular soil type. Most of the soil belonging to this group were sandy loams | |

and were well drained. The soil had good water holding capacity and good infiltration, and it resisted erosion (Table 8). The soil became hard when it was dry but had good tilth when wet. All crops could be grown on emyufu (Table 9 and 10).

Table 6. Positive and negative soil characteristics cited by farmers for one or more soils.

| *Soil characteristics* | *Positive (% of 35 farmers)* | *Negative (% of 35 farmers)* |
|---|---|---|
| Water-holding capacity | 59 | 38 |
| Tilth | 49 | -- |
| Nutrient supply | 46 | 37 |
| Infiltration rate | 44 | -- |
| Aggregate stability | 23 | -- |
| Internal drainage | 18 | -- |
| Soil depth | 15 | 6 |
| Stickiness (to hoe) | -- | 22 |
| Erodibility | -- | 16 |
| Gravel/stones | -- | 15 |
| Compaction | -- | 11 |

Table 7. Soil pH, organic matter, and available P, K and Ca for major soil types at Ikulwe

| *Soil type* | *pH* | *OM* | *P* | *K* | *Ca* |
|---|---|---|---|---|---|
| | | *(%)* | *(ppm)* | *(mg/100g soil)* | |
| Elyolubalebale | 5.6 a | 2.9 a | 1.4 c | 20.0 a | 49.0 ab |
| Lusenyhosenyho | 5.7 a | 2.3 a | 4.5 bc | 14.5 a | 30.3 b |
| Emyufu | 5.7 a | 2.5 a | 4.1 bc | 22.2 a | 43.3 ab |
| Eliirugavu | 5.8 a | 3.4 a | 20.2 a | 20.0 a | 70.6 a |
| Elyekibali | 5.8 a | 5.0 b | 17.0 ab | 19.6 a | 72.8 a |
| Lyamutala | 5.9 a | 2.6 a | 7.2 abc | 24.8 a | 52.2 ab |
| Mean | 5.75 | 3.12 | 9.06 | 20.18 | 53.03 |

*Elilugavu* was black soil found in newly opened fields. It was generally considered to be the most fertile soil and was high in available P and Ca. The fertility quickly declined, however, with annual crop production and the soil becomes *emyufu* or another type. It generally had good water holding capacity and good infiltration. These soils were suitable for most crops.

*Elyolubalebale* contained a fraction of coarse fragments (>2 mm). It was found on most farms and was considered to be productive when rainfall was adequate. All crops could be produced on this soil type, but it was not well suited for maize production due to low water holding capacity. It was very low in available P and susceptible to erosion. These soils were considered inappropriate for banana production.

Table 8. Frequency of mention of positive and negative characteristics[1] by farmers for different soil types.

| | | Percent of farmers mentioning a characteristic as positive (+) or negative (-) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WHC | | NS | | STN | | SD | | TIL | IFR | AS | IDR | ERB | GR |
| Soil type | Frequency | + | - | + | - | + | - | + | - | + | + | + | + | - | - |
| Elylubalebale | 22 | 32 | 64 | 14 | 64 | 14 | 18 | 5 | 18 | 54 | 50 | 18 | 23 | 23 | 50 |
| Lusenyhosenyho | 14 | 57 | 29 | 64 | 74 | 21 | 14 | 0 | 0 | 50 | 36 | 21 | 21 | 21 | 0 |
| Emyufu | 12 | 75 | 25 | 42 | 58 | 33 | 25 | 17 | 0 | 75 | 33 | 25 | 0 | 0 | 8 |
| Eliirugavu | 10 | 70 | 30 | 80 | 10 | 10 | 20 | 30 | 0 | 30 | 60 | 30 | 40 | 20 | 0 |
| Elyekibali | 8 | 88 | 0 | 100 | 0 | 25 | 25 | 25 | 0 | 50 | 25 | 13 | 0 | 0 | 0 |
| Lymutala | 7 | 71 | 43 | 43 | 43 | 0 | 14 | 43 | 14 | 14 | 100 | 71 | 29 | 29 | 0 |
| Kikusikusi | 5 | 20 | 80 | 20 | 60 | 20 | 20 | 20 | 0 | 60 | 20 | 0 | 0 | 0 | 0 |

WHC = water-holding capacity; NS = nutrient supply; IFR = infiltration rate; AS = aggregate stability; IDR = internal drainage; STN = stickiness; SD = soil depth; TIL = tilth; ERB = erodibility; GR = gravel/stones.

Table 9. Well-adapted crops on major soil types as mentioned by farmers in Ikulwe.

| Soil type | Number of times mentioned | Well-adapted crop (% of times mentioned) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cooking Banana | Cassava | Maize | Beans | Sweet Potato | Ground nut |
| Elyolubalebale | 22 | 0 | 68 | 50 | 41 | 55 | 41 |
| Lusenyhosenyho | 14 | 29 | 57 | 64 | 29 | 43 | 14 |
| Emyufu | 12 | 25 | 67 | 75 | 67 | 58 | 67 |
| Eliirugavu | 10 | 20 | 70 | 90 | 70 | 80 | 40 |
| Lyekibali | 8 | 25 | 2 | 88 | 50 | 25 | 13 |
| Lyamutala | 7 | 29 | 71 | 86 | 57 | 29 | 43 |
| Kikusikusi | 5 | 20 | 0[1)] | 80 | 80 | 20 | 40 |

Table 10. Poor adaptation of crops on major soil types as mentioned by farmers in Ikulwe.

| Soil type | Number of times mentioned | Poorly adapted (% of times mentioned) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cooking Banana | Cassava | Maize | Beans | Sweet potato | Ground nut |
| Eliyolubalebale | 22 | 77 | 9 | 36 | 41 | 27 | 23 |
| Lusenyhosenyho | 14 | 50 | 0 | 21 | 21 | 21 | 21 |
| Emyufu | 12 | 83 | 0 | 8 | 33 | 17 | 17 |
| Eliirugavu | 10 | 60 | 10 | 10 | 10 | 0 | 10 |
| Lyekibali | 8 | 38 | 13 | 0 | 50 | 12 | 38 |
| Lyamutala | 7 | 57 | 29 | 0 | 14 | 29 | 14 |
| Kikusikusi | 5 | 60 | 20 | 20 | 0 | 40 | 20 |

*Lusenhyosenhyo* and *elyoluchangachanga were* sandy soils which occur on most farms. The productivity of these soils was low due to low nutrient supply and frequent water deficit stress (Table 6 and 8). *Elyochangachanga lilugavu* was dark in color and more productive than the lighter colored *elyomuchangachanga omweru*. The preferred crops on these soils were cassava, maize, sweet potato and millet, but banana is poorly adapted.

*Elyolubale/elyamabale* were stony soils found in isolated pockets. Only 22% of the farmers reported having these types. Fertility was relatively low and the soil was used for cassava, millet, sorghum and sweet potato production. Cultivation was difficult because of the stones. The soils were shallow and very drought-prone.

*Elyolunyu* were very shallow soils which occur amidst *emyufu* soils. The fertility was low and the soil was not suitable for crop production.

*Valley (elyekibali) soils*

Farmers named five soil types found in valleys. These were cultivated primarily during the dry season after the water had receded. Maize, sweet potatoes, beans, millet, vegetables, groundnuts, cassava, sugarcane and yams might be grown on these soils. Yields were generally better than on upland soils.

*Lusenyhosenyho* were sandy soils appropriate for crop production during the rainy season.

*Elyeibumba/lumanto* had a very high clay content and were used for making pottery. These were not suitable for crop production.

*Eyitosi/elyeitosi were* clay soils which were best suited for rice production. Other crops could be grown during the dry season utilizing residual soil moisture.

*Omusenyo* had a very high sand content and was used for construction purposes.

*Elilugavu* were black, fertile valley soils. All annual crops could perform well, with rice grown during the rainy season and other annual crops during the dry season.

**Identification and prioritization of problems**

In exercises to identify and prioritize problems, farmers first identified about 30 problems in a full group. They then allocated these problems as topics for discussion in small groups and prioritized the problems using a pair-wise ranking method (Fischler *et al.*, 1997). Farmers expressed most concern with biotic stresses (Table 11). Following discussions with researchers, farmers later revised their priorities giving soil fertility more importance: possibly because low soil fertility is a persistent problem that developed over time, farmers often give it low priority relative to problems which may occur only sporadically but with dramatic effects. Farmers and researchers agreed to focus research on African cassava mosaic virus, groundnut rosette, bean diseases, banana weevils, soil erosion control and soil fertility management.

Table 11. Priority problems identified by farmers in Ikulwe.

| Problem | Priority ranking |
| --- | --- |
| African cassava mosaic | 1 |
| Groundnut rosette | 1 |
| Banana weevil | 1 |
| Bean diseases | 2 |
| Sweet potato weevil | 2 |
| Cassava mealy bug | 2 |
| Tomato wilt | 3 |
| Soil erosion | 3 |
| Low coffee yield | 3 |
| Maize diseases, esp. streak | 4 |
| Root (mole) rats | 4 |
| Termites | 4 |
| Low soil fertility[1] | 5 |
| Unreliable rainfall | 5 |
| Monkeys | 5 |

[1]Later farmers revised their view on soil fertility and gave it a high rating.

## CROPPING SYSTEMS RESEARCH

Problem solving research was conducted using approaches and methods judged to be most appropriate for the topic. In cases where farmers were not very knowledgeable of the topic, such as in inoculum use and fertilizer use, researchers designed the experiments (Table 12). In other research, such as that on green manures, farmers and researchers designed the experiments together. In other work, such as that on tephrosia and living barriers for erosion control, farmers were recognized as being sufficiently knowledgeable to be able to experiment on their own. In these cases, researchers provided farmers with information, planting material and encouragement to experiment; farmers then proceeded on their own and, later, researchers and farmers evaluated the results of the farmers' efforts together. Researcher-farmer designed experiments with green manures stimulated the farmers' interest; they then began much experimentation on their own, the results of which were evaluated collaboratively by researchers and farmers.

The constraints addressed, the potential solutions tested, the type of trials conducted, and a summary of the results are presented in Table 12. Other results presented below in more detail.

***Nitrogen fixation in bean and soybean***

Nitrogen fixation trials were conducted for two seasons with beans (6 farms per season with 2 reps) and one season with soybean (11 farms with one rep).

Bean yield was not much improved by inoculation alone but yield was significantly improved with use of phosphate fertilizer (Table 13). Using P fertilizer and inoculation together appeared to most economical. Bean derived 13-22% of its N from the atmosphere when no P was applied. When P was applied, 28% of the plant N was obtained through N-fixation; when P was applied and seed inoculated with rhizobia, 30% of the N was derived from the atmosphere. Approximately 30 kg $ha^{-1}$ of N was obtained through N-fixation with the 'P + inoculation' treatment.

Soybean yield was dramatically improved with inoculation but there was less response to P fertilizer (Table 14).

Table 12. Summary of research activities conducted with farmers in Ikulwe.

| Constraint | Potential solutions | Type of trial[1] | Outcome of evaluations |
|---|---|---|---|
| Cassava mosaic | Varieties | RD;FI;F&RE | Resistance verified; initially, little farmer interest but more interest as severity increased; farmers now multipling Nanse 2 and SS4. |
| Rosette, groundnut | Planting density | F&RD; FI;F&RE | Results were variable. Farmers lost interest in the trial. |
| Bean diseases | 29 varieties evaluated | F&RD; FI;F&RE | Significant adoption and seed increase of K 131, K 132, OBA 1 and UBR(92)32. Limited adoption of MCM 2001, MCM 3030. |
| Storage pests | Local products | F&RD; FI;F&RE | Only tephrosia leaves gave consistently good control of bean bruchids, but adoption has not been significant. |
| Root rats | Tephrosia | FD;FI; R&FE | Researchers advised farmers and they experimented. The technology has been verified (pages 21-22) and rate of adoption is high. |
| Banana weevils | Corm treatment | RD;R&FI;F&RE | The practices were effective. Farmers have not developed the facility for hot water treatment and have not adopted paring of the corms. |
| Nutrient deficiency | Hedgerows | RD;FI; F&RE | Generally lack of yield increase with hedgerows; little interest in use of prunings for fodder; most hedgerows have been neglected (pages 32-35). |
| Nutrient deficiency | Green manures | R&FD; FD;FI; R&FD | Significant farmer experimentation and significant adoption. Some seed increase (pages 23-31). Collaboration established with numerous organization for technology dissemination. |
| Nutrient deficiency | Composting | FD;FI;FE | A few farmers tried but none continued. |
| Soil infertility | Mulching | F&RD;FI; F&RE | A few farmers tried but none continued. |
| Soil erosion | Living barriers | FD;FI; F&RE | Researchers provided information and planting materials. Farmers experimented. Low rate of adoption achieved (pages 22-23). |
| N deficiency | Inoculate seed | RD;FI; F&RE | Bean responded to inoculation when P was applied. Soybean responded well to inoculation (pages 19-21). Inoculation has not been adopted. |
| P deficiency | Application of P | RD;FI; F&RE | Bean responded well to applied P (pages 19-21). No adoption of fertilizer use as yet. |
| P deficiency | Tolerant lines | RD;FI; F&RD | Tolerance was verified, especially for XAN 76. Farmers showed little interest as the lines have non-preferred seed types. |
| Low soil fertility | Integrated nutrient management | RD; FI; R&FE | Various abundant organic materials were characterized for nutrient content and release. Combining lantana with fertilizer is under evaluation (pages 35-36). |

In the column “type of Trial”, R and F in the abbreviations refer to researcher and farmer, respectively, while D, I and E refer to trial design, implementation and evaluation.

Table 13. Effects of P fertilizer and inoculation on percent and amount of N from N-fixation and bean yield.

| | N-fixed % of N | N-fixed (kg/ha) | Yield (kg/ha) |
|---|---|---|---|
| Control | 22 | 8.0 | 605 |
| Inoculation | 13 | 5.6 | 694 |
| 46 kg/ha phosphate | 28 | 18.0 | 851 |
| Inoculation plus P | 30 | 29.6 | 985 |

Fertilizer and inoculum were subsequently made available to farmers through members of the participatory research committee. Sales were negligible. When asked, farmers attributed the failure to adopt to the lack of planning their farming activities; they said the custom is to go out in the morning following a rainfall with seed they find in the home, prepare a piece of land, and plant it immediately. They have little experience in purchasing inputs beforehand; therefore, farmers claim that they failed to purchase the inputs either because they simply forgot about them or because they had failed to set aside money for the purchase.

Table 14. Soybean yield response to P fertilizer and inoculation.

| *Treatment* | *Yield (kg ha$^{-1}$)* |
|---|---|
| Control | 609 |
| Inoculation | 1048 |
| 46 kg ha$^{-1}$ phosphate | 906 |
| Inoculation plus phosphate | 1082 |

### *Farmer experimentation on root rat control*

Farmers identified root rats (mole rats, *Tachyoryctes splendens*) as a priority problem. The root rats tunnel extensively and do much damage to crops, especially sweet potato and cassava. The root rats were not often seen, but damage to crops and the presence of under-ground tunnels indicated their presence. Plant parts were often found in the tunnels during tillage.

Researchers advised farmers of the use of tephrosia (*muluku, Tephrosia vogellii*) in root rat control, and showed them the plant. Farmers collected the seed, and initially six farmers experimented with tephrosia. Farmers planted tephrosia either as barriers around their fields or as scattered plants in the field. They found it easy to establish, although a few farmers experienced damage by goats and chickens. Once established, it survived for years with little maintenance.

Most farmers reported that control was achieved within six months after planting tephrosia, but some said it may take as long as a year. Lack of damage to crops, root growth old tunnels, and exposed tunnels left unplugged indicated the absence of root rats from the field.

Some farmers were convinced that the tephrosia was killing the root rats; 43% observed dead root rats in the vicinity of the tephrosia. Others were not sure and suggested that the root rats simply migrated to other fields.

Several benefits and alternative uses of tephrosia were mentioned by farmers. It was known traditionally as a medicine for treating wounds, and as an insecticide for control of storage pests, ticks and termites. The prunings were recognized as useful in soil management. The wood was used as cooking fuel. It produced seed easily.

Farmers expressed concern about tephrosia, including that it might be used to maliciously kill fish in neighbors' ponds and that it competed with nearby crops. It needs to be pruned to prevent it from becoming too competitive, but severe pruning kills the plant.

All farmers said that they were offering the tephrosia technology to other farmers by informing them of its usefulness in root rat control and by providing them with seed.

### *Vetiver grass in living barriers for erosion control*

Farmers recognized soil erosion as a cause of declining soil productivity. Some farmers knew of recommendations for use of paspalum grass and napier grass in living barriers but few used such barriers. Researchers suggested that vetiver grass may be a good alternative for those not interested in feeding the grass to livestock but who were concerned that living barriers might be damaged due to uncontrolled grazing by animals of other people. Researchers provided farmers with planting material of vetiver grass.

Several farmers tried vetiver on their farms. Some planted barriers across the full width of sloping fields. More commonly, others planted short barriers to protect the most susceptible parts of their farms. After five seasons, researchers interviewed farmers on their experiences with vetiver grass barriers.

All of the farmers interviewed acknowledged the effectiveness of vetiver grass in forming living barriers for erosion control. Evidence observed included the accumulation of soil in front of the barriers and in the crown of the plant; reduced water run-off; less rill formation; less damage to crops by run-off and erosion.

Vetiver grass established easily, but in a few cases it was damaged by termites after planting. Once established, it tolerated termite feeding. It was appreciated that vetiver did not spread and become strongly competitive with adjacent crops.

Vetiver grass was appreciated for thatching due to scarcity of the commonly-used spear grass. Other farmers, however, said that it was not very durable as thatch as it decomposed too quickly. Some successfully used the grass in making crafts, as a mulch and as a substitute for spear grass when extracting juice from banana.

Problems were mentioned. A few farmers indicated a preference for a grass palatable to livestock. The grass was difficult to cut using a machete. Even when cutting with a sickle, it was not easy and one has to be cautious to avoid being cut by the leaves. The crowns of plants were difficult to uproot to obtain planting material. The rate of increase of the planting material was slow, and the technology was slow to be disseminated.

Most farmers had not disseminated the grass to other farmers. Only three farmers had significantly increased the amount of barriers on their farm to increase the protection from erosion.

***Crotalaria trials***

Several farmers participated in researcher-designed trials to evaluate crotalaria as a green manure crop. Crotalaria was produced in sole crop as well as intercropped with maize or bean.

Bean and maize yields were reduced by about 15% during the first season due to competition with the intercropped crotalaria (Table 15). In the subsequent season, maize yield following crotalaria grown in sole crop was twice that of maize following maize, and maize following bean or maize following the crotalaria intercrops gave intermediate yields.

Table 15. Maize yields in the season following crotalaria and/or food crop production. Trials were conducted in Iganga and Palissa Districts.

| *First season crop* | *Second season crop* | *Maize yield ($kg\ ha^{-1}$)* |
|---|---|---|
| Maize (Longe 1) | Maize | 1141 |
| Bean (K20) | Maize | 1748 |
| Maize-crotalaria intercrop | Maize | 1928 |
| Bean-crotalaria intercrop | Maize | 2050 |
| Crotalaria | Maize | 2751 |

Source: Wortmann *et al.*, 1994.

In another trial, use of crotalaria as an improved fallow was compared to a weedy fallow. Maize yield was about 40% higher following crotalaria as compared to the weedy fallow (Table 16). Bean yield was generally low, but also about 40% higher following crotalaria. The benefits of crotalaria carried into the second season; both maize and beans had higher yields following crotalaria.

Table 16. Grain yields (t $ha^{-1}$) of maize and beans grown as the first and second crops after sole cropped crotalaria and weedy fallow[1].

| | 1st subsequent crop | | 2nd subsequent crop | |
|---|---|---|---|---|
| Treatment | Maize | Beans | Maize[2] | Beans[2] |
| Crotalaria[3] | 3.99 a | 0.56 a | 2.63 a | 0.74 a |
| Weedy fallow | 2.82 b | 0.40 b | 2.15 a | 0.66 a |

[1]Mean separation in a column by LSD (0.05).
[2]Maize and beans grown on alternate sub-plots.
[3]All crotalaria biomass was applied as mulch to the first subsequent maize crop.

Source: Fischler, 1997; Fischler and Wortmann, in press.

***Research on crotalaria, mucuna and lablab***

Mucuna and lablab produced more biomass than crotalaria (Table 17). Intercropped mucuna and lablab were grown in association with maize during the first season and allowed to continue to grow as an improved fallow during the following season; with this system they produced more biomass than when grown in sole crop for a single season. Lablab was generally more productive than mucuna.

Table 17. Biomass yields (kg $ha^{-1}$)of sole cropped crotalaria (8 farms), and of mucuna and lablab grown for either one season in sole crop or intercropped with maize and left to grow for an additional season (6 farms).

| Crop association | Crotalaria | Mucuna | Lablab_ |
|---|---|---|---|
| Sole crop | 6.32 | 7.87 b | 8.04 b |
| Intercropped with maize | | 9.98 a | 11.66 a |

[a]Mean separation in a column by LSD (0.05).

Source: Fischler, 1997; Fischler and Wortmann, forthcoming

Maize and bean yield were improved when grown following mucuna and lablab (Table 18). The increased production, however, did not compensate for the loss of food crop production which occurred when the green manure was being produced.

Farmers evaluated the green manure species favorably (Table 19). They judged soil quality to be improved, weeds to be less and crop productivity to be increased following production of green manures. Uprooting of the green manures was laborious, especially for the mucuna and lablab.

Table 18. Maize yield when intercropped with mucuna and lablab, and maize and bean yield as subsequent crops to mucuna and lablab sole crops and intercrops, as compared to corresponding yields with maize monocropping[1].

| Treatments, first season | Grain yield (t/ha) | | | |
|---|---|---|---|---|
| | Maize | | | Bean |
| | 1st season | 2nd season | 3rd season | 4th season |
| Mucuna-maize | 2.40 b | n/a | 3.71 a | 0.80 a |
| Mucuna | n/a | 4.24 a | a | 0.67 ab |
| Maize | 3.18 a | 2.66 b | b | 0.50 b |
| | | | | |
| Lablab-maize | 1.60 b | n/a | 2.75a | 0.88a |
| Lablab | n/a | 3.88 a | 2.28 ab | 0.70 ab |
| Maize | 2.23 a | 2.59 b | 1.58 b | 0.50 b |

[1]Mean separation in a column for same green manure by LSD (0.05) for maize and by LSD (0.10) for beans.
Source: Fischler, 1997; Fischler and Wortmann, in press.

### *Farmers' own experimentation with green manure species*

Farmers did much experimentation on their own with crotalaria, mucuna, lablab and canavalia, producing these in association with different crops including banana, coffee, cassava, sweet potato, maize, bean, as well as sole crop. This experimentation yielded much information which is of potential value to farmers in other areas.

All species could be produced in sole crop, but lablab and mucuna were most preferred for sole crop production (Table 20). They were easy to manage in sole crop, produced much biomass and suppressed weeds.

Table 19. Evaluation of three green manure species by farmers in small groups.

| Observation | Green manure (sole crop) | | | Maize |
|---|---|---|---|---|
| | Crotalaria | Mucuna | Lablab | |
| Soil condition at planting of the first subsequent crops. | The soil after a sole crop of crotalaria was soft (pliable) and thus easy to till. | The soil was dark, soft, and loose (porous). In most cases, there was a thick layer of leaves protecting the soil from erosion. | The soil was moist, cool and soft at the end of the season. A thick layer of leaves protected the the soil from erosion. Improved soil tilth persisted. | The soil was hard and dry at the planting of the subsequent maize crop. |
| Labor demand for uprooting green manure crops, and planting and mulching of subsequent crops. | It was easy to uproot and mulch the crotalaria. (Two elderly farmers said that uprooting and mulching was tiresome). | Uprooting mucuna was difficult: it was deep-rooted and the base of the twining plant was hard to find. It was very easy to till[a]. Weeds were few at planting of the subsequent maize crop. | Uprooting lablab was difficult because it was deep-rooted. Coarse material had to be cut to ease the planting of maize. Little tillage was needed and weeds were few at planting of the subsequent maize crop. | Tillage and weeding were laborious but planting was easy. |
| Incidence of weeds in first subsequent crops. | Generally, no or one weeding was needed for beans and maize, because weeds were few. | There were no weeds at planting of the subsequent crop. A few volunteer mucuna plants emerged. | There were no weeds at planting and only few weeds during the season. | There were a lot of weeds at planting and during the season. |
| Growth of first subsequent crops. | Both maize and bean established and yielded well, in most cases. | Maize germinated well and was greener and taller than maize grown after maize. The yields were high. | Maize grew and yielded better than maize which followed maize. | The maize crop did not perform well compared to maize grown after the green manure crops. |

[a]Farmers did not till the whole plot but only a narrow band where maize was planted.
Source: Fischler, 1997.

Table 20. Evaluation of four green manure species by 12 farmers, using a matrix scoring method, for different production methods and uses (more favorable status indicated by higher numbers).

| Green manure species | Sole crop | Intercrop with banana | Intercrop with maize | Intercrop with sweet potato | Intercrop with cassava | Fodder quality | Soil improvement | Weed suppression |
|---|---|---|---|---|---|---|---|---|
| Crotalaria | 5.7 | 4.4 | 5.0 | 4.3 | 4.8 | 2.5 | 6.4 | 5.4 |
| Canavalia | 4.7 | 6.8 | 4.2 | 3.8 | 5.0 | 0.9 | 5.5 | 6.0 |
| Mucuna | 8.8 | 6.3 | 6.0 | 0.6 | 6.8 | 5.2 | 8.7 | 9.0 |
| Lablab | 8.1 | 5.3 | 4.7 | 0.8 | 5.0 | 7.5 | 7.7 | 7.9 |
| LSD (0.05) | 1.04 | 1.77 | 1.26 | 2.03 | ns | 2.09 | 1.06 | 1.27 |
| Error df | 32 | 30 | 31 | 17 | 36 | 23 | 32 | 32 |

Source: Fischler, 1997; Fischler and Wortmann, in press.

All species can be intercropped with banana but canavalia was most frequently intercropped with banana (Table 21). Mucuna and lablab were problematic as they climbed on the banana plants but appeared to be compatible with banana when planted at a low plant density and away from the banana plants.

Table 21. Percentage of farmers interviewed who had conducted farmer experimentation on intercropping green manure species with various crops.

| | *Canavalia* *n = 11* | *Mucuna* *n = 17* | *Lablab* *n = 11* | *Crotalaria* *n = 10* |
|---|---|---|---|---|
| Banana | 73 | 18 | 18 | 10 |
| Coffee | | | 9 | 10 |
| Ban/Coffee | 18 | | | |
| Maize | 9 | 88 | 73 | 90 |
| Bean | | | | 80 |
| Cassava | | 18 | | 10 |
| Sole crop | | 6 | 18 | 10 |

Mucuna was more frequently intercropped with maize than were other green manure species. Mucuna was sown 3-4 weeks after sowing the maize. The climbing of mucuna on the maize was recognized as a problem. Canavalia appeared to have good potential for intercropping with maize as it did not climb and its deep rooting pattern caused less below ground competition.

Only canavalia and crotalaria were found to be suitable for intercropping with sweet potato. The sweet potato was planted on mounds and the green manure was planted in the furrows around the mounds. Crotalaria seed was often deeply buried, however, when heavy rain washed soil down from the mounds. The deep root system of the canavalia should reduce its competitiveness with sweet potato while allowing it to produce much biomass.

Farmers judged the potential of the four species to be similar for intercropping with cassava but only a few farmers have tried it. Those who intercropped mucuna with cassava waited until the cassava was well established, four to six months after planting, and then planted the mucuna. The mucuna eventually climbed on the cassava while it produced much biomass and suppressed weeds. The mucuna was competitive with the cassava and farmers suggested that this intercrop system be used only if the farmer intended to delay harvest of the cassava until 18 to 24 months after planting.

Lablab was most preferred, and mucuna was found to be acceptable, for fodder production (Table 22). Farmers judged mucuna and lablab to be best for weed suppression. All were believed to be good for improving soil productivity but crotalaria was thought to be marginally better than the other species.

Farmers expressed concern about several problems that were likely to affect adoption (Table 22):

1. Crotalaria was laborious to produce as it was tedious to sow and weed control was time-consuming.
2. Several farmers found that lablab and mucuna were difficult to uproot.
3. Lablab has a low seed multiplication rate.

Table 22. Positive and negative features of four green manure species as indicated by percent of farmers who mentioned the characteristic.

| | *Canavalia* *n = 11* | *Mucuna* *n = 17* | *Lablab* *n = 11* | *Crotalaria* *n = 10* |
|---|---|---|---|---|
| <u>Positive features</u> | | | | |
| Improve soil fertility | 82 | 88 | 91 | 100 |
| Suppress weeds | 55 | 47 | 45 | 50 |
| Keep soil cool, reduce evaporation | 64 | 41 | 27 | |
| Produce much seed | 18 | 29 | | 30 |
| Prolonged growth | 9 | | 18 | |
| Good fodder | | 12 | 64 | |
| Reduce erosion | 27 | 29 | 18 | 30 |
| Improve soil tilth | | 4 | | |
| <u>Negative features</u> | | | | |
| Climb on associated crops | | 76 | 45 | |
| Seed not edible | 18 | 18 | | |
| Laborious to produce | | 12 | | 70 |
| Uprooting was difficult | | 18 | 7 | 10 |
| Threshing was difficult | | 6 | | 30 |

***Guidelines to the use of green manures***

The green manure species can be integrated into farming systems in different ways and for different uses. A green manure species may be more preferred than others for different situations and objectives. In consultation with farmers, researchers developed a decision guide to the use of four green manure species (Table 23) to assist farmers in their choice and use of the species. Ultimately, they will need to learn through experience in their own situation and to fine-tune the green manure technology for their farming systems.

Table 23. Guidelines to the use of four green manure species in Central and Eastern Uganda

| **If you want to.....** | **plant ..............** | **do not plant .........** |
|---|---|---|
| produce in sole crop | mucuna or lablab | Canavalia |
| intercrop with maize | canavalia, or lablab at very low density | mucuna |
| intercrop with newly planted banana or coffee | canavalia | mucuna or lablab |
| intercrop with established banana or coffee | canavalia or mucuna at low plant density | crotalaria |
| intercrop between sweet potato mounds | crotalaria or canavalia | mucuna or lablab |
| intercrop with newly planted cassava | canavalia or crotalaria between rows of cassava | mucuna or lablab |
| intercrop with established cassava | canavalia or mucuna at low density | crotalaria |
| produce fodder | lablab or mucuna | canavalia or crotalaria |
| suppress weeds | mucuna or lablab | crotalaria or canavalia |
| reduce nematodes | crotalaria | Canavalia |
| produce durable mulch | crotalaria and canavalia (allow to mature) | lablab or mucuna |

Source: Fischler and Wortmann, in press.

### *Hedgerow intercropping*

Agroforestry, for soil improvement and wood production, was one of the research topics chosen by farmers. An experiment on hedgerow intercropping with *Calliandra calothyrsus* and *Leucaena leucocephala* was designed jointly by farmers and researchers. Due to severe damage to leucaena by psyllid in 1993, the trial design was subsequently limited to calliandra. A P treatment was incorporated.

Tree seedlings of Calliandra were planted as single hedgerows in April 1993 (2 rows per plot, 5 m apart, trees spaced 0.25 m within row). The first pruning of the Calliandra trees was carried out by farmers (under guidance of a FORI research officer) in October 1993 with four prunings per year thereafter. The first pruning was always conducted shortly before planting or before emergence of the food crop (for pruning dates see Table 24). The cuttings were applied as a mulch between crop rows. In season 1994A and 1995A (third and fifth cropping season after tree planting, respectively) P at a rate of 46 kg $P_2O_5$/ha (100 kg TSP/ha) was applied side-dressed to maize on half of the plots. No P was applied to beans planted in 1994B and 1995B, nor to all crops thereafter. Spacings for maize (0.75-0.90 x 0.5-0.6 m) and beans were according to farmers practice. Data from six farms were available up to season 1995B; thereafter data (combined over sub-plots) were only collected from two (1996A and 1996B) and one farm (1997A).

Approximately 15 t/ha of fresh biomass containing about 130 kg N/ha was produced from the hedgerows within the duration of experimentation (Table 24). Hedgerow intercropping did not result in increased maize and bean yield (Table 25, 26, 27). Bean was especially responsive to residual P with yield increases of 31 and 64% in 1994B and 1995B, respectively.

Table 24. Fresh pruning biomass (t/ha) and estimated N content (kg/ha) of calliandra in hedgerow intercropping.

| Pruning No. | Date | Fresh biomass yield (t/ha) per pruning and farm<br>Farm: 1 | 2 | 3 | 4 | 5 | 6 | Mean | Estimated mean N yield per pruning (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | October 93 | 4.9 | 3.1 | 3.4 | 3.0 | 4.6 | 1.9 | 3.5 | 30 |
| 2 | April 94 | 6.2 | 3.5 | 4.7 | 4.4 | 6.8 | 2.6 | 4.7 | 40 |
| 3 | July 94 | 5.5 | 3.4 | 2.6 | 2.1 | 5.7 | 3.1 | 3.7 | 30 |
| 4 | September 94 | 5.6 | 1.5 | 1.8 | 1.9 | 1.8 | 2.0 | 2.4 | 20 |
| 5 | November 94 | 2.7 | 2.4 | 2.2 | 1.5 | 2.2 | 3.0 | 2.3 | 20 |
| 6 | March 95 | 12.0 | 3.7 | 4.4 | | 10.6 | 5.9 | 7.3 | 61 |
| 7 | May 95 | 7.3 | 2.1 | 2.4 | | 5.8 | 3.1 | 4.1 | 35 |
| 8 | September 95 | 10.9 | | | 8.7 | | 5.5 | 8.4 | 70 |
| 9 | November 95 | 3.9 | | | | | 3.0 | 3.5 | 29 |
| 10 | March 96(?) | 11.8 | | | | | 3.1 | 7.5 | 67 |
| Mean per pruning | | 7.1 | 2.8 | 3.1 | 3.6 | 5.4 | 3.3 | 4.7 | 40 |

Table 25. Grain yield of maize as affected by Calliandra hedgerow intercropping (cuttings applied as a mulch), and P fertilizer.

| Calliandra | Maize grain yield (kg/ha)[1)] With P | Without P | Mean[2)] |
|---|---|---|---|
| | *1994A* | | |
| With Caliandra | 1822 | 1265 | 1544 b |
| Without Caliandra | 3360 | 2607 | 2984 a |
| Mean[2)] | 2591 a | 1936 b | |
| CV = 19.5% | | | |
| | *1995A* | | |
| With Calliandra | 2640 | 2222 | 2431 b |
| Without Calliandra | 3982 | 3387 | 3685 a |
| Mean[2)] | 3311 a | 2804 b | |
| CV = 17.4% | | | |

[1)] Average of six farms with three replications per farm.
[2)] In a row (or column), means followed by a common letter are not significantly different at 5 % level.

Table 26. Grain yield of beans as affected by Calliandra hedgerow intercropping (cuttings applied as a mulch) and residual effect of P fertilizer.

| Calliandra | Bean grain yield (kg/ha)[1)] P applied in previous season | No P applied in previous season | Mean[2)] |
|---|---|---|---|
| | *1994B* | | |
| With Caliandra | 528 | 392 | 460 a |
| Without Caliandra | 612 | 480 | 546 a |
| Mean[2)] | 570 a | 436 b | |
| CV = 19.5% | | | |
| | *1995B* | | |
| With Calliandra | 1198 | 722 | 960 a |
| Without Calliandra | 1413 | 873 | 1143 a |
| Mean[2)] | 1305 a | 798 b | |
| CV = 17.4% | | | |

[1)] Average of six farms with three replications per farm.
[2)] In a row (or column), means followed by a common letter are not significantly different at 5 % level.

Table 27. Grain yield of bean and maize (kg/ha) in seasons 1996A, 1996B and 1997A[1)]. (Combined over sub-plots with previous P treatments). Hedgerow intercropping trial Ikulwe.

| Calliandra | Beans 1996A | Maize 1996B | Beans 1997A |
|---|---|---|---|
| With Calliandra | 770 a | 1504 a | 491 a |
| Without Calliandra | 710 a | 1840 a | 285 a |
| Mean | 740 | 1672 | 388 |
| CV(%) | 29.6 | 24.0 | 42.6 |

[1)] Average of two farms in 1996A and 1996 B, data of 1997A from one farm only.

## NUTRIENT BALANCES

Ten farms in Iganga District were surveyed and 30 samples of surface soil were collected. The median values were as follows: organic carbon, 2.4%; Olsen P 3.4; pH (water 1:1) 5.8; Ca cmol/kg, 4.9; Mg cmol/kg, 1.4; K, cmol/kg 0.6; total N, 1400 ppm; total P, 350 ppm; total K, 1540 ppm; 26% clay; 13% silt and 61% sand.

P was judged to be very low and low on 43 and 27% of the fields, respectively.

Generally, farmyard manure was well used, but the amount available on average was enough to supply only 12, 5 and 18 kg per farm of N, P and K. With zero grazing, these amounts could be increased.

Erosion was estimated to remove 4.4 ton of soil/ha/yr. This amounts to about 9.2, 2.4 and 11.9 kg/ha of N, P and K. Simple control measures on more easily eroded land could reduce overall mean soil loss to 2.8 tons/ha.

Nutrient balances were favorable in the banana-based land use type where the soil productivity was maintained by addition of organic materials. Annual nutrient balances with banana were estimated to be positive while the balance for the annual crop land use type was negative (Table 28). The N balance was most negative for soybean, grown without inoculation, while K balance was most negative with sweet potato (Table 29). Much of the loss was accounted for by nutrients removed in the harvested products, erosion and leaching of N.

Table 28. Nutrient balances by land use type (kg $ha^{-1}$ $year^{-1}$) and at farm-level (kg $farm^{-1}$ $year^{-1}$) in Mayuge and Buyemba parishes of Iganga District.

| | Banana-based | Annual crops | Fallow | Pasture | Farm-level |
|---|---|---|---|---|---|
| Nitrogen | 10 | -60 | 11 | 1 | -67 |
| Phosphorus | 9 | -7 | -1 | 0 | -9 |
| Potassium | 5 | -60 | -6 | -1 | -86 |

Source: Wortmann and Kaizzi, in press.

Table 29. Nutrient balances by crop (kg $farm^{-1}$ $year^{-1}$), in Mayuge and Buyemba parishes of Iganga district.

| | Banana | Maize | Bean | Sweet potato | Soybean |
|---|---|---|---|---|---|
| Nitrogen | 13 | -42 | -12 | -35 | -52 |
| Phosphorus | 11 | -4 | -4 | -5 | -7 |
| Potassium | 6 | -26 | -17 | -33 | -22 |

Source: Wortmann and Kaizzi, in press.

Nutrient losses at the farm-level were primarily due to erosion and leaching. Net losses to marketing were small as nutrients gained through purchases were only slightly less than that lost through marketed products.

## TECHNOLOGY DISSEMINATION

The Ikulwe farmers and researchers of CIAT and NARO have worked to facilitate the diffusion of information and varieties to farmers in other places.

The Ikulwe farmers initiated the Ikulwe Farmers Bean Association (IFBA) for the sake of producing and marketing seed of new bean varieties. While amounts of seed produced have not been large (approximately 400 kg per season), the effort has enabled farmers in the vicinity to obtain seed as needed. A participatory evaluation conducted in 1997 indicated that a high percentage of the neighboring farmers have sown K131 and K132 while local cultivars continued to be important.

There were no externally supported efforts specifically for the promotion of green manure technology in Ikulwe, but the participatory research resulted in spontaneous adoption and dissemination. A preliminary assessment of adoption was made in late 1995 by interviewing 22 farmers who had participated in research. Farmers who had participated in experimentation with a species previously, and had a crop during the current growing season, were considered to have adopted. It is recognized that some may still have been experimenting, and some who did not have a species during the season could plant again another season. Adoption was poor for crotalaria (5%), intermediate for mucuna (43%) and lablab (45%), and high for canavalia (62%). Reasons for discontinuing use of a species (and number of farmers giving the response) were: insufficient labor (17), insufficient land (1), lack of seed (6), no benefit observed (7), and domestic and personal problems such as illness (6). The responses do not apply equally to all species, and insufficient labor was cited most frequently for crotalaria. It is noteworthy that less than 5% cited insufficient land as a reason for discontinuing use of a green manure species given that land scarcity is often perceived as the major obstacle to green manure use.

The PR with green manure stimulated much interest amongst other farmers who requested seeds from the participating farmers. Most farmers reported giving seed of one or more species to several other farmers: 26% of those who had grown a species previously did not disseminate it; 27% gave to 1-3 farmers; 26% gave to 4-6 farmers; 4% gave to 8-10 farmers; 10% gave to 10-18 farmers; and 12% gave to more than 20 farmers. Adoption by recipient farmers has not been assessed, but one seed recipient and non-participating farmer was observed to have relay-sown mucuna into a field of maize estimated to be more than one hectare.

The survey indicates significant adoption of green manure technology, but researchers observed in 1997 that while most farmers continued to sow one or more species, generally this was done on small areas. The abnormality of rainfall distribution during 1997 undoubtedly affected farmers' use of green manures. A concern of the authors is that management of the green manures often is inadequate to fully benefit from their use; this is especially true with intercropping with mucuna, which is occasionally observed to severely suppress the food crop.

The Ikulwe farmers have hosted numerous groups of farmers who visit to observe and discuss alternative practices, which the researching farmers have adopted. The Ikulwe farmers have produced and marketed seed of green manure legumes, especially of mucuna and tephrosia, but sales have been primarily to extension-oriented organizations rather than to farmers. Organizations which have obtained seed and/or information from Ikulwe include: Kigulu Development Group in Iganga District; SAFAD and IDEA in Kamuli; VI Tree Planting in Masaka and Rakai; ACORD in Gulu; Appropriate Technology in Lira and Apac; the Cotton Development Corporation; Talent Calls in Mukono; Sangalo Institute Soil Analysis Project in Bungoma, Kenya; EAT in Kitale, Kenya; the Kabaka's Foundation for Development; the District Rural Development Project in Bukoba, Tanzania; and the Dutch-supported rural development project for Lira, Soroti and Katikwe Districts. Feedback from these organizations is inadequate to determine if significant adoption is being achieved, but rainfall during 1997 was atypical which hindered development efforts generally.

In another initiative, the Ikulwe farmers worked with the professional drama group, Ndere Dance Troupe, to prepare a local group to use drama for dissemination of information. The use of drama has been found to be very effective in conveying information to farmers on agricultural technology in southwest Uganda (Munro, 1998), and is expected to be effective in eastern and central Uganda which has a long tradition of drama.

It is too early to estimate the impact that the information generated through the participatory research will have on the farming systems of the agro-ecological zone that Ikulwe represents. Widespread adoption of alternative practices typically occurs in a sigmoidal fashion. Initially the rate of adoption is low as information diffuses, ways of integrating the practice into cropping systems are tried and either rejected or accepted, ridicule of neighbors is overcome, and a knowledge base of the practice develops at the community level. Thereafter, rapid adoption by many farmers may occur until a plateau is approached. The time required to achieve significant adoption depends on the feasibility and potential impact of the practice. Also important to rate of adoption are adjustments needed in cropping systems and infrastructure to accommodate the practice, information needed to apply it, and time required to achieve the benefits. New varieties of established crops are easily adopted and a stage of rapid adoption occurs relatively early. Some types of technology, such as green manure/cover crop technology, are expected to require more time until a rapid rate of adoption can occur. While rejection can be detected early, more time is needed to verify that a new practice will be widely adopted.

Adoption of bean and cassava varieties identified as most promising appears now to be in the stage of rapid increase, and in some cases near the plateau of adoption. The adoption of green manures, other soil management and IPM technologies apparently have not yet reached the stage of rapid increase in adoption and we cannot yet be certain that the practices will achieve significant impact.

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