SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

INTERNATIONAL UNION
OF
FORESTRY RESEARCH ORGANISATIONS
PROJECT GROUP P 2.04.00
ON
SEED PROBLEMS

PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON FOREST SEED PROBLEMS IN AFRICA

HARARE, ZIMBABWE AUG 23 — SEPT 2, 1987

COMPILED AND EDITED BY
S. K. KAMRA and R. D. AYLING

Published by

Department of Forest Genetics
and Plant Physiology
Swedish University of Agricultural Sciences
S-901 83 Umeå, Sweden

In cooperation with
International Development Research Centre,
Regional Office for Eastern and Southern Africa,
P.O. Box 62084, Nairobi, Kenya
and
Forest Research Centre
P.O. Box HG 595
Highlands, Harare, Zimbabwe

Report 7
Umeå 1987

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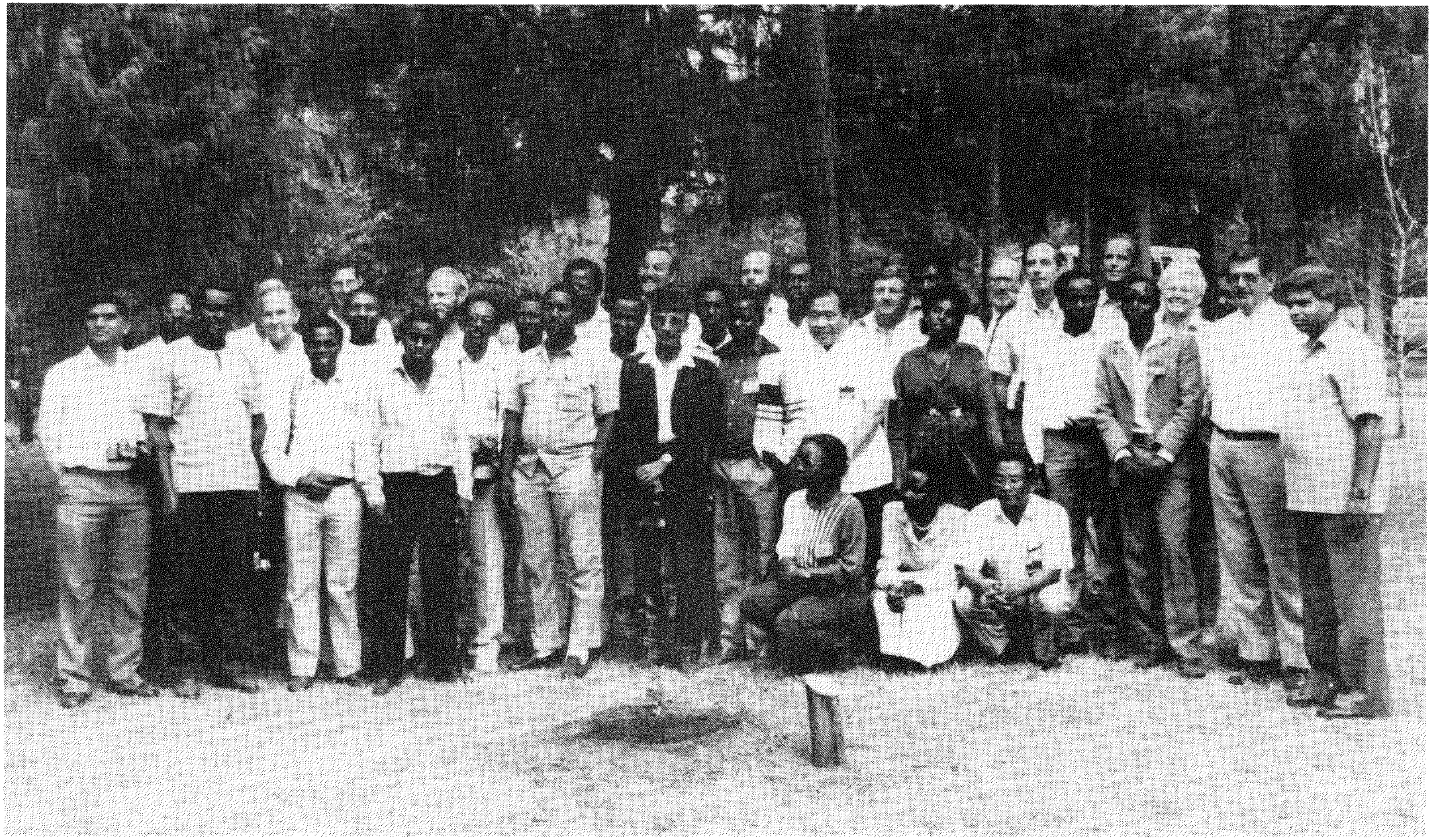

PARTICIPANTS OF THE SEED SYMPOSIUM IN HARARE 1987

FOREWORD

The IUFRO International Symposium on Forest Seed Problems in Africa was held at the Forest Research Centre, Harare, Zimbabwe from August 23 to September 2, 1987. It was attended by 48 scientists from 24 countries.

A large number of papers were submitted to the symposium. All of them are included in these proceedings. Since the contents of the papers are the responsibility of the authors, the editing has been kept to a minimum. Most of the papers were received in camera-ready form, but some had to be retyped. For typing as well as other secretarial work, we are very grateful to Mrs. Gertrud Lestander and Mrs. Helene Risberg of the Dept. of Forest Genetics and Plant Physiology, Swedish University of Agricultural Sciences (SUAS), Umeå, Sweden and to Ms. Dorothy Rwigi of the International Development Research Centre, Nairobi, Kenya. All of them have rendered us very valuable help.

The printing of the proceedings was carried out by Mr. Ture Lindh, in-charge of the printing press of the SUAS, Umeå. We are thankful to him for his able assistance.

The funds for printing of the proceedings were provided jointly by the International Development Research Centre, Regional Office for Eastern and Southern Africa, Nairobi, Kenya and the Dept. of Forest Genetics and Plant Physiology, Swedish University of Agricultural Sciences, Umeå, Sweden. We are much obliged to both these agencies for the generous financial support.

All the authors of the papers have contributed in their own way to the success of the symposium. We express our thanks to them for their contributions.

The local arrangements for the symposium were made by the Organizing Committee consisting of the staff members of the Forest Research Centre, Harare, Zimbabwe. We are deeply grateful to all of them for their tremendous work which made this symposium an unforgetful experience.

S. K. Kamra and R. D. Ayling

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Additional paper:

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Zimbabwe	Mary Edyvean, -"-
Zimbabwe	Trish McNamara, -"-
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IUFRO International Symposium on Forest Seed Problems in Africa,
Harare, Zimbabwe, Aug. 23 to Sept. 2, 1987

PROGRAMME

Sunday, August 23:

Registration: Ophir Room, Monomatapa Hotel. 14:00-17:00hrs.

"Ice Breaker"/Cocktail Party: Ophir Room, Monomatapa Hotel. 18:00-20:00hrs.

Monday, Aug. 24: Forest Research Centre

Opening Ceremony:	09:00hrs.	The Minister of Natural Resources and Tourism - The Hon. Victoria Chitepo.
	09:30-10:00	Presentation of Paper 1
	10:00-10:30	Tea Break
	10:30-11:30	Presentation of Papers 2 and 3 and Discussion on Papers 1, 2 and 3
	11:30-12:30	Presentation of Papers 4, 5 and 6
	12:30-13:30	Lunch Break
	13:30-14:00	Discussion on Papers 4, 5 and 6
	14:00-15:30	Presentation of papers 7, 8 and 9
	15:30-16:00	Tea Break
	16:00-16:30	Discussion on Papers 7, 8 and 9
	End of Day 1.	Delegates return to Hotel.

Tuesday, Aug. 25: Forest Research Centre

08:30-09:30	Presentation of Papers 10, 11 and 12
09:30-10:00	Discussion on Papers 10, 11 and 12
10:00-10:30	Tea Break
10:30-11:30	Visit to Seed Services Seed Testing Laboratory
11:30-12:30	Return to F.R.C. Tour of Regional Seed Centre
12:30-13:30	Lunch Break
13:30-14:30	Presentation of Papers 13, 14 and 15
14:30-15:00	Discussion on Papers 13, 14 and 15
15:30-16:30	Presentation of Papers 16, 17 and 18
16:30-17:00	Discussion on Papers 16, 17 and 18
End of Day 2.	Delegates return to Hotel

Wednesday, Aug. 26:	07:00	Depart Harare on 1,5 day field trip.
Thursday, Aug. 27:	12:15	Return to Forest Research Centre, Harare
	12:30-13:30	Lunch
	13:30-14:30	Presentation of papers 19, 20 and 21
	14:30-15:00	Discussion on Papers 19, 20 and 21
	15:00-15:30	Tea Break
	15:30-17:00	General Discussion on Seed Problems of Africa
Friday, Aug. 28: Forest Research Centre		
	08:30-09:30	Presentation of Papers 22, 23 and 24
	09:30-10:00	Discussion of papers 22, 23 and 24
	10:00-10:30	Tea Break
	10:30-12:30	Presentation of papers of authors not present
	12:30-13:30	Lunch Break
	13:30-14:30	Business meeting and summing up
	19:30	Symposium Dinner
Saturday, Aug. 29:	07:30	Depart Harare on Post-Symposium Tour
Wednesday, Sept. 2:	18:00	Return to Harare. End of Tour and end of Symposium

OPENING SPEECH

by

Honourable Mrs. V.F. Chitepo, Minister of Natural Resources and Tourism, Government of Zimbabwe, Harare, Zimbabwe.

Mr. Chairman, Distinguished Guests, Ladies and gentlemen,

I am glad to be here this morning to participate at this opening session, and am particularly pleased that you have chosen Zimbabwe as the venue for this meeting of your project group on seed problems. I understand that this is the first time you have met on the African continent. The international union of forestry research organizations is the oldest international scientific organization in the world and we value Zimbabweś membership of it. We welcome you to our country, Mr. chairman, you and all the delegates to this meeting - and I give you our traditional shona greeting - mauya!

It is something of a platitude to say that trees have always been as fundamental to man's needs as the food he eats and the air he breathes, but it does need re-stating from time to time for we tend to take trees and their benefits for granted. It is appropriate, I think, to go back to some of the oldest lines in our literature, the opening verses of genesis: "In the beginning God created the heaven and the earth, and the earth brought forth grass ... and the tree yielding fruit ..." and he "planted a garden ... and made to grow every tree that is pleasant to the sight and good for food ..."

Trees are our life - our legacy of yesterday, our blessing for today, and our hope for tomorrow. Here in Zimbabwe the governmentś nation-wide programme of tree planting to reclaim deforested land and enhance the quality of life of all our people, especially those who live and work in the rural areas, has gained great momentum since its inception. This programme is one of the major responsibilities of my ministry and is managed by the forestry commission through its rural afforestation division.

The emphasis has been on planting fast-growing exotic trees, such as Eucalyptus, because they offer the best for arresting the deforestation of our indigenous woodlands by providing more productive and more easily renewable alternative sources of poles and fuel for our rural people. But I must emphasise that we do not, as a matter of policy, intend to replace indigenous woodlands with exotic plantations. Our intention is to take the pressure off the remaining woodlands by providing plantation-grown timber for domestic and destructive uses of trees, i.e. poles and fuel - and to preserve the woodlands for general amenity, for the conservation of watersheds and grazing land and for the non-destructive uses of trees, such as fruit and honey production, traditional medicines and the like.

My ministry, through the forestry commission research division, has over the past years tested about 300 species of forest trees in 5 000 plots, and more than 140 replicated provenance trials located all over the country. And, going back 40 or 50 years earlier, there was a great deal of informal introduction and trial trees for various purposes. Initially, the formal research was directed largely towards the needs of the commercial forestry sector which was establishing itself to provide for the industrial timber needs of our country, and the trials were concerned almost entirely with exotic softwoods and hardwoods. More recently, the changing needs and priorities of the Zimbabwe society have required my ministry to shift policy towards the species-screening programme.

Greater research effort is being directed into the testing of multi-purpose trees and shrubs that may be suitable for integration into other economic and social needs which have multiplicity of uses. Traditional plantations lacked some of the species suitable for social consumption and new species must be selected to provide the different products now required.

All of this research has required, and will continue to require, considerable quantities of seed - seed that is authentically named, of known origin, and collected, documented, processed, tested and stored in accordance with internationally accepted standards. No other standards will do.

It is the intention of the Zimbabwe government to present a balanced forest research programme that offers benefits to both the commercial and public sectors.

We are not neglecting our own indigenous trees in this research. Although they are not generally suited to commercial plantation management, many of them will have a very definite role in social forestry and we already have extensive trials of some species, including that great African tree, Acacia albida, which we know as Mutsangu, in Chishona and Umpumbu in Sindebele. Our indegenous species require the full weight in our research capabilities. In this respect, I would like to urge forest researchers in this part of Africa to double their efforts in examining the potential some of our indigenous trees have in alleviating many of our social and economic problems.

The forestry commission in Zimbabwe, has had for more than twenty years close contact with the commonwealth scientific and industrial research organisation (CSIRO), the division of forest research in Canberra, Australia, and its widely known tree seed centre which supplied us with nearly 900 well-documented seed collections of more than 130 tree species for trial in this country. The Australian tree seed centre has gone further than that. It has given most valuable assistance to four Zimbabwean seed-collecting teams to Australia between 1982 and 1984, which resulted in collections from 900 individually identified trees of 30 species for use in our tree improvement programme.

The experience and expertise that was gained on these missions is now available for passing on to forest seed collectors in our own eastern and southern African region.

I am pleased to welcome to this meeting in Zimbabwe, Mr. John Doran, who served for eleven years as officer-in-charge of the Australian tree seed centre and has given a great deal of personal assistance, encouragement, and advice to the forest research centre in Harare, and to our research officers who have visited his country.

Recently, my ministry with aid from the international development research centre (IDRC) of Canada, established a regional forest tree seed centre in Harare to serve the research and development needs of our eastern and southern African region. As developing countries we have common problems of procuring seed for research purposes and of positively identified provenance, because of shortage of foreign exchange for purchasing seed, and the biological restrictions of free movement between our territories, and the lack of suitable storage facilities. Zimbabwe was in a more fortunate position in this respect than other African territories because there was already an established export-oriented seed enterprise to supply improved pine and eucalyptus seed from our tree-breeding progamme, and we had built up considerable expertise in the handling of this type of seed when the concept of a regional seed centre was proposed.

To say the least, Mr. chairman, my ministry has even exported commercial quantities of Eucalyptus seed to Australia! It was quite natural then that the International Development Research Centre (IDRC) should have agreed to expand the existing facilities at the Forest Research Centre in Harare to serve the needs of the region. And, again, I am pleased to welcome to this meeting in Harare the IDRC forestry programme officer, Dr. Ron Ayling, who has been instrumental in bringing the regional seed centre project to its present state. My ministry would like to give him the assurance that it will do all in its power to promote this project.

But, Mr. chairman, the mere fact of establishing a regional seed centre does not mean that seed problems will automatically go away. If they did, your project group of the International Union of Forestry Research Organizations would have no work to do, and this symposium on forest seed problems in Africa would not be taking place.

The need for manpower development in forestry research cannot be overemphasized. It takes a long time to train researchers. Although Zimbabe has benefited tremendously from foreign experts who have served us on temporary basis, the government is developing a policy that will assist us in establishing our full complement of local experts to meet our needs. It is our fervent hope that by the year 2 000, we will have moved closer to meeting this goal.

It is my sincere hope that other nations, on an exchange programme basis will also benefit from our work here and the continuous inter-dependent training programme will certainly lead us to self sufficiency in the near future.

Finally, Mr. chairman, when you have completed your deliberations, many of you will travel on the post-conference tour to our indigenous forest areas, to Hwange National Park, and to the Victoria Falls: I know that you will be delighted with what Zimbabwe has to offer to the tourist in our country. I hope you will take the message back to your friends and colleagues - Zimbabwe is a good place for a conference and a beautiful country to visit!

Mr Chairman, it gives me great pleasure to declare this symposium on seed problems in Africa officially open.

Thank you.

WELCOME ADDRESS BY DR. S. K. KAMRA
Dy. Project Leader IUFRO P2.04.00

Madam Minister:
Distinguished Guests:
Ladies and Gentlemen:

On behalf of the IUFRO Project Group on Seed Problems, it is my pleasure to welcome you to this symposium. In our IUFRO Project Group we consider the Forest Seed Problems of Africa as important. That is why we have chosen this as the theme of our symposium. Africa is a large continent with many countries and many problems. I am glad that we have representatives of several African countries present here. Please tell us about your seed problems and let us work together to solve them.

The success of this symposium will depend upon how much each one of you is willing to contribute to it. Every one of you has brought some valuable knowledge and experience with you from your home country. Please feel free to put forward your views both during the sessions and during the breaks. When we discuss, we learn from each other. In this way through exchange of ideas, we gain a better understanding and can take home more knowledge and experience than what we brought with us. This is the main purpose of our symposium.

However, knowledge and experience can only help us, if we utilize them properly. Let us therefore try to make an efficient use of our knowledge and experience in forestry for the benefit of mankind.

Mr. John Wiltshire, Mr. Richard Seward and the members of their Organizing Committee have put in a tremendous effort to organize this symposium in their beautiful country. I wish to thank them all most heartily for their hard work. Without their selfless devotion, this symposium would not have been possible.

Once again, I welcome you all very warmly and wish you a pleasant stay and a successful symposium.

TREE SEED AND COMMUNITY FORESTRY - A DONOR'S PERSPECTIVE

by

Dr. R.D. Ayling

Program Officer (Forestry)

International Development Research Centre

ABSTRACT

Reversing environmental degradation and restoring the agricultural base of many developing countries may only be a possibility, but money and optimism alone are not enough to tackle the problem. Industrial plantations and single-purpose "energy" plantations are expensive and rarely benefit the majority of people - the rural poor. Community-based forestry programs led by researchers and individuals prepared to work with villagers, farmers and their families to plant the right trees in the right places may be the only viable solution. And to support their activities, more research must be supported on the performance of multipurpose species and ensuring that supplies of quality seed of these species are readily available.

The forestry program of IDRC provides an example of how, in small but significant way, local researchers are being supported to help "make trees serve people".

INTRODUCTION

There continues to be a steady and increasing deterioration of the natural environment in many developing countries in spite of large infusions of aid and the good intentions of recipient governments and donor agencies alike. The World Bank, for example, invested more than $US 425 million in Africa alone between 1968-1984 on forest management, watershed protection and agricultural development projects with a forestry component (Brown & Wolf, 1986).

"Declining food production...

However, according to recent estimates, the rate of deforestation of closed-canopy tropical forests continues at approximately 7.5 million hectares each year, while the annual depletion and degradation of open forests amounts to about 3.8 million ha (FAO, 1986). This destruction of often fragile and irreplacable ecosystems not only reduces global animal and plant gene-pools, it threatens natural life support systems. Agricultural potential and food production for growing populations are adversely affected. In Africa, where more than 70% of land clearance is due to shifting cultivation by subsistence farmers, per capita grain production is declining. In 1983 and 1984, years of meagre rainfall throughout the continent, an average of less than 120 kgm of grain per person was produced, down from a 1967 high of 180 kgm. "Declining per capita food production, abandoned cropland, rising food imports, and famine are among the most visible features" of Africa's agriculture, according to Brown and Wolf (1986). While there are other contributing factors, this per capita decline is largely due to unchecked population growth rates and the associated deterioration of the natural environment. The pressing need to feed more people forces farmers to expand their activities to hillsides and mountain slopes and into areas of low rainfall. Vegetative cover is removed, crops fail after one or two growing seasons, and valuable topsoil is lost through wind and water erosion.

...and shortages of fuelwood

Firewood collection is another major cause of forest depletion. For more than 1.5 billion rural and urban poor in developing countries, wood and charcoal are the principal sources of energy for cooking foods and heating homes. Eighty percent of all energy used in thousands of Asian villages is wood-based; in some African countries, wood and charcoal account for more than 95% of national energy consumption. The UN Conference on New and Renewable Sources of Energy, meeting in Nairobi, Kenya in 1981, estimated that more that 100 million people were unable to satisfy their minimum daily energy needs. Unless present trends are altered, wood shortages would affect an additional two billion people by the turn of the century (Saouma, 1981).

Across the developing world, woodfuel deficits occur or will occur in precisely those areas under intense agricultural pressure, and especially in the semi-arid and arid regions of Africa (less than 800 mm of yearly rainfall), The mountainous areas of Asia and the Andean plateau of South America. As scarcities occur, people are forced to use animal and agricultural residues for fuel, depleting even further soil nutrient inputs and reducing crop yields. Soils become impoverished and erosion occurs. These areas become more prone to desertification and desert induction in times of low rainfall. Gorse (1985) notes that while drought alone does not in the short-run produce resource degradation, drought accelerates the negative consequences of human resources abuse.

...undermine a nation's economic progress"

Social as well as environmental costs are high as a result of uncontrolled agricultural expansion and increasing woodfuel demands of growing populations. As supplies diminish, people who depend almost entirely on wood energy suffer increasing physical and/or economic burdens to avoid hunger and malnutrition. More and more effort is required to collect the minimum amount of woodfuel. Fewer warm meals are possible, and lower protein intake results in weakened physiques and poorer health.

El Hadji Sene, writing in FAO's Unasylva observed:

"whenever there is hunger, there is first ecological misery - lack of water, lack of trees, sometimes not even a sparse grass cover, but everywhere there is dust raised by a hot and dry wind" (Sene, 1985).

Environmental deterioration undermines a nation's economic progress and is a casual factor in social and political unrest. While the restoration of vegetative cover is essential for the recovery of the agricultural base, developing countries often lack the technical and financial resources to initiate effective programs. Conservation of natural resources is often seen as a luxury they can ill-afford.

Searching for solutions

Although there has been more than two decades of rapidly increasing international support for reforestation, little real progress has been made in reversing or even slowing environmental degradation. Reasons often put forward for the failure of many projects include concentration on single-purpose species, lack of involvement of the local population in the program and, in many instances, the use of genetically inferior planting stock. An additional reason is often the failure to carry out the necessary pre-project resear

In the 1960's and early 1970's, the bulk of official forestry investments in developing countries went into the establishment of large-scale industrial plantations of species such as pines and eucalypts for urban and export markets. The benefits of such programs seldom extended down to the majority of the people. Then, following the publication of "The Other Energy Crises": Firewood" (Eckholm, 1975), national governments and donor agencies began to stress the need for fuelwood plantations of fast-growing species.

However, in Africa, these plantations may only meet some 5% of the continent's wood energy needs, and the forested area cleared each year continues to exceed the area planted each year by a ration of 29:1 (FAO, 1984). Economist David French suggests that with the high cost of establishment and maintenance, fuelwood plantations alone cannot reverse deforestation (French, 1986).

One needs to recognize, therefore, the complex inter-relations between forests, farmlands and household energy needs in order to determine the way money should be spent to plant trees. The important questions are which trees and where, for whom and by whom?

"Making trees serve people"

The 1978 theme of the World Forestry Congress, "Forests for People", stressed that community-based forestry is a practical necessity requiring effective strategies to create village woodlots and encourage tree planting on farms. Trees must be planted in the vicinity of users, not primarily for fuel but also to demonstrate the role of trees in protecting and restoring soil fertility and improving farming systems.

FAO's recent Tropical Forestry Action Plan also reemphasizes the growing of more wood for fuel using fast-growing, multipupose species at farm and community level and in non-conventional areas (FAO, 1986).

This emphasis on community forestry will require greater research on non-traditional tree and shrub species, on appropriate low-input technologies, and on ways to successfully integrate trees, crops and livestock. Support must also be provided to "grassroot" foresters who care less about the elegance of silvi-culture and more about working with peasant farmers.

DEVELOPMENT & PEOPLE - THE WORK OF IDRC

In 1970, the International Development Research Centre (IDRC) was created by the Parliament of Canada to support indigenously-determined research promoting social and economic advancement in developing countries. The Centre's belief that development must be a process for the benefit of people results in the focus of IDRC-supported activities on the problems of poverty. Research by local scientists that can have direct and immediate benefit to those most in need is supported.

From its earliest beginnings, the forestry program has concentrated on social rather than on commercial or industrial forestry, the main distinguishing factors being the decision-making process, the sources of land and labour, and the distribution of the research outputs (Lessard, 1986). Financial and technical resources are concentrated in four major areas.

a) integrated production systems - the incorporation of trees within agricultural systems;

b) fuelwood and energy issues - the improvement of wood-energy technologies such as cook stoves and charcoal production, and the identification of species for fuelwood production:

c) forest management and production - the improved management of natural forests and plantations, research on shelterbelts, soil fertility, tree breeding and improved seed production; and

d) forest product utilization - the development of improved technologies on minor forest products such as bamboos, rattans, and natural gums.

In spite of these broad categories, a major program emphasis on research concerned with the integration of woody species into small-scale farming systems, especially those with soil improvement properties and of multiple value. Table 1 provides a small sampling of the type of projects supported globally which have an agricultural component.

Research in these projects is directed at finding solutions to problems in the most difficult and usually the most neglected environments - mountainous sites and arid and semi-arid areas.

Problems of seed - quality and quantity

The choice of species is often not a difficult one, although finding the "ideal" species and the best provenances are long-term goals. References such as CFI's "A Guide to Species Selection for Tropical & Sub-Tropical Plantations" (Webb et.al., 1984) and CSIRO's computer-based homoclime analysis (Booth et.al., 1987) provided useful starting points to project researchers.

The question of seed supply is more difficult. An underlying assumption in all these projects, in other not listed and indeed in all reforestation programs in developing countries, is that adequate supplies of quality seed are readily available. This certainly not often the case, although the recently published "Multipurpose Tree & Shrub Seed Directory" will become an invaluable aid to identifying seed suppliers of lesser-known species (Carlowitz, 1986). It is obvious that the efforts of researchers and forest services are easily frustrated when their programs fail to materialize for want of the desired seed. Time and scarce financial resources are wasted, and public expectations deminish. Turnbull (1983) also notes that failing to obtain the best quality seed influences the success or failure of planting efforts even though the cost of seed is a small fraction of other project costs.

Table 1. IDRC-Supported Projects on Multipurpose Species for Farming Systems

Title & Location	Major Objective
Farm Forestry (Nepal)	To encourage small-holder farmers to plant trees for fuelwood, forage, green manure & small timber by identifying multipurpose species & simple propagation techniques
Silvipasture (India)	To improve forage & tree crop productivity of degraded semi-arid grazing lands by inter-planting fast-growing trees & shrubs of high potential for animal feed & firewood production.
Fuelwood Production (China)	To select fast-growing multipurpose species for small-scale plantations in villages & on farms.
Rural Production Modules (Mexeco)	To develop integrated resource management systems in semi-arid areas to increase the production of food, fuelwood & forage
Fuelwood Production (Boliva)	To select tree species suitable for high evalations & promote community plantations.
Native Fruit Trees (Peru)	To promote the incorporation of native fruit trees on small farms in the Amazon basin.
Leguminous Species (Cameroon)	To improve farming systems in the humid tropics to west Africa by using woody legumes to enhance soil fertility & crop yeilds.
Nitrogen-Fixing Trees (Sierra Leone)	To evaluate indigenous fast-growing N-fixing species for incorporation into bush fallow & other agricultural systems.
Multipurpose Trees (Ethiopia)	To identify species for highland farm systems to improve crop production & soil fertility, provide firewood & dry season forage, & to be used as living fences.
Agroforestry (Kenya)	To develop tree-crop-livestock systems for the arid and semi-arid areas of Kenya with a view to improving the quality of life of the rural poor.
Afforestation (Zimbabwe)	To provide fuelwood, building poles & forage sources on arid communal lands by integrating tree crops with agricultural activities.

A dependable supply of quality seed of known origin is an essential ingredient in all community forestry projects. With IDRC support, tree improvement research is being carried out on a number of important genera and species in several countries, the objectives being the eventual establishment of seed production orchands of multipurpose species and the provision of quality seed.

Multipurpose species for farming systems

In Costa Rica, scientists at CATIE (Centro Agronomico Tropical de Investigacion Ensenanza) have established a breeding arboretum of Erythrina, a nitrogen-fixing genus of the lowlands and middle elevations of the humid tropics. Species such as E.Poeppigiana, E.berteroana, E.costaricensis and E.fusca are widely used as nurse trees in coffee and cacao plantations. Seed and cuttings are provided to other countries on request.

A germplasm collection of several Prosopis species and provenances has been established in Sudan. Researchers are evaluating arid zone adaptability, productivity and species potential for animal forage. Similar work has begun in north eastern Brazil to broaden the genetic base of Prosopis juliflora and to identify other Prosopis species for introduction onto small-holder farms. Researchers will investigate techniques for the vegetative propagation of superior genetic material, establish seed orchards and share material and results with other dry zone projects in the region.

IDRC has also supported research on Leucaena leucocephala, an important legume species for interplanting with agricultural crops. Between 1977-1982, several Philippine research groups assembled and evaluated a world-wide collection of 125 accessions of L.leucocephala. Work has also been carried out on this species in Nigeria, Cameroon and India. In 1982, in association with the Nitrogen Fixing Tree Association, IDRC convened an international workshop on Leucaena research in Singapore to help identify research needs and priorities for development (IDRC, 1983).

At the International Livestock Centre for Africa's field station in Ibadan, Nigeria, financial assistance has permitted the evaluation of several provenenances of Gliricidia sepium. Material provided by the Commonwealth Forestry Institute (Oxford) covers the whole of the species natural range in Central America. Trials have demonstrated the potential of the species to improve soil fertility and crop yields, and to provide supplemental feed for small ruminants. Over sixty small-holder farmers are now involved in on-farm alley cropping work in Nigeria, and seed technical assistance have been provided for establishing Gliricidia lines in Benin, Cameroon, Senegal and Sierra Leone.

Species of the endemic, broad-leaved genus Paulownia are not widely known outside China where for several centuries they have been used for intercropping with wheat, maize and cotton. Leaves and flowers are rich in protein, minerals and carbohydrates and provide forage for sheep and pigs. The timber is used for firewood, construction of houses and for pulp and paper. A recent monograph describes the eight species of the genus in detail (CAF, 1986) Over a million hectares of farmland are currently under Paulownia cultivation.

In spite of a long history of utilization, breeding programs and provenance evaluation have been neglected. In 1983, the Chinese Academy of Forestry with IDRC support began a complex and highly labour intensive project to promote this remarkable genus, and carried out the first country-wide selection program based on more than 800 plus trees. By 1985, over eight million root cuttings and 350,000 high quality seedlings had been distributed to farmers and villagers from 3,000 small community nurseries. The immediate beneficiaries of this research are the Chinese farmers and their families, but the successful development of superior Paulownia lines should also be of interest to other countries which have similar problems of competing priorities between agriculture and wood production.

Finally, in eastern Africa there are two research programs in early stages of development that are of potential importance to the region.

In Zimbabwe, there has been considerable interest in the use of need (Azadirachta Indica) for dry zone planting as an additional firewood crop and for the use of neem fruit extracts to protect small-farm grain storage units. In recent months, the Forest Research Centre has imported several seed provenances of neem for trial planting. The work is part of a new phase of a larger project based in the communal farming lands.

In Zambia, researchers are just beginning an important investigation of lesser-known Australian acacias. The project benefits from the technical assistance of Australia's CSIRO (Commonwealth Scientific & Industrial Research Organization) and complements Australian-supported research underway in Zimbabwe in other species of Acacia. In late 1985, a Zambian researcher participated in an extensive six-week CSIRO seed collecting mission in northwestern Australia. Many of the species from this area have been studied (Table 2). In Zambia, seedlings are to be planted on two trial sites with maximum temperatures of 35 C and annual rainfall between 600-1,200 mm. The objective of the work will be to provide new knowledge on species performance outside Australia, and eventually to establish seed orchards to meet regional needs.

Table 2. Lesser-Known Australian Acacias for Zambian Trials

A. aneura	A. anceps	A. aulacocarpa
A. auriculiformis	A. cowleana	A. crassicarpa
D. difficilis	A. hammondii	A. hemselyi
A. holosericea	A. jenneral	A. julifera
A. leptocarpa	A. ligulate	A. maconochieana
A. monticola	A. murrayana	A. platycarpa
A. plectocarpa	A. salicina	A. saligna
A. simsil	A. stenophylla	A. trachycarpa
A. Tumida	A. victoriae	

"Regional" Seed Centres

In addition to these projects on specific genera and species, perhaps one of the most important forms of IDRC support on the topic of seed quality and supply is the assitance provided to national seed centres to expand their activities to serve a region ("region" here refers to IDRC's geographic area of interest and not to a political or economic region). Because of limited financial resources, these expanded centres are supported in areas where the need for assitance is greatest.

In columbia, the seed centre of the Corporacion Nacional de Investigacion Forestal (CONIF), in conjuction with the National Seed Bank established by FAO in 1976, is investigating techniques to improve the quality and quantity of seed native hardwoods of the coastal lowlands. A second objective is to conserve the genetic variation within several important agroforestry species by establishing protected gene banks. The project represents an important addition to an active afforestation network of six IDRC-funded projects, complements an Ecuadorian seed improvement project concentrating on exotic species for the Andean uplands, and benefits the neighbouring countries of Ecuador, Panama and Venezuela which share some species.

In West Africa, the identification and management of seed production areas, and the development of appropriate collection, storage and testing techniques for the countries of the Sahelian region are the major objective of a seed centre project started in 1986 in Burkina Faso. Some 200 seed stands are to be established of species such as Acacia gourmaensis and various provenances of A. senegal and A. nilotica. Research quantities of seed known genetic origin will be provided to the national arid zone planting programs of several countries.

The regional tree seed centre in Zimbabwe is a relatively new venture but has developed a good regional program in seed and species research. In a meeting in Harare in early 1983, representatives of national forest services from ten countries of eastern and southern Africa brought to IDRC's attention the need for collective action on seed procurement. Some of the seed-related problems confronting national centres were identified as:

a) unreliable seed supply of specific species & provenances;

b) delays in receiving seed, often due to shipping & import restrictions, which reduces seed viability.

c) inadequate seed testing & storage facilities in national centres;

d) shortages of trained personnel;

e) inadequate information on climatically-adaptable species - flowering & seeding habits, handling, testing & storage requirements of exotic & indigenous seed:

f) lack of expertise in establishing seed orchards; and,

g) government restrictions on foreign exchange for the purchase of imported seed.

It was suggested that a regional centre might assist in overcoming many of these problems, and at the invitation of the Government of Zimbabwe, IDRC was requested to support the expansion of the national centre to serve the region (IDRC, 1985). Because of its lengthy history and considerable expertise in pine and eucalypt breeding, the Zimbabwe centre was a logical choice to establish this regional service.

"Membership" in this centre is informal and open to any country of Africa willing to share information on species performance and seed technology, and to work actively with other African states to solve common seed problems. A steering committee of Zambian, Ethiopian and Zimbabwean researchers helps to ensure the "regionality" of the project.

Once again, this project and the region benefits from Australian support. In July, 1985, the first training workshop under the auspeices of the centre was organized by three CSIRO scientists, and provided participants from several African countries with information on the taxonomy and seed handling of

Australian genera (RSC, 1986). The scientists, with support from ACIAR (the Australian Centre for International Agriculture Research), also initiated a preliminary study for the certification and registration of Eucalyptus seed orchards in Kenya, Malawi, Zambia and Zimbabwe.

The project has enabled the establishment of several resource conservation stands and breeding orchards of major dry zone Eucalyptus species. Future plans include the consideration of important multipurpose species. A national seed collection of Acacia albida was first carried out in 1985 by the Forestry Commission, and because of the high standards and usefulness of the exercise, support was provided for forest technicians from Kenya and Zambia to participate in a second collection in 1986. Other technicians from several countries will receive valuable experience in the third collection trip planned for later this year.

Other work of the regional centre has included the provision of technical literature on request to several national seed centres, and consideration is being given to providing assistance, where required, with the computerization of seed records and breeding programs.

Much has been accomplished in a short period of time, and with the continued support and good-will of the Government of Zimbabwe, future prospects are good for the centre to satisfy an important regional need.

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THE PRESENT STATUS OF FOREST SEED AQUISITION FOR AFFORESTATION PROGRAMES IN SOMALIA

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Somalia

INTRODUCTION

Somalia occupies total land area of 638.000 Km^2 with an estimated population of almost 6 million including refugees.

Nomadic pastoralists comprises almost 60% of the population. As the result of this the country's economy is dominated by livestock production, not only, but also it's population derive their income from livestock related activities.

Climaticaly the country is divided into three (3) regions as follows:-

1. The Northern Sea Coast, the North-East and Central Regions where average rainfall varies from 50 - 250 mm. ranging upto 250-300 mm in parts of Central Regions.

2. The North-West with an average rainfall of 400 mm.

3. The Inter-riverine area in the South with an average rainfall of 600 mm.

Most of the country consists of plateux and steeplands. Across the Northern region, there is a chain of mountains with highest peak of 2.073 M.

The arid coast line is 3.000 Km. about 5.000 Km^2 is occupied by coastal and inland sand dunes, four-fifth (4/5) of which are actively moving.

The range resources comprise 85% of land area, carrying about 6 million camels 5 million cattle, 31 million sheep and goats.

Vegetation

The vegetation in Somalia is dominated by shrubs although there are also varying amounts of grasslands, particularly along the coast, and limited areas of forest, which are restricted to the immediate vicinities of the elevations on mountains in the north. The forests are small in area constituting less than 1% of the total area of the country. The woodlands and wooded bushlands of the rangelands accounts for nearly 87% of the total land area, part of which (14% of total land area) supports shrubs and trees of sufficient size and density to provide wood products as well as forage for browsing livestock.

Deforestation Problems & Desertification

The combined effects of some factors have accelerated the desertification of most of the forest cover, loss of genetic resources, hydrological destruction as well as production.

These factors include indiscriminate over-cutting of trees and shrubs around most of the towns, villages, water bore holes, wells, ground cement water tanks (locally known as berkeds). This deforestation problems is aggravated by overgrazing by livestock.

Land clearance for large scale agriculture coupled with prevalent shifting cultivation practices by subsistence farmers have helped to lay the soil bare, making them susceptible to erosion by wind and water with consequent impoverishment.

Besides, a rising concentrated centralized need to satisfy human demand for fuelwood, poles, livestock feed and construction purposes is taking place due to a high population growth rate (3%/annum) and refugee settlements.

The reactivation and formation of sand dunes have continued to threat human settlements, access roads, rangelands and agricultural areas. This is a problem of a great concern in Somalia because a presently active dunes are over 400.000 ha. lying along the Indian Ocean coast, and within Central Rangelands. The deteriorating land conditions is as a result of above mentioned combined factors some of which we have no control over. This continued environmental degradation precipitated the monumental problem of desertification, a prevalent feature in many parts of Somalia.

Due to the undesirable effects of the resultant continuing desertification in Somalia, there is a great need to control and reverse it through preservation of remaining forests and range reserves, various tree planting schemes such as community wood lots, shelterbelts, windbreaks and fuelwood plantations, which will be effective in bringing back the lost vegetation cover.

Afforestation & Reforestation Programmes

The assistance provided by different international organisations and friendly countries for reforestation programmes or projects have spread in various regions and districts throughout Somalia. Unfortunately, however, the greatest constraint in implementing our reforestation schemes is that most of the projects todate have been of short duration (2-4 years),

Local Collection of Seeds

No formal seed collection areas for indigenous and exotic species exist in Somalia. However, measures are being taken to establish seed stands of economically important timber, fuelwood and fodder species.

Seed is locally collected by the staff members of forestry department from natural stands in small pockets and plantations at scattered areas. Moreover, in Somalia todate no tree species have been tested for their provenance variation. An exotic species in the plantation programmes are so far only used on a very limited scale, such Eucalyptus, Leucaena, Prosopis juliflora, Neem, Casuarina.

Seed collections in small pockets (units) is generally less satisfactory. Here the problem is that seed has shown promise in only a limited number of varied environments in which it is to be planted.

Another problem is collection of seeds from isolated road sides and compound plantations. In this case cost of collection is relatively high and the seed may be of lower quality due to inadequate interpollination.

In order to facilitate and minimize costs in seed collection, it is essential to know at what age the individual tree species can be expected to reach sexual maturity, their possible periodicity in flowering, fruiting, and what time of the year is best carried out. However, up untill now no conclusive studies have been done in Somalia in this regard. For example, personal observation in the field reveals that Cordeauxia edulis fruits are usually ready for harvesting, within 14 days after flowering initiation following commencement of the rains. This is significant because there is strong competition for its edible fruits between pastoralists, wildlife and would be seed collectors.

Similarly, availability of Acacia tortilis pods for collection is seriously hampered because apart from being seriously damaged on the tree by insects prior to collection, A. tortilis pods are an important seed for livestock in northern Somalia during the prolonged dry season. At such times when fodder is extremely scarce, A. tortilis pods can readily be bought in the local markets.

Ziziphus mauritiana fruits are also an important human food source during the dry season. Fortunately only the pulp is edible and the hard kernel protecting the seeds are spit out. These can usually be collected in a viable state around stands. Moreover, Ziziphus mauritiana is a consistent annual prolific fruiter, and viable fruits can readily be collected from the ground.

Alternatively, projects acquire seeds through procurement from overseas dealers. The problems encountered with the importation of tree seeds are:

a) inadequate resource in funds, both in local and foreign currency,
b) lack of accessible seed stands and seed production areas, especially of desired origins,
c) lack of reliable data about the seed origin,
d) risks of reduction in quality of seed i.e reduced germination capacity due to unusually long transit periods.

In addition to these problems, there are those which are specific to individual species. They may comprise periodicity in seed production short viability, low seed production. However, because of the difficulties and restrictions in getting bulk imports of desired species and provenances, it is necessary to seriously contemplate how to produce seed locally as soon as a seed source has shown promise.

Besides,there is insufficient knowledge about taxonomy of species and provenances which adversely affects the establishment of seed production areas. The problems encountered with imported tree seeds also include time delays caused by requests for foreign exchange from member governments seriously delay seed aquisitions and hence planting projects.

Seed Storage

Essentially the afforestation projects involve establishment of plantations using large numbers of trees and shrubs. It is therefore important that large quantities of seeds be obtained and stored under conditions condusive to preservation of seed viability. Unfortunately however, Somalia currently lacks adequate seed storage facilities. All seed storage is being done under normal environmental conditions. Since most projects todate are of short duration, a valuable portion of project life is usually wasted in waiting for seed orders to arrive.

Similarly, left over seeds at project termination can not be effectively stored for use by subsequent projects or regional forest programmes.

Seeds of several important species lose their viability relatively quickly except for hard coated and well dried legumes and other species e.g Zizyphus.

Some indegenous species fruit at different time of year, which may be out of phase with the seed sowing period of the nursery work programme.

Finally Somalia sees the creation of a regional seed centre as a very welcome move to achieve the following:-

1. promote reasearch and facilitate the exchange of research information especially endangered and extincting species.

2. store reasonable quantities of surplus seed for subsequent projects, thereby saving time & money.

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LIST OF IMPORTED SEEDS SINCE 1985

SPECIES

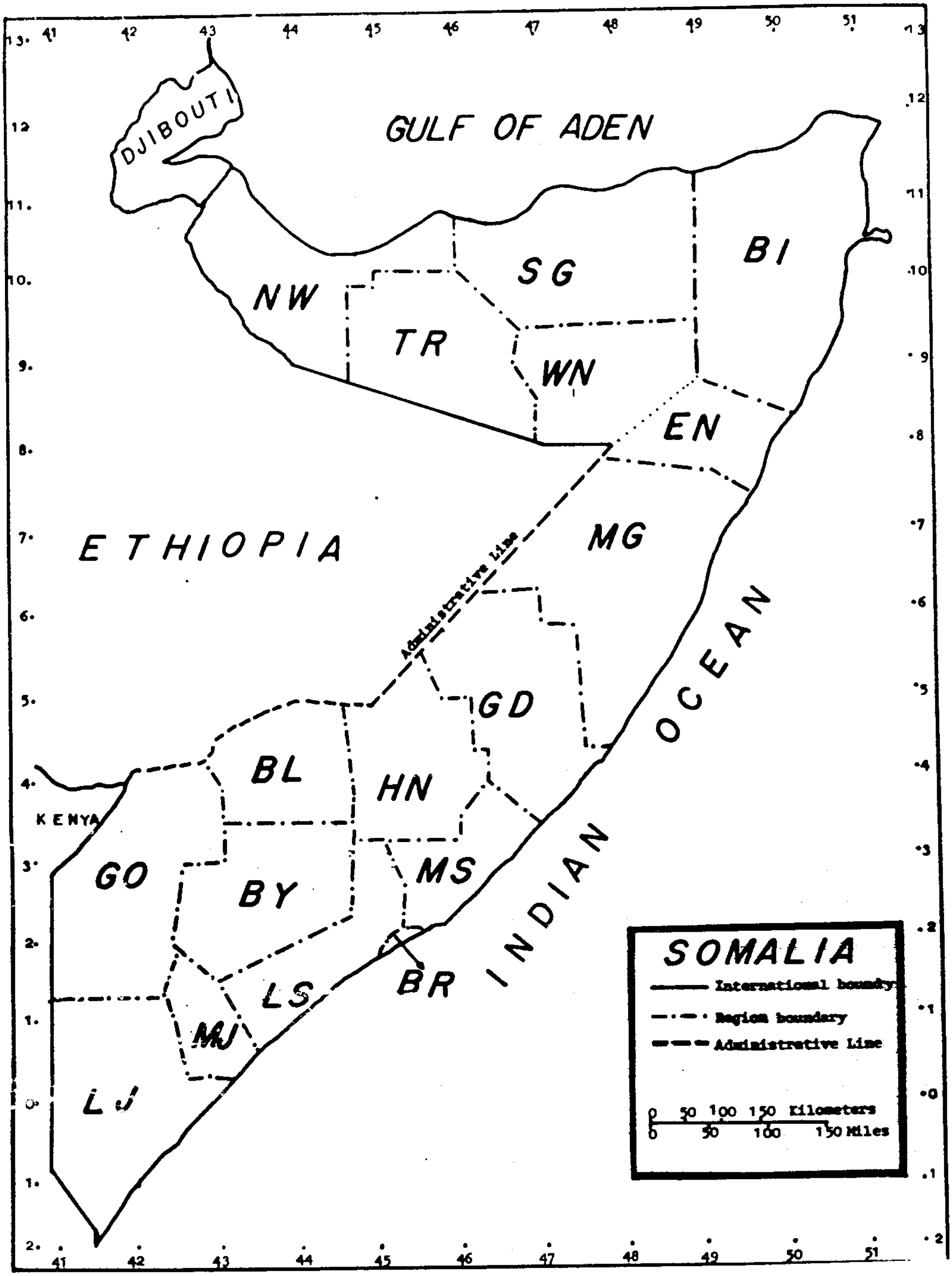
Acacia albida
Acacia aneura
Acacia auriculiformis
Acacia brachystachya
Acacia bussei
Acacia cambagei
Acacia campylacantha
Acacia coriacea
Acacia cowleana
Acacia cyanophylla
Acacia dealbata
Acacia etbaica
Acacia georginae
Acacia holosericea
Acacia horrida
Acacia leptocarpa
Acacia ligulata
Acacia linarioides
Acacia melanoxylon
Acacia mellifera
Acacia millefolia
Acacia moluccana
Acacia nilotica
Acacia nubica
Acacia ogadensis
Acacia pendula
Acacia prunocarpa
Acacia pycnantha
Acacia pyrifolia
Acacia reficiens
Acacia salicinia
Acacia senegal
Acacia seyal
var. fistula
Acacia shirleyi
Acacia stipulata
Acacia tortilis
Acacia tortilis
subsp. raddiana
Acacia victoriae
Adenium obesum
Ailanthus glandulosa
Albizia anthelmintica
Albizia lebbek
Anacardium occidentale
Annona muricata
Atalaya hemiglauca
Atriplex amnicola
Atriplex canescens
Atriplex halimus
Atriplex nummularia
Atriplex rhagodioides
Atriplex undulata
Atriplex vesicaria
Azadirachta indica
Balanites aegyptiaca
[illegible]
Balanites rotundifolia
Bauhinia carronii
Blepharispermum
fruiticosum
Boswellia carteri
Boswellia freriana
Brachychiton gregorii
Caesalpinia coriaria
Caesalpinia erianthera
Caesalpinia pulcherrima
Caesalpinia tinctoria
Calotropis procera
Carica papaya
Cassia eremophila
Cassia fistula
Cassia marginata
Cassia nemophylla
Cassia oligophylla
Cassia siamea
Cassia sturtii
Casuarina cristata
Casuarina cunninghamiana
Casuarina decaisneana
Casuarina equisetifolia
Casuarina stricta
Cedrela odorata
Ceiba pentandra
Ceratonia siliqua
Citrus spp.

SPECIES

Cocos nucifera
Colodendrum capense
Combretum hereroense
Commiphora myrrha, et al
Conocarpus lancifolius
Cordeauxia edulis
Cordia rothii
Cordia senegalensis
Cordyla somalensis
Cupressus arizonica
Cupressus benthami
Cupressus lusitanica
Cupressus sempervirens
Dalbergia commiphoroides
Dalbergia sissoo
Delonix baccal
Delonix regia
Dobera glabra
Dodonaea viscosa
Entandrophragma caudatum
Erythrina indica
Eucalyptus argillacea
Eucalyptus camaldulensis
Eucalyptus citriodora
Eucalyptus colossea
Eucalyptus cornyocalix
Eucalyptus crebra
Eucalyptus diversicolor
Eucalyptus drepanophylla
Eucalyptus eugenioides
Eucalyptus globulus
Eucalyptus gomphocephylla
Eucalyptus hemiphloia
Eucalyptus intertexta
Eucalyptus maculata
Eucalyptus melanophloia
Eucalyptus microtheca
Eucalyptus obliqua
Eucalyptus occidentalis
Eucalyptus occidentalis
var. stenantha
Eucalyptus ochrophloia
Eucalyptus oleosa
Eucalyptus oleosa
var. obtusa
Eucalyptus panicolata
Eucalyptus planissima
Eucalyptus pruinosa
Eucalyptus punctata
Eucalyptus resinifera
Eucalyptus robusta
Eucalyptus rostrata
Eucalyptus sargentii
Eucalyptus siderophloia
Eucalyptus sideroxylon
Eucalyptus spathulata
Eucalyptus tereticornis
Eucalyptus thozetiana
Eucalyptus trachyphloia
Euphorbia tirucalli
Ficus sycomorus
Garcinia livingstonei
Gardenia fiorii
Gmelina arborea
Grevillea robusta
Haematoxylon campechianum
Hagenia abyssinica
Hyphaene thebaica
Inga saman
Jacaranda mimosifolia
Juniperus excelsa
Khaya senegalensis
Kigelia aethiopium
Lawsonia inermis
Leucaena leucocephala
Mangifera indica
Melia azedarach
Mimusops angel
Mimusops fruiticosa
Moringa oleifera
Moringa stenopetala
Newtonia paucijuga
Pandanus odoratissimum
Parkinsonia aculeata
Phoenix spp.
Phragmites mauritianus
Pinus brutia
Pinus eldarica
Pinus halepensis
Pinus pinea
Pinus radiata
Populus spp
Prosopis alba

SPECIES

Prosopis chilensis
Prosopis cineraria
Prosopis glandulosa
Prosopis juliflora
Prosopis spicigera
Prosopis tamarugo
Prosopis velutina
Psidium guajava
Punica granatum
Raphia ruffia
Robinia pseudoacacia
Salix sp.
Santalum album
Scaevola plumieri
Schinus molle
Sequoia gigantica
Sesbania grandiflora
Sesbania sesban
Simmondsia chinensis
Swietenia macrophylla
Swietenia mahagoni
Syncarpia laurifolia
Tamarindus indica
Tamarix aphylla
Tecoma stans
Tectona grandis
Terminalia catappa
Terminalia orbicularis
Terminalia parvula
Terminalia polycarpa
Terminalia superba
Thespesia danua
Thevetia nerifolia
Trinax argentea
Washingtonia filifera
Widdringtonia whytei
Ziziphus hamar
Ziziphus mauritiana
Ziziphus spina-christi


SOMALIA
International boundary
Region boundary
Administrative Line
0 50 100 150 Kilometers
0 50 100 150 Miles
GULF OF ADEN
DJIBOUTI
ETHIOPIA
KENYA
INDIAN OCEAN
Administrative Line
NW
SG
BI
TR
WN
EN
MG
GD
BL
HN
GO
BY
MS
LS
BR
MJ
LJ

PRESOWING TREATMENTS OF TROPICAL ACACIAS

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INTRODUCTION

It is well documented that the developing world has a critical fuelwood shortage and that if the rate of tree planting is not accelerated the situation will further deteriorate.

The Philippines today is besieged by the problem of 193,500 Kaingenero families with 687,000 dependents, occupying an area of 547,436 hectares of forest lands. In addition to this and other population pressures there is the conversion of forest to agricultural lands, bush fires, drought and insect attacks. With this situation 1.6 million hectares of open and denuded and degraged forest lands is in need of immediate reforestation and afforestation.

It is the responsibility of the Bureau of Forest Development to intensify nationwide reforestation. Since 1983 the Bureau has maintained a total of 97 managed BFD projects, 12 foreign assisted and 6 national special reforestation projects, covering a total area of 258,600 hectares. The annual target area of reforestation is 25,500 hectares and 400 forest nurseries are maintained to produce 90,536,000 seedlings annually.

Land available to forestry in the Philippines is characterized by its poor quality, low pH, eroded bare soil and vast tracts of grasslands. Traditional species and some exotic species are failures due to infertile soil, grass competition, pests and diseases, incidence of fire, drought and typhoon damage. It is now high time for the Philippine forestry to look at alternative species.

Acacias constitute a very large genus. More than 800 species of Acacia are trees and shrubs with a natural distribution in Australia. A few species are extensively planted outside their natural range, others are little known but have attributes that suggest they should be more widely utilized to improve the well-being of people in the developing countries.

Acacias possess many attributes which characterise successful exotic species. They are multipurpose plants producing among other things, excellent fuelwood; they are adaptable to a range of environments including infertile; saline and acid soils; and can be easily established and managed. They have the ability to fix atmospheric nitrogen, many grow and can be reproduced by seed or coppice.

Although acacias are being grown in some countries the utilization of both proven and potentially useful species is hampered because information is fragmented and not readily available to researchers and field workers.

Particular reference is made to *Acacia aulacocarpa*, *A. auriculiformis*, *A. cincinnata*, *A. crassicarpa*, *A. holosericea*, *A. leptocarpa*, *A. mangium*, eight species identified as having potential for use in the Philippines.

Materials and Methods

PART I OF THE STUDY :

A series of germination trials were conducted at the Division of Forest Research CSIRO, Canberra, Australia to determine the most effective means of breaking seed coat dormancy in the eight species of special interest: *A. aulacocarpa*, *A. auriculiformis*, *A. cincinnata*, *A. crassicarpa*, *A. flavecens*, *A. leptocarpa*, and *A. mangium*.

Two seedlots, bulk samples from several parent trees, were arbitrarily selected to represent each species. These were removed from store and small subsamples (two tablespoons) of seed taken. Each subsample was further divided to give 25 seed samples for this trial.

The following treatments were applied to 100 seeds (4 replicates of 25 seeds) from each seedlot:

O = Control - no pretreatment
N = Nicking the seed coat
B = Boiling water poured - 10 times the volume of boiling water was poured over the seed and allowed to cool for 1 hr.
1 = Boiling water 1 min. - seeds were immersed in boiling water for 1 min.
2 = Boiling water 2 min. - seeds were immersed in boiling water for 2 min.
3 = Boiling water 3 min. - seeds were immersed in boiling water for 3 min.
S = Scarification in DFR machine - The machine was under development and proved ineffective except in the case of one lot of *A. auriculiformis*.

After treatment each 25 seeds replicate were placed in 9 cm glass petri dishes containing vermiculite (7g) moistened with 30 ml distilled water. Four replicates representing each treatment were placed in a germination cabinet set at the recommended germination temperature for the particular species. Germination counts were made at regular intervals up to 21 days.

PART II OF THE STUDY WAS CONDUCTED AT THE ASEAN-Canada Forest Tree Seed Centre, Muaklek, Saraburi, Thailand.
This study aims to duplicate and expand the presowing treatments conducted at CSIRO, Canberra, Australia.

A series of germination trivals were conducted using the walk in germinator with constant 30°C temperature and 8 hrs. light to determine the most effective means of breaking seed coat dormancy using eight species, two seedlots per species.

The following presowing treatments were applied to 100 seeds (4 replicates of 25 seeds) from each seedlot:

1. Control - No pretreatment
2. Nicking - small portion of the seed coat was removed/cut
3. Soaking in Concentrated Sulphuric Acid 5 Minutes
4. " " " " " 15 "
5. " " " " " 30 "
6. " " " " " 45 "
7. " " " " " 60 "

8. Seeds were immersed in Boiling water 85°C for 1 minute
9. " " " " " " " " 2 minutes
10. " " " " " " " " 3 "
11. Seeds were immersed in boiling water 95°C for 1 minute
12. " " " " " " " " 2 minutes
13. " " " " " " " " 3 "
14. Seeds were soaked in hot water 85°C and left to cool for 5 minutes
15. " " " " " " " " " " " " 60 "
16. " " " " " " 95°C " " " " " 5 "
17. " " " " " " " " " " " " 60 "

After treatment each 25 seeds per replicate were placed in germination boxes containing filter papers as growing media. Four replicates representing each treatments were then placed in the walk in germinator. Germination counts were made at regular intervals up to 30 days.

Results and Discussions

PART I

Number 1 to 8 give the cumulative germination (%) over 21 days for each treatment and each of the sixteen seedlots (8 species) tested.

1 _Acacia aulacocarpa_

Nicking and immersion in boiling water were clearly superior. Mechanical scarification showed promise but the results are inconclusive as only one seedlot was tested and the machinery is still under development.

2 - _A. auriculiformis_

Nicking and mechanical scarification gave significantly better results than the other treatments. Immersion in boiling water was moderately effective and results indicated that a longer immersion period, say up to minutes, would be worth testing.

3 - _A. cincinnata_

Nicking the seed coat and immersion in boiling water for 1,2 and 3 minutes were highly effective methods.

4 - _A. crassicarpa_

Nicking the seed coats gave the best results. The poor initial germination response to the boiling water treatments indicates that the seed coat dormancy has not effectively been broken by these treatments. A longer immersion time (5 min.) would be worth testing.

5 - *A. flavescens*

Nicking predictably was the best treatment followed by immersion in boiling water. There is no significant difference between immersion period.

6 - *A. holosericea*

The boiling water treatments were just as effective as the manual nicking with seeds of this species.

7 - *A. leptocarpa*

Nicking gave the best response followed by the boiling water immersion treatments.

8 - *A. mangium*

The interesting feature is the different response of the two seedlots to the boiling water treatments. Nicking was again the most effective method but while the immersion treatments in boiling water suited the seedlot from Indonesia they were much less effective with the Australian lot. More work is needed to define the optimum treatment for seeds of this species.

PART II

Table 2 *A. auriculiformis* - Muaklek

Nicking is superior among the treatments. Sulphuric acid 45 minutes and soaking in hot water 5 minutes have the same results. Boiling water and soaking in hot water have good results of germination. Control and Sulphuric Acid 5 minutes has the lowest germination.

Table 3 *A. aulacocarpa* - Seedlot No. 13865

Control has the lowest germination result followed by Sulphuric Acid, 30 minutes. Boiling water 85°C, 1,3 & 5 minutes has the best germination % among the treatments. Followed by Boiling water 95°C, 1 minute. Nicking gave good results and soaking in hot water 85°C, 95°C, 5 to 60 minutes respectively.

Table 4 *A. auriculiformis* - 0216

Boiling water 85°C 1 & 3 minutes is the best among the treatments. Sulphuric acid 30 & 45 minutes gave promising results. Boiling water 95°C and Soaking in hot water 85°C to 95°C more or less has the same results of germination. Control and Sulphuric acid 5 minutes gave the lowest germination.

Table 5 A. cincinnata - 13864
Nicking is suprisingly 100% germination. Boiling water 85°C 1 & 3 minutes and Sulphuric acid 30 minutes has good germination results. The rest of the treatments shows poor results.

Table 6 A. cincinnata - 13878
Control and Sulphuric acid 5 minutes gave the lowest germination results. Boiling water 95°C 3 minutes. Boiling water 85°C 5 minutes and Nicking have good results, respectively. Boiling water 85°C 1,3 & 5 minutes have the highest % of germination among all treatments.

Table 7 A. flavescens - 14590
Soaking in hot water 85°C 5 and 60 minutes is superior. Soaking in hot water 95°C and Nicking have good germination results. Sulphuric acid 30 to 60 minutes, Boiling water 85°C and 95°C have more or less desame results.

Table 8 A. flavescens - 15481
This seedlot has the lowest germination results among seedlots used. Boiling water 85°C 3 & 5 minutes is superior. Soaking in hot water 95°C 5 and 60 minutes show some promising results. Sulphuric acid and Control has the lowest germination results.

Table 9 A. crassicarpa - 13682
Control and Sulphuric acid 5 minutes has the lowest results among all pre-treatments. Soaking in hot water 60 minutes; Boiling water 85°C 1 &5 minutes and Nicking have good germination results. Sulphuric acid 15 & 60 minutes are to severe which resulted in poor germination.

Table 10 A. crassicarpa - 13683
Control and Sulphuric acid 5 minutes again has the lowest germination. Soaking in not water 85°C 60 minutes; Soaking in hot water 95°C 5 minutes; Boiling water 85°C 5 minutes and Boiling water 95°C 1 minute respectively have good germination. Sulphuric acid has the lowest germination second to Control.

Table 11 A. holosericea - 13879
Boiling water 85°C 1 & 3 minutes are superior among the treatments. Nicking and Soaking in hot water 85°C has good results. Control and Sulphuric acid 5 minutes have poor results. Sulphuric acid 60 minutes is to severe. Among all treatments Boiling water 85°C has good results.

Table 12 A. holosericea - 13853
Boiling water 95°C 3 minutes; Soaking in hot water 85°C 60 minutes; Soaking

in hot water 95°C 5 & 60 minutes and Sulphuric acid 45 minutes respectively have good germination. Boiling water 95°C; Soaking in hot water 85°C and Soaking in hot water 95°C have the highest germination results among all treatments.

Table 13 <u>A</u>. <u>leptocarpa</u> - 14966
Soaking in hot water 85°C and 95°C gave good results. Nicking is superior among all treatments. Sulphuric acid is second to Control on the lowest % germination.

Table 14 <u>A</u>. <u>leptocarpa</u> - 14139
Control has the lowest results. Nicking is superior among all treatments. Sulphuric acid 30 minutes; Boiling water and Soaking in hot water gave good results.

Table 15 <u>A</u>. <u>mangium</u> - 0211
Control and Sulphuric acid 5 minutes have the lowest germination. Soaking in hot water 85°C 60 minutes & Boiling water 95°C 1 minute have the highest % germination. Boiling water 95°C is the best among all treatments.

Table 16 <u>A</u>. <u>mangium</u> - 15328
Soaking in hot water 85°C 5 minutes; Boiling water 85°C 3 and 5 minutes and Boiling water 95°C 1 and 3 minutes have good results. Soaking in hot water 85°C is the best among all treatments.

CONCLUSSION

In this study nicking gave good results but this is time consuming. Boiling water and Soaking in hot water are promising pre-treatments for Acacias.

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Table. 1 A. aulacocarpa - 13866

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	6	g	
Nicking	Nil	96	ab	
Sulphuric Acid	5 minutes	40	f	
	15 "	97	a	
	30 "	93	ab	
	45 "	69	de	
	60 "	66	e	
Boiling Water 85°C	1 minute(s)	85	bc	
	3 "	86	bc	
	5 "	87	abc	
Boiling Water 95°C	1 "	92	ab	
	3 "	88	abc	
	5 "	79	cd	
Soaking in Hot Water 85°C	5 "	92	ab	
	60 "	93	ab	
Soaking in Hot Water 95°C	5 "	91	ab	
	60 "	78	cd	

Table. 2 A. auriculiformis - Muaklek

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	7	g	
Nicking	Nil	93	a	
Sulphuric Acid	5 minute(s)	53	f	
	15 "	89	abc	
	30 "	86	cd	
	45 "	93	a	
	60 "	75	e	
Boiling Water 85°C	1 "	87	bcd	
	3 "	92	ab	
	5 "	81	de	
Boiling Water 95°C	1 "	89	abc	
	3 "	86	cd	
	5 "	87	bcd	
Soaking in Hot Water 85°C	5 "	87	bcd	
	60 "	83	d	
Soaking in Hot Water 95°C	5 "	93	a	
	60 "	90	abc	

Treatment means with different subscripts differ significantly at the 1% level using Duncan New Multiple Range Test Table.

Table. 3 A. aulacocarpa - 13865

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	2	h	
Nicking	Nil	95	abc	
Sulphuric Acid	5 minute(s)	61	g	
	15 "	9	h	
	30 "	83	ef	
	45 "	89	bcdef	
	60 "	89	bcdef	
Boiling Water 85°C	1 "	94	abcd	
	3 "	97	ab	
	5 "	98	a	
Boiling Water 95°C	1 "	97	ab	
	3 "	87	cdef	
	5 "	79	fg	
Soaking in Hot Water	5 "	96	abc	
	60 "	91	abcde	
Soaking in Hot Water	5 "	92	abcde	
	60 "	85	ef	

Table. 4 A. auriculiformis - 0216

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	24	e	
Nicking	Nil	86	abc	
Sulphuric Acid	5 minute(s)	41	d	
	15 "	79	c	
	30 "	90	ab	
	45 "	90	ab	
	60 "	80	bc	
Boiling Water 85°C	1 "	91	a	
	3 "	91	a	
	5 "	82	abc	
Boiling Water 95°C	1 "	87	abc	
	3 "	82	abc	
	5 "	85	abc	
Soaking in Hot Water 85°C	5 "	87	abc	
	60 "	86	abc	
Soaking in Hot Water 95°C	5 "	90	ab	
	60 "	78	c	

Treatment means with different subscripts differ significantly at the 1% level using Duncan New Mutiple Range Test Table.

Table. 5 A. cincinnata - 13864

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	0	g	
Nicking	Nil	100	a	
Sulphuric Acid	5 minute(s)	16	f	
	15 "	54	fe	
	30 "	90	ab	
	45 "	85	bc	
	60 "	75	cd	
Boiling Water 85°C	1 "	91	ab	
	3 "	90	ab	
	5 "	83	bc	
Boiling Water 95°C	1 "	66	de	
	3 "	73	cd	
	5 "	65	de	
Soaking in Hot Water 85°C	5 "	84	bc	
	60 "	80	bcd	
Soaking in Hot Water 95°C	5 "	75	cd	
	60 "	72	cd	

Table. 6 A. cincinnata - 13878

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	2	g	
Nicking	Nil	92	abc	
Sulphuric Acid	5 minute(s)	16	f	
	15 "	80	e	
	30 "	82	de	
	45 "	84	cde	
	60 "	80	e	
Boiling Water 85°C	1 "	93	ab	
	3 "	92	abc	
	5 "	93	ab	
Boiling Water 95°C	1 "	90	abcd	
	3 "	96	a	
	5 "	89	abcde	
Soaking in Hot Water 85°C	5 "	89	abcde	
	60 "	81	e	
Soaking in Hot Water 95°C	5 "	88	abcde	
	60 "	87	bcde	

Treatment means with different subscripts differ significantly at the 1% level using Duncan New Multiple Range Test Table.

Table. 7 A. flavescens - 14590

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	13	g	
Nicking	Nil	64	bc	
Sulphuric Acid	5 minute(s)	32	f	
	15 "	45	ef	
	30 "	50	de	
	45 "	61	cd	
	60 "	66	abc	
Boiling Water 85°C	1 "	64	bc	
	3 "	61	cd	
	5 "	64	bc	
Boiling Water 95°C	1 "	55	cde	
	3 "	53	cde	
	5 "	61	cd	
Soaking in Hot Water 85°C	5 "	78	a	
	60 "	75	ab	
Soaking in Hot Water 95°C	5 "	63	bcd	
	60 "	64	bc	

Table. 8 A. flavescens - 15481

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	3	g	
Nicking	Nil	30	ab	
Sulphuric Acid	5 minute(s)	2	fg	
	15 "	5	fg	
	30 "	11	defg	
	45 "	10	efg	
	60 "	17	cdef	
Boiling Water 85°C	1 "	24	bcd	
	3 "	31	ab	
	5 "	36	a	
Boiling Water 95°C	1 "	21	bcde	
	3 "	25	abc	
	5 "	29	abc	
Soaking in Hot Water 85°C	5 "	21	bcde	
	60 "	27	abc	
Soaking in Hot Water 95°C	5 "	30	ab	
	60 "	28	abc	

Treatment means with different subscripts differ significantly at the 1% level using Duncan New Multiple Range Test Table.

Table. 9 A. crassicarpa - 13682

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	4	f	
Nicking	Nil	93	ab	
Sulphuric Acid	5 minute(s)	15	ef	
	15 "	23	e	
	30 "	64	d	
	45 "	69	cd	
	60 "	72	cd	
Boiling Water 85°C	1 "	94	ab	
	3 "	92	ab	
	5 "	95	a	
Boiling Water 95°C	1 "	91	ab	
	3 "	91	ab	
	5 "	83	bc	
Soaking in Hot Water 85°C	5 "	96	a	
	60 "	90	ab	
Soaking in Hot Water 95°C	5 "	92	ab	
	60 "	94	ab	

Table. 10 A. crassicarpa - 13683

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	0	g	
Nicking	Nil	91	abc	
Sulphuric Acid	5 minute(s)	4	g	
	15 "	29	f	
	30 "	73	e	
	45 "	84	cd	
	60 "	77	de	
Boiling Water 85°C	1 "	92	abc	
	3 "	91	abc	
	5 "	98	a	
Boiling Water 95°C	1 "	96	ab	
	3 "	95	ab	
	5 "	95	ab	
Soaking in Hot Water 85°C	5 "	87	bc	
	60 "	99	a	
Soaking in Hot Water 95°C	5 "	97	a	
	60 "	93	abc	

Treatment means with defferent subscripts differ significantly at the 1% level using Duncan New Multiple Range Test Table.

Table. 11 A. holosericea - 13879

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	20	e	
Nicking	Nil	92	ab	
Sulphuric Acid	5 minute(s)	58	d	
	15 "	88	abc	
	30 "	81	c	
	45 "	82	bc	
	60 "	66	d	
Boiling Water 85°C	1 "	94	a	
	3 "	95	a	
	5 "	91	abc	
Boiling Water 95°C	1 "	86	abc	
	3 "	86	abc	
	5 "	82	abc	
Soaking in Hot Water 85°C	5 "	89	abc	
	60 "	93	a	
Soaking in Hot Water 95°C	5 "	86	abc	
	60 "	88	abc	

Table. 12 A. holosericea - 13853

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	4	f	
Nicking	Nil	87	bcd	
Sulphuric Acid	5 minute(s)	17	e	
	15 "	81	d	
	30 "	83	cd	
	45 "	99	a	
	60 "	91	abc	
Boiling Water 85°C	1 "	97	a	
	3 "	96	ab	
	5 "	96	ab	
Boiling Water 95°C	1 "	95	ab	
	3 "	99	a	
	5 "	96	ab	
Soaking in Hot Water 85°C	5 "	96	ab	
	60 "	98	a	
Soaking in Hot Water 95°C	5 "	97	a	
	60 "	97	a	

Treatment means with different subscripts differ significantly at the 1% level using Duncan New Multiple Range Test Table.

Table. 13 A. leptocarpa - 14966

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	26	g	
Nicking	Nil	78	a	
Sulphuric Acid	5 minute(s)	63	bc	
	15 "	59	bcd	
	30 "	46	def	
	45 "	49	def	
	60 "	42	efg	
Boiling Water 85°C	1 "	51	cdef	
	3 "	59	bcd	
	5 "	61	bcd	
Boiling Water 95°C	1 "	52	cde	
	3 "	36	fg	
	5 "	49	def	
Soaking in Hot Water 85°C	5 "	67	ab	
	60 "	59	bcd	
Soaking in Hot Water 95°C	5 "	64	bc	
	60 "	44	ef	

Table.14 A. leptocarpa - 14139

Treatment	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	11	e	
Nicking	Nil	86	a	
Sulphuric Acid	5 minute(s)	70	ed	
	15 "	75	abcd	
	30 "	85	ab	
	45 "	67	d	
	60 "	71	bcd	
Boiling Water 85°C	1 "	81	abcd	
	3 "	74	abcd	
	5 "	72	bcd	
Boiling Water 95°C	1 "	82	abcd	
	3 "	79	abcd	
	5 "	84	abc	
Soaking in Hot Water 85°C	5 "	84	abc	
	60 "	80	abcd	
Soaking in Hot Water 95°C	5 "	80	abcd	
	60 "	77	abcd	

Treatment means with different subscripts differ significantly at the 1% level using Duncan New Multiple Range Test Table.

Table. 15 A. mangium - 0211

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	5	g	
Nicking	Nil	89	abc	
Sulphuric Acid	5 minute(s)	27	f	
	15 "	40	e	
	30 "	73	d	
	45 "	89	abc	
	60 "	76	d	
Boiling Water 85°C	1 "	91	abc	
	3 "	88	abc	
	5 "	91	abc	
Boiling Water 95°C	1 "	96	ab	
	3 "	87	bc	
	5 "	91	abc	
Soaking in Hot Water 85°C	5 "	91	abc	
	60 "	97	a	
Soaking in Hot Water 95°C	5 "	82	bcd	
	60 "	89	abc	

Table. 16 A. mangium - 15328

Treatments	Soaking Time	Germination %	DNMRT	ANOVA
				Highly significant
Control	Nil	3	f	
Nicking	Nil	77	cd	
Sulphuric Acid	5 minute(s)	29	e	
	15 "	68	d	
	30 "	70	cd	
	45 "	78	bcd	
	60 "	86	abcd	
Boiling Water 85°C	1 "	93	ab	
	3 "	96	a	
	5 "	95	a	
Boiling Water 95°C	1 "	94	ab	
	3 "	96	a	
	5 "	88	abc	
Soaking in Hot Water 85°C	5 "	97	a	
	60 "	93	ab	
Soaking in Hot Water 95°C	5 "	92	ab	
	60 "	93	ab	

Treatment means with different subscripts differ significantly at the 1% level using Duncan New Multiple Range Test Table.

Importance of Seed Size In Germination and Seedling Growth

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Summary

A cursory review of past work suggests that in most cases seedling size is positively correlated with seed size. The same is not always true for rate of germination, as new data for *Liquidambar styraciflua* L., *Pinus elliottii* Engelm. and *P. echinata* Mill. illustrate. Large seeds of *L. styraciflua* germinated best. But in three lots of *P. elliottii*, small seeds germinated best among three sizes in one lot, large in another, and there were no differences in the third. Seed size was not significant in *P. echinata*. Possible reasons for these differences are discussed.

INTRODUCTION

In the quest for best use of seed supplies, one intriguing question has always been seed size. Do bigger seeds germinate at a faster rate than smaller ones? Further, do seedlings from big seeds grow faster than seedlings from small seeds; and if so, does this advantage persist long enough to make it worthwhile to separate seed sizes prior to sowing? The questions may be of particular importance to developing countries where seed supplies may be limited. For some species in certain situations, separation by seed size has enhanced production of plantable seedlings.

A cursory review of literature on this subject shows that seed size has influenced seedling size in most studies, but results have been divided on the influence of seed size on rate of germination (Table 1). In this review both weight and dimensional differences were included in "size differences," although in some species weight and dimensional separations have produced different results (Belcher et al. 1984; Wrzesniewski 1982a). Most of the studies cited in Table 1 found that the largest seeds performed best. In some cases, however, different sizes did better in different environments (Wrzesniewski 1982c).

Many factors, including biological and environmental, probably can influence seed performance enough to mask seed size effects. Shear and Perry (1985) concluded that total seed weight was not nearly as important as the combined embryo/gametophyte weight in *Pinus taeda* seeds. This aspect of the problem could explain some of the conflicting results in seed size studies. In this paper, data are presented on the influence of seed size on rate of germination for three tree species of the southern United States. For one of these species, separate measurements made of seed coat and embryo/gametophyte tissue weights are also presented.

EXPERIMENTAL METHODS

Three seed lots were used for both *Pinus elliottii* Engelm. and *P. echinata* Mill., and two seed lots for *Liquidambar styraciflua* L. The pine lots, all seed orchard collections, were sized with screens into three fractions, while the *L. styraciflua* seeds were separated into four density fractions on a small laboratory gravity separator. Each fraction was mixed, and weight data were taken.

Germination tests were carried out with four replications of 100 seeds each according to ISTA Rules (International Seed Testing Association 1983) in Stults Engineering[1/] cabinet germinators. Germination was counted three times per week to furnish data for the calculation of germination rates, expressed as peak value (PV) (Czabator 1962).

Nursery germination data were obtained in 1985 for the two pines from plots at the U.S. Forest Service Ashe Nursery, Brooklyn, Mississippi. From four to twelve plots were established for each size fraction, and germination counts were made one or two times per week for 30 days.

Additional seed weight data were obtained for the *P. elliottii* sized lots. Fifty seeds from each lot were carefully and quickly cracked open, and both seed coat and embryo/gametophyte tissue fresh weights were determined individually to the nearest 0.1 mg.

1/ Mention of a trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U. S. Forest Service and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Table 1.--Some past studies on the effect of seed size on germination rate and seedling size for tree species.

Species	Seed Size Significantly Correlated With: Germination rate	Seedling size	Reference
Acer saccharum Marsh	Yes	--	Milby, 1986
Araucaria angustifolia O. Kuntze	Yes	Yes	Candido, 1974
Carya illinoensis (Wangenh.) K. Koch	--	Yes	Adams & Thielges, 1979
Picea abies (L.) Karst	No	No	Vanselow, 1933
P. abies (L.) Karst	No	Yes	Girgidov & Gusev, 1976
P. glauca (Moench) Voss	--	Yes	Khalil, 1981
Pinus elliottii Engelm.	No	Yes	Belcher et al., 1984
P. koraiensis Sieb. & Zucc.	--	Yes	Han et al., 1982
P. roxburghii Sarg.	--	Yes	Chauhan & Raina, 1980
P. sylvestris L.	Yes	No	Wrzesniewski, 1982a-c
P. sylvestris L.	No	Yes	Girgidov & Gusev, 1976
P. taeda L.	Yes	Yes	Dunlap & Barnett, 1983
P. taeda L.	--	No	Barnett & Dunlap, 1982
Quercus alba L.	--	Yes	Korstian, 1927
Q. ilex L.	No	--	Aissa, 1983
Q. petraea (Mattushka)Lieblein.	--	Yes	Kleinschmit & Svolba, 1979
Q. prinus L.	--	Yes	Korstian, 1927
Q. robur L.	--	Yes	Kleinschmit & Svolba, 1979
Q. rubra L.	--	Yes	Korstian, 1927
Q. velutina Lam.	--	Yes	Korstian, 1927
Shorea contorta Vidal	Yes	Yes	Basada, 1979
Theobroma cacao L.	No	Yes	Ravindran, 1981
Tsuga heterophylla (Raf.) Sarg.	--	No	Kuser & Ching, 1981

RESULTS

A significant effect of seed size on germination rate was found for all three lots of L. styraciflua (Table 2), although the means of all fractions within lots were not different. In general, smaller seeds germinated slower than large ones.

Table 2.--Relationship of seedweight and germination for three lots of Liquidambar styraciflua.

Lot	Density Fraction	1000-seed Weight	Laboratory Test Germination	Laboratory Test PV
		-g-	-%-	-%/day-
A	light	3.2	42	3.7 a*
	light/medium	3.8	79	7.0 b
	heavy/medium	4.6	88	7.3 b
	heavy	4.9	91	7.7 b
B	light	4.9	81	6.7 a
	light/medium	5.3	82	6.8 a
	heavy/medium	5.4	94	8.1 b
	heavy	5.6	95	8.1 b
C	light	3.8	52	4.8 a
	light/medium	4.7	78	7.3 b
	heavy/medium	5.1	88	8.3 c
	heavy	5.4	95	8.7 c

* Values followed by the same letter are not significantly different at p=0.05.

Results for the two pine species were varied. In the two lots of P. echinata, seed size had no effect on germination rate (Table 3). In P. elliottii, all possible combinations occurred (Table 4). In lot A, seed size was not significant. In lot B, the smallest seeds germinated faster than the other sizes. In lot C, the largest seeds germinated faster than the others.

The nursery data were not collected from a designed study, so no statistical tests were possible. Germination did not appear to be highly correlated with seed size, however (Table 3 & 4). The results also demonstrate that field germination and laboratory germination may not always coincide, as many experienced nurserymen can testify.

Seed weight data for P. elliottii seed coats and embryo/gametophyte tissues did not explain the differences between lots (Table 4). In all three lots, both seed coat and embryo/gametophyte tissue weights increased in proportion to the 1,000-seed weight of each fraction. In lot B the seeds with the smallest embryo/gametophyte germinated faster than the larger ones.

Table 3.--Relationship of seed weight and germination for two lots of *Pinus echinata*.

Lot	Size Fraction	1000-seed Weight	Laboratory Test Germination	PV	Nursery Test Germination	PV
		-g-	-%-	-%/day-	-%-	-%/day-
A	small	11.2	78	4.4 a*	30	1.1
	medium	13.3	74	4.3 a	18	0.7
	large	15.4	77	4.2 a	49	2.1
B	small	7.7	75	3.7 a	24	1.0
	medium	9.5	78	4.0 a	23	0.8
	large	14.8	66	3.4 a	31	1.3

* Values followed by the same letter are not significantly different at p=0.05.

Table 4.--Relationship of seed weight and germination for three lots of *Pinus elliottii*.

Lot	Size Fraction	1000-seed Weight	Lab Test Total germ.	PV	Nursery Test Total germ.	PV	Emb./gam. Weight	Seed coat Weight
		-g-	-%-	-%/day-	-%-	-%/day-	-mg-	-mg-
A	small	41.9	82	5.0 a*	65	3.1	262.4±4.4	168.2±2.8
	medium	46.7	87	5.8 a	56	2.7	277.3±3.6	197.6±3.6
	large	53.7	85	5.6 a	71	4.5	318.5±4.9	226.7±4.4
B	small	42.5	93	6.4 a	84	5.2	253.3±4.7	193.7±3.5
	medium	49.1	93	5.4 b	73	4.7	291.6±4.9	214.6±3.7
	large	59.7	90	5.3 b	70	4.2	328.9±4.8	260.0±4.5
C	small	35.3	55	3.8 a	24	1.1	214.3±4.4	156.5±3.3
	medium	41.6	55	3.2 a	20	0.9	257.7±5.4	172.5±4.3
	large	51.4	63	7.6 b	12	0.6	334.6±7.0	238.5±5.2

* Values followed by the same letter are not significantly different at p=0.05.

DISCUSSION

The data presented in this paper demonstrate the frustration in dealing with seed size effects. Size was positively correlated with germination rate for one species (L. styraciflua), was completely insignificant in a second species (P. echinata), and was widely varied in significance among three seed lots in a third (P. elliottii). It must be pointed out that these data sets were not extensive and were drawn from only a few lots of each species. A different set of sources or lots could possibly give different results. And yet, many of the references cited in Table 1 used just as few or fewer lots.

It has been suggested that larger seeds have the advantage over smaller ones partly because of larger embryo/gametophyte tissue (Shear and Perry 1985), more cotyledons (Wrzesniewski 1982c), or greater initial leaf area (Farmer 1980). Other studies, however, have found a low correlation between seed weight and cotyledon number for Tsuga heterophylla (Kusar and Ching 1981) and seed weight and number of leaves in Theobroma cacao (Ravindran 1981).

In a species which usually exhibits seed dormancy, such as P. taeda, the seed coat may play a large role in imposition of dormancy (Barnett 1972). Thorbjornsen (1961) found a clinal pattern of increasing seed coat thickness in P. taeda from the western part of its range to the eastern. Shear and Perry (1985) suggested that total seed weight of P. taeda was largely determined by seed coat weight, and that was why seed weight was a poor predictor of seedling size. Weight may not be the crucial parameter that reflects dormancy, however, and this aspect of the problem deserves further study.

It is probable that the key to understanding the relationship of seed size to germination and seedling growth can be found at the cellular level or below. Wrzesniewski (1982a,b) concluded that the degree of embryo development in P. sylvestris was more important than seed size parameters. Recent research on soybean (Glycine max [L.] Merr.) indicated that seeds with higher numbers of cells per cotyledon had greater rates of dry matter accumulation (Guldan and Brun 1985).

Genetic factors must also be considered. Because the maternal influence on seed size is so great, discarding the smallest seeds from sized lots can practically eliminate some genetic components (Silen and Osterhaus 1979). Discarding the small fraction of lot B of P. elliottii used in this study would have thrown away the best fraction (Table 4). The obvious answer is not to discard any fraction of a sized lot, but to plant each seed size in a separate area. This practice is common in pine nurseries of the southern United States, where research has demonstrated improved seedling production when slowly germinating seeds are sown separately from those which germinate more rapidly (Wasser 1978). If seed orchard collections are kept separate by clone, the same thing can be accomplished by planting clonal lots separately. Sizing is normally not needed for clonal lots.

CONCLUSIONS

Although size and weight are not very sensitive measurements of seed quality, a considerable body of evidence indicates that large seeds produce larger seedlings than small seeds for many species. While the evidence is weaker, seeds of certain sizes (usually the largest) germinate at a faster rate in some species or lots. If conditions allow, sized samples of all seed lots should be tested before planting to determine if sizing will be advantageous. Even without such testing, heterogeneous seed lots should probably be sized anyway, because uniform seed size should facilitate sowing. Small seeds should not be discarded, but they should be planted in areas apart from those of larger size seeds.

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PRELIMINARY STUDIES ON DORMANCY AND GERMINATION OF CAMPHOR TREE SEEDS

by

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SUMMARY

The camphor tree is a typical species of the subtropical evergreen broad-leaved woods. The seeds of camphor tree germinate slowly in the nursery. The results of our studies show that: (1) the seed is in dormancy; (2) the embryo is not in dormancy; (3) the air permeability of entire seed is poor; (4) increase in the concentration of oxygen can stimulate germination. Therefore, one of the causes for the dormancy of camphor tree seeds is the impermeability of seed coat, belonging to the type of forced dormancy.

Keywords: Camphor tree, dormancy, impermeability

Introduction

The Camphor-tree, Cinnamomum camphora, is a representative species of the evergreen subtropical broad-leaved woods. It is a timber tree of high value because of its fast growth, long life-span, and strong resistance to diaeases and conditions. The timber of camphor-tree can be used for ship-building, furniture-making, and carving, so it is considered as a high class timber. Camphor is an important export goods and plays an important role in the forestry production. However, the seeds of Camphor-tree germinate slowly. The germination stage may continue for two months and develop quite unevenly.[1] Appropriate methods to test the quality of the seedlings of the Camphor-tree have not been found yet.

In 1981-1983 we carried out a set of studies on this subject. Our first results are as follows.

Materials and Methods

The seeds we use are provided by The Hangzhou Botanical Garden. 1,000 seeds weigh 144.9 grams. Moisture content of the seeds from sand-storage is 33.8%. Respiratory intensity is measured by Alkali absorbent.[2]

The method we used to increase oxygen concentration consists in the following processes:

add 500 ml distilled water onto the bottom of a vacuum drier, inner diameter of which is 240 mm., and its capacity measures 7,730 ml.

Put two layers of square cotton gauze on the division plate in the drier, so that four corners of the square gauze could dip into water.

Put the seeds onto the gauze and then cover them with another layer of gauze.

Seal the drier tightly, and then pump oxygen into it.

The oxygen concentration in the drier is measured with cy-7 oxygen-meter. The drier is filled up with oxygen once a week. Each treatment is repeated 3--4 times. Details are stated in other parts of this report.

Results and Analyses

I. Dormancy of seeds

Camphor-tree seeds stored in sand at low temperatures (0--5°C) till next spring are unable to germinate at constant room temperature. If the seeds are exposed to changing temperatures, or treated with 45°C warm water, germination will slightly increase, however, the germination percentage will not exceed 16% at most. It clearly shows the dormancy of seeds. (Fig. 1)

Fig. 1 Germination percentage of Camphor-tree seeds exposed to differently changing temperatures

Notes: Treatment 1. The seeds are cultivated at 25°C for 8 hrs and at 5°C for 16 hrs per day, the germination continues for 50 days.

Treatment 2. The seeds are cultivated at 30°C for 8 hrs and at 5°C for 16 hrs per day, the germination continues for 50 days.

Treatment 3. Seeds are treated with 45°C hot water for 24 hus, then let them cool down naturally. After cooling, seeds are cultivated at 30°C under 1150 Lux light for 8 hus and at 20°C for 16 hus per day. As a result, the germination continues for 13 days.

Treatment 4. Seeds are cultivated at 25°C constantly. The germination continues for 38 days.

II. Causes of seed dormancy

1. The germination of embryo-square

In order to test if the embryo is in dormancy, we use 150 seeds and cut 0.5 mm.embryo-square from each, then put the squares on paper-bed evenly in three petri dishes.The embryo-squares are cultivated in the dark at 20°C constantly (green light is given when we work).[3] After 18 days, most of the embryonic roots and buds germinated and grew longer. Germination percentage reached 91.7, length of embryonic root-- 16.6 mm., and embryonic bud -- 16.5 mm. These data show that the embryo is ripe and is not in dormancy.

2.The germination of coat-removed seeds

It has been reported that embryo-cuting may stimulate the seeds to produce ethene.[4] In order to avoid this affection, we performed a germination test on seeds without seed-coat. The uncoated seeds are put on the sand bed in petri dish and cultivated in the 25°C incubator. On 8th day the embryonic root appears, and on 14th day the germination process ends. The germination percentage is high. The result further shows the embryo is not in dormancy. (see table 1)

Table 1. The germination of coat-removed seeds of Camphor-tree

Treatment	Age of seeds (month)	Germinating energy	Germination %
Coat-removed seeds	3	52.7	88.7
Entire seeds	3	-	0

Note: Each treatment repeated 3 times.
Each time 50 seeds are used.

3. The respiratory intensity of coat-removed seeds

The uncoated seeds are put evenly on the sand bed in the petri dish and cultivated in the incubator at 25°C. Each dish contains 50 seeds and repeats 3 times. The respiratory intensity is measured when the embryonic roots just begin to grow. The results from measuring show that the respiratory intensity of uncoated seeds obviously increases while that of controls (the respiratory intensity of entire seeds) can scareely be measured. (see Table 2) It shows the air permeability of entire seeds is poor and its breathing is checked.

Table 2. The respiratory intensity of coat-removed seeds of Camphor-tree

Treatment	Age of seeds (month)	Respiratory intensity
Coat-removed seeds	15	$\frac{1.4660 \quad mgCO_2}{1\ hr \quad 100\ seeds}$
Entire seeds	15	measured nothing

4. The effects of oxygen concentration on the germination of Camphor-tree seeds

The seeds stored in sand at low temperature are put in the vacuum drier (desiccator) filled with highly concentrated oxygen. The concentration of oxygen is measured weekly when filling up the drier with fresh oxygen. The four different concentrations of oxygen measured are 61%, 62%, 65%, and 54%. One week later, the concentrations reduced by 4--8%. The controls are done as follows:

The seeds are put in a drier with normal oxygen concentration in the atmosphere. Then the drier is sealed, but not vacuumized.

Both vacuumized and unvacuumized driers are put in the incubator at 23°C. Each treatment repeats 2 times. Each repeat contains 50 seeds. After 4 weeks, most seeds in highly concentrated oxygen are germinating well. The germination percentage is obviously higher than that of controls. It further shows that the air permeability of Camphor-tree seeds is poor. It is the real cause of seed dormancy. Therefore, it can be assumed that the Camphor-tree seeds belong to the type of forced-dormancy. (see Table 3).

Table 3. The effects of increased oxygen concentration on Camphor-tree seed germination

Treatment (Oxygen %)	Age of seeds (month)	Germination %	
		2 weeks	4 weeks
61.0	12	22	62
21.0	12	0	3

Discussion

Owing to the application of plant tissue culture techniques in the study of dormancy and germination, the causes and position of dormancy of a variety of seeds are revealed. For example, the embryo of red pine is lack of dormancy, when it is developed from an isolated cut embryo. It is considered that a certain inhibitory substance in the seed may check the germination[7] The same result has been observed in testing the seeds of pond cypress[8]. Some scientists assume that there are certain substances in the cotyledons of sugar-maple which may check the germination[5]. The test shows that embryo is able to germinate. It further shows that it is not the embryo, but the poor permeability of seed coat that effects the germination. It seems true that the effect of permeability of seed dormancy and germination is related with respiration. Mr. Shull proves that the epigyous seeds of Xanthium are able to germinate only in pure oxygen at 21°C,but the hypostatic seeds germinate fully in 6% oxygen.[6] Among the forest trees, the dormancy of seeds of Fraxinus pennsylvanica, Pinus Jeffreyi, Pinus strobus, etc. is related with the permeability of their seed coats. The test shows that the Camphor-tree seeds have a quite long period of dormancy, the permeability of seed coat is poor, the respiration is week, so the entire seeds are unable to germinate well, while the seed coat is removed, the concentration of oxygen is increased, the respiration will carry on better and stimulate the germination.

Studies on dormancy and germination of Camphor-tree seeds play an important role in the understanding of seed germination. Sakaguchi Katsumi made a germination test at 23⇄5°C changing temperatures, wraping up the Camphor-tree seeds in filter paper, but we have not done in the same way. There are no indications of Camphor-tree seeds test in the book "THE METHODS OF FOREST TREE SEEDS EXAMINATION" published in China. In china, the quality of Camphor-tree seeds is usually examined by measuring their superiority or vigour, but the results are not accurate enough. Therefore, we have treated the seed coats with H_2O_2 in different concentrations over different period of time. (15 combinations of treatment) in order to increase the air permeability of seeds. The results show that the combination of 19% concentration of H_2O_2 and 2 hours is the best-21% germinating energy after 9 days, 66% germination percentage after 17 days. This method is quite simple and easy to do, the germinating stage is short, so, we think, it may meet the needs of seed-quality examination. In order to increase the seedling rate and reduce the cost of seedling cultivation in field, there is still much to be done, for example, what concentration of H_2O_2 and how long to treat the seeds will be the best.

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FORESTRY SEED PROBLEMS IN MALAYSIA

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ABSTRACT

Agricultural and urban development in Malaysia has resulted in the increasing depletion of the tropical forests. This has led to the recognition of the need for conservation of genetic resources, simultaneously, planting fast growing tree species, consequently there is a great demand for forestry seeds. Many problems have arisen such as the shortage of seeds for these programmes, in particular the indigenous species as flowering and seed production are very unpredictable that is very irregular. More efforts have to be made to handle seed production, harvesting, collection and processing. Besides, the majority of forestry species possess seeds which are recalcitrant in nature that is sensitive to dehydration and chilling, unlike the field crops. Recalcitrant seeds are also very perishable when not stored properly may even lose their viability during collection or on transit. In this paper the major problems encountered are discussed.

Introduction

In Malaysia, as in many other developing counties in the tropics, there is constant demand for agricultural and urban development. This has led to the depletion of the tropical rainforests caused by over-exploitation. The need for conservation needs no further emphasis and fortunately the Malaysian Government is well aware of the need to establish new forests on cleared or degraded forest land. Plans have been made to study the possibility of planting fast growing species of trees such as Acacia mangium, Gmelina arborea, Eucalpytus camadulensis. Simultaneously, there is increasing emphasis on protection of forest reserves, to conserve the rich and diverse germplasm. In all these programmes of afforestation and reforestation, seeds play a vital role whether species be indigenous or exotic. Large quantities of seeds are required annually, and this demand leads to many problems.

The forestry seed industry in Malaysia is only at its infancy compared to agricultural and horticultural crop seeds. In terms of seed production and technology, forestry seed is lagging far behind and faces many problems.

In this paper the various problems encountered in seed production, collection, handling, storage and seed testing or quality determination of both indigenous and introduced exotic species will be discussed.

Seed Production

The sources of seeds for planting of indigenous species are presently harvested or collected from existing trees in the forests. Seed orchards are not available except in arboreta where limited number of species are planted. The flowering and fruiting of most of the species, in particular those of the Dipterocarpaceae family in which many flower once in a few years. So the seed source is very unreliable and is difficult to predict. The best one can do is to observe and minitor flowering in various selected plots or arboreta in the country. Flowering in most of the trees is irregular, an observation by Medway (1972) showed that only 10 out of the 45 selected species of canopy trees flowered annually. Flowering fluctuates from year to year and its intensity also differs. According to reports a large proportion of tropical species flower intermittently at irregular intervals especially in Dipterocarpaceae

(Burgess, 1972; Chan, 1981; Cockburn, 1975; Medway 1972; Ng, 1977). During years of gregarious flowering, occurring once in 3 to 5 years, large quantities of seeds of the same species are available. This shows that there is definite need to minitor trees for seed production.

Besides the natural forests, introduced exotic species have been planted in pure stands. This makes seeds production relatively easier. In the state of Sabah for example the first Acacia mangium was introduced in 1967 and since then a number of generations had been planted. It has been noted that there is evidence for a progressive decrease in both vigor and health in generation after the first. It is therefore necessary to introduce from other places so that there is a wider genetic base as a seed source to overcome the problem of production of non vigorous and unhealthy seeds.

Forestry seeds have not been specially bred like other crops, it is common to have inbreeding depression leading to low yield. It has been shown wood yield of some species could be doubled simply by using seeds from selected wild populations. The identification of well adapted seed sources has been an important step in immediately raising the yield from plantations as well as being the first stage in breeding programmes (Turnbull and Boland, 1984).

The dependence of a natural supply of seeds from the forest floor is no longer sound. Efforts to seed production must be emphasized to produce quality seeds, with the help of machinery and other means to ensure production of quality seeds. This is not at all easy, many problems are to be encountered such as flowering, seed set, diseases and pests and to ensure genetic purity. It is possible in the future that seeds produced in local seed orchards may be even certified to improve their provenance.

Harvesting, collection and processing

The problems in harvesting, collection and processing of forestry seeds far exceed those of agricultural crop seeds. First and foremost, there is no definite time of harvesting, the time and quantities produced vary from year to year depending on natural seedfall. The organization of labourers for collection is erratic and labour force can be scarce and expensive. Many problems are also associated with collection of natural seedfalls such as uneven maturity of seeds, weathering of seeds in the field all resulting in a generally poor seed quality. The main difficulty in harvesting forestry seeds is that the trees grow to great heights of over a hundred feet especially the Dipterocarps and it is almost impossible to harvest them by hands. Although these can be overcome in some cases with special guns, cranes or even trained climbers and monkeys. In extreme cases and in desperate situations there is a necessity to fell the tree. Many of the tropical forestry species are very large seeded and there are not too many seeds available per tree as compared to Eucalyptus. After harvesting, the fruits or seeds fall to the ground and it is difficult to find and collect them in the thick undergrowth below the canopy. Fortunately with the introduction of exotic species and growing them in plantation scale in pure stands, it is easier for seed harvesting and collection. With trees like Acacia mangium harvesting the seed pod is not too much of a problem and no undue difficulties were experienced except that climbers are occasionally bitten by ants or bees.

After harvesting and collection the seeds have to be transported long distances and this can be a problem. Many of the species have recalcitrant seeds and have to be tranported as quickly as possible or else their viability will decline rapidly. Even with orthodox seeds, a number of remote places may be a few hundred kilometres away from the processing centres. The transport of bulky unprocessed pods of legumes may present economical problem of high cost of transporation. As electricity is often not available in the field the processing of seed pods at collection site is not practical. Even if electricity is available the transporation of extraction equipment for processing would have incurred extra transport costs. With most forestry species, the processing techniques for seeds are not available, besides since there is such great diversity in seed types mechanical processing of these seeds may not be practical or economical.

Seed storage

The storage of seeds of agricultural crops was in practice centuries ago. It is indeed at a very advanced stage of technology as in the case of the modern genebanks for long term storage. As for forestry seeds, the orthodox species can be stored in the same manner as agricultural crop seeds. But unfortunately many of the tropical rain forest species belong to the recalcitrant group ie. they have short life span and cannot tolerate desiccation or low temperature. With recalcitrant seeds, there is not a single method available to store seeds for over a year (Chin, 1978). In case of the Dipterocarps, the seeds present numerous problems eg. chilling damage, fungal infestation, desiccation injury and germination during storage. Yap (1981) tried different techniques on Dipterocarp seeds. At best, period of storagte was extended to 90 days. It is very important that before storage, one must identify the type of seeds whether they are orthodox or recalcitrant. Wrong identification can mean failure in storage of seeds (Chin et al, 1984). Although long term storage for conservation of genetic resources is not yet possible, any improvement to storage life even for short term can be useful for the transportation of seeds from collection sites to processing centres or nurseries. Transportation of seeds in the forests is slow and tedious, and the seeds are very sensitive especially the recalcitrant ones and their quality can be badly affected. Seeds are living things as such they must be handled with great care (Chin, 1979).

At present the problems on storage may not be apparent, as there are often no seeds for storage. What is collected is immediately used up for planting except those which are imported from overseas. Most of the species introduced belong to the orthodox group, hence they can be easily stored in a dry cool store. With recalcitrant seeds the typical ones are the Dipterocarps. These are very sensitive seeds having very short life span. They cannot tolerate desiccation of below 33% moisture content (Tamari, 1976) and the so called low temperature, which may be as high as 15 C and 4 C for Shorea talura (Sasaki, 1976). Collection of such sensitive species must be given special attention. Many of these species germinate very rapidly even without water, while on transit or during transportation. These germinated seeds are very susceptible to mechanical damage and their quality can be greatly affected.

Seed testing

At present, in the latest international seed testing rules of ISTA (1985), there are no rules available for the testing of most tropical forestry seeds. But in any seed programme, seed quality is normally assessed at all stages of production, processing, storage and before planting. It is important that the right technique or method be used by different people, as uniformity is the essence of seed testing. There is a lack of study of germination of the tropical species. Many germinate readily while others like palms and rattans take weeks to germinate. Calamus species take as long as 41 weeks to germinate. Methods of scarification have to be developed to break dormancy in seeds such as using hot water, concentrated sulphuric acid or use of a mechanical scarifier for hard seeded species. Other quality tests such as moisture determination is very critical as storage life is dependent on moisture content. Most of the recalcitrant seeds are very large and heavy, sampling is difficult and no rules for moisture tests of these seeds are available. One has to improvise tests for the species they are studying. Lastly other physiological and biochemical tests for seed vigour and viability have also to be improvised to determine their quality. Methods of testing forestry tree seeds have yet to be developed. A seed analyst in forestry faces many more problems that his or her counterparts in the agricultural sector.

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STUDIES ON THE VIABILITY OF *PAULOWNIA* SEED.

by

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Abstract:

Seed of four *Paulownia* species were examined for viability. The control of fungi and bacteria found on the seed coats will increase the number of germinants obtained when the seed is sown. The most effective method to do this is by immersion in 5 % sodium hypochlorite for 20 minutes, followed by two washes in distilled water. Soaking the disinfected seed in a 1:1 000 solution of Kelpak 66 for one hour will further increase the number of germinants. Routine seed testing by numbers is difficult and time consuming. Viability testing by mass, which is much easier to do, is recommended.

Introduction:

The genus *Paulownia* contains several fast growing hard-wood tree species whose timber is in great demand in the Far East, particularly in Japan. Suitability trials with *P.fortunei* were started at Stellenbosch in 1982 with seed from mainland China. Growth was excellent and more intensive, country wide trials were started in 1986 and 1987, following the author's sabbatical in Taiwan in 1985. *Paulownia* propagates vegetatively with ease, either from root-cuttings or stem-cuttings but the use of vegetative material for introduction is undesirable, because of the danger of importing associated diseases. Seed of four species and three to four seedlots or provenances of each species have been collected to provide the plants for the above mentioned trials. Studies to maximise germination and to facilitate the routine testing of the seed are reported here. The first two trials and part of the fourth were done at the Taiwan Forest Research Institute (TFRI) in Taipei, Taiwan. The third and most of the fourth were undertaken in the silvicultural laboratory of the Faculty of Forestry, Stellenbosch.

Methods and materials:

Three seed lots of *P.taiwaniana*, Kukuan 1980, Taipei 1984 and Taipei 1985, taken from the 0°C coldstore of the TFRI were used for all the tests conducted in Taiwan.

Trial 1 tested the effect of seed coat disinfection on fungal incidence on the seed coats and on the viability of the seed. Four treatments and a control each replicated ten times were tested. Five treated seed were plated under a laminar flow bench on to water agar in petri dishes for each replicate. The treatments were as follows:

1. Control, seed untreated.
2. Seed subjected to 20 minutes soaking in 5 % sodium hypochlorite and washed twice in distilled water.
3. Seed immersed in hot water (water bath at 50°C) for 20 minutes then cooled rapidly in distilled water.
4. Seed treated with Captan (10% of dry weight).
5. Seed placed in 33,3 % H_2O_2 for three minutes, then washed twice in distilled water.

The petri dishes were placed in incubators at a constant temperature of 25°C with 14 hours light. Plates were examined every three days for germination and fungal development, the position of the germinants being noted at each inspection. Examples of the fungi which developed were collected for identification.

Trial 2 tested the effect of seed coat disinfection and Kelpak 66 soaking on the routine testing of the seed. Seed testing was still being done by numbers at this stage. Kelpak 66 is a South African seaweed product which has been shown to be benefical to the germination of pine seed (Donald,1984). It is manufactured by Kelp Products, South Africa and registered as an organic fertilizer no. B377 of Act 36 of 1947.

Four treatments in a 2 x 2 factorial design with eight replicates were used; each replicate had 50 seed. The treatments were without and with 5 % sodium hypochlorite and without and with a 24 hour soak in a 1:500 Kelpak 66 solution. Seed not Kelpak soaked were given a 24 hour water soak.

The seed were germinated on horticultural grade vermiculite in 200 mm x 200 mm x 55 mm PVC germination trays, with tight fitting lids, placed in incubators kept at 27°C with light for 16 hours and at 15°C in the dark for eight hours. Light is necessary for the germination of *Paulownia* seed (Schopmeyer,1974). Germination was checked every third day for 30 days, when the trial was broken down. Germination capacity (the total number of viable seed in the seedlot expressed as a percentage of the full seed sown. ISTA,1985) and dormancy percent (the number of viable seed which have not germinated within a fixed period, in this case 14 days, expressed as a percentage of the total viable seed in the seedlot. Donald, 1968) were calculated for all replicates.

Trial 3 tested reduced concentrations of Kelpak 66 with reduced soaking periods on the Taipei '84 seedlot, which was also used in Taiwan. Two concentrations 1:500 and 1:1000 with six soaking periods, doubling from 0,5 to 16 hours, were compared with an untreated control. Four replicates of 50 seed were used. Treatments, which were applied to disinfected seed, were sown on horticultural grade vermiculite in 125 mm x 125 mm x 100 mm PVC trays with loose fitting lids and kept in the seed room of the Faculty of Forestry at 27°C for 16 hours with light and 15°C for eight hours in the dark. Counts were done as described in trial 2, except that a final count was made at 60 days in lieu of the normal breakdown, which had proved very time consuming, and difficult to do.

Trial 4 was designed to test the efficacy of viability determination by mass. Viability determinations were done by number counts and by weighed sub-samples for four species, each with a number of seedlots or provenances. Four to eight replicates of each method were tested depending upon the quantity of seed available. Replicates consisted of 50 seeds for the number method and a weighed mass of 0,025 g for the mass method. Each 50 seed replicate was also weighed to allow comparisons on the number of viable seed per gram to be made. The exact weight of the weighed replicates was recorded for the same reason.
All seed were disinfected with 5 % sodium hypochlorite and washed twice in distilled water before sowing. Seed were sown and enumerated as described in trial 3.

Results:

Trial 1. Of the four treatments tested to disinfect the seed coats only the sodium hypochlorite treatment reduced the number of infected seed and improved the germination. The viability of the three seedlots differed significantly but there were no interactions. Table 1 summarises the results.

Table 1: Mean number of 1) infected *Paulownia taiwaniana* seed and 2) germinants, out of five seed sown on to water agar.

	Control	Sodium Hypochlorite 5%	Hot Water 50°C	Captan 10%	H_2O_2 33,3%	SE	P,01
1)	2,7	1,1	2,9	2,6	2,9	0,17	0,42
2)	0,80	2,10	0,87	0,87	0,90	0,23	0,59

The following organism were identified from the incubated seed, *Fusarium* sp, *Cladosporium* sp, frequently both occurring on the same seed, *Odiodendron* sp, *Trichoderma* sp, *Penicillium* sp, Streptomyces and an unknown pink bacteria. Although the pathogenicity of these samples was not tested directly, there was a significant negative relationship between their incidence and the number of germinants, (R^2 = -0,65).

Trial 2. The routine germination tests confirmed that the three seedlots differed in their viability and that seed coat disinfection increased viability. The Kelpak treatment proved to be detrimental to disinfected seed but had no effect on untreated seed (Table 2). Although the seedlots differed in viability, they all reacted in the same way to the treatments.

Table 2: The effect of seed coat disinfection and Kelpak soaking on the viability of *Paulownia taiwaniana* seed.

	No seed coat disinfection	Seed coat disinfection	Mean	Body of Table SE	Body of Table P,01
No Kelpak	11,0	30,0	20,5	2,2	4,3
				Disinfection SE	Disinfection P,01
Kelpak	12,5	24,1	18,3		
Mean	11,8	27,0	19,4	1,5	4,0

Trial 3. Kelpak soaking increased the viability of *Paulownia taiwaniana* seed when the period of soaking was reduced and or the concentration was reduced. Soaking for periods longer than 30 minutes was mostly detrimental with solutions of 1:500. Seed could be soaked in solutions of 1:1000 for up to 16 hours without significantly reducing viability. Table 3 summarises the significant responses. Kelpak soaking had no effect on the dormancy percent of the seed.

Table 3: The effect of Kelpak soaking on the viability of *Paulownia taiwaniana* seed (%).

Control	Kelpak soaked	SE	P0,05
18,5	37,0	3,6	7,0

	Time (Hours) 0,5	1,0	2,0	4,0	8,0	16,0	Body of table SE	Body of table P,0,5
1:500	44,0	23,5	34,5	38,0	33,0	33,0	3,6	10,3
1:1000	38,5	43,5	36,00	44,0	36,5	40,5		

Means 1:500 = 34,3 1:1000 = 39,8 SE = 1,4 P ,05 = 4,2

Trial 4. Subjecting the calculated viable seed per gram for seedlots and method to analysis of variance showed that species and seedlots within species differed significantly but that the method of testing did not differ significantly. The coefficients of variation for the individual tests showed that the variance was fairly evenly balanced, sometimes favouring the number test and sometimes the mass test (Table 4). The mass of 1 000 seeds also differed by species and by seedlots within species but the variance was much less than for the number of viable seeds per gram (Table 4). Unlike *Eucalyptus* there is no difficulty in determining which particles are seed and which impurities. Purity of the seedlots used was close to 100 %.

Table 4: Coefficients of variation for seedlots of *Paulownia* for the determination of viability by number and by mass and for the mass of 1000 seed (%).

Species	Seedlots	Viable seed / g Number	Viable seed / g Weight	Mass of 1000 seed
P. taiwaniana	Kukuan '80	20,7	17,7	3,6
	Taipei '84	32,6	12,6	2,7
	Taipei '85	33,1	6,4	3,4
P. kawakamii	Taipei '80	12,1	14,3	1,2
	Taipei '84	4,6	11,7	2,2
	Taipei '85	4,6	12,4	3,4
	Guaugxi (China)	31,0	16,7	3,3
P. fortunei	Taipei '85	21,8	32,8	4,2
	Sichuan You-Yang (China)	11,5	27,8	2,6
	Tougling (China)	6,4	7,7	4,0
	Japan	1,6	2,9	1,7
P. tomentosa	Hachioji (Japan)	3,5	3,9	2,6
	Yamagata (Japan)	3,6	2,5	2,3
	Korea	6,8	3,7	1,8
	Naijing (China)	4,8	5,9	4,8

The number of viable seed per gram, the mass of 1 000 seed and the percentage viability of the 15 seedlots used in this trial are given in Table 5.

Table 5: Mean number of viable seed per gram and mass of 1 000 seed for *Paulownia* seedlots.

Species	Seedlots	Viable seed/g	SD	Mass of 1000 seed	% viability	% Dormancy
P. taiwaniana	Kukuan '80	879	155	0,1789	15,7	81,5
	Taipei '84	2911	366	0,1595	46,4	39,6
	Taipei '85	2495	159	0,1584	39,5	30,7
P. kawakamii	Taipei '80	2382	342	0,1678	40,0	24,4
	Taipei '84	4306	504	0,2036	87,7	10,3
	Taipei '85	3587	446	0,1889	67,8	11,8
	Guaugxi (China)	1676	279	0,1254	21,0	96,6
P. *fortunei*	Taipei '85	985	323	0,2200	21,7	47,5
	Sichuan You-Yang (China)	938	260	0,2738	25,7	12,9
	Tougling (China)	2304	177	0,3111	71,7	50,4
	Japan	2655	77	0,3558	94,5	1,4
P. tomentosa	Hachioji (Japan)	4429	173	0,1830	81,0	26,9
	Yamagata (Japan)	3434	87	0,1605	55,1	20,2
	Suwon (Korea)	3053	113	0,2424	74,0	82,2
	Naijing (China)	3296	194	0,1610	53,1	45,2

Discussion:

Paulownia seed is small; of the seedlots tested the average number of seed per kilogram varied from 2,81 million for the largest *P.fortunei* seedlot to 7,97 million for the smallest *P.kawakamii* seedlot. Viability is equally variable. The disinfection of the seed coats of *P.taiwaniana* by immersion in a 5 % solution of sodium hypochlorite significantly improved the viability, most likely by the removal of fungi and bacteria. These organisms may have been picked up during the drying and cleaning of the seed, but there is evidence from agricultural crops that Fusarium spp, at least, can occur in the internal tissues of the seed (Gopinath & Shetty,1985). The failure of the sodium hypochlorite to remove all the fungi from the seed appears to indicate that this is so. The complete failure of the hot water treatment, however, which should have been equally effective on both testa and interior placed organisms make it impossible to prove.

Viability can also be improved by soaking the seed in weak solutions of Kelpak. The initial trials using 1:500 for 24 hours were detrimental, causing a reduction in viability, but when the concentration was halved or the time reduced to 30 minutes, there was a marked improvement in the number of germinants. Kelpak contains a wide variety of substances including gibberellins, cytokinins, auxins, vitamins, and a large number of macro and micro elements. Whether it is the combination of all these or just one or two ingredients, such as gibberellin (Bonner,1976) which causes the stimulation has not been tested. Bonner found that gibberellin reduced dormancy whereas Kelpak has had no effect on it. It is also unlikely that any of the mineral elements are responsible as a concentration of 1:500 for 24 hours was sufficient to cause a reduction in germination. The 1:1 000 solution is safer than the 1:500 as the time factor is less critical. The cost of Kelpak 66 (R 7,95 per litre retail) is unlikely to be a factor as one millilitre Kelpak 66 will give sufficient solution to treat 200 g *Paulownia* seed.

Although the seed of *Paulownia* are small, it is not unduly difficult to count them to run standard germination tests. It is very difficult and time consuming, however, to determine which seeds are full and which empty when the test is broken down. This in turn makes the calculation of germination capacity impossible, as it requires the number of full seed in the sub-samples. Viability determination by mass, similar to that already permitted for *Eucalyptus* (ISTA,1985) would solve the problem and make the testing of *Paulownia* relatively simple. If leaving the tests an additional period in lieu of the more normal breakdown is acceptable, then testing by numbers met the allowed tolerances of ISTA (1985) for standard germination (Table 5 b). The mass test equally met the tolerances set in Appendix C, Table 2 or the chi-square test (Banyai et al,1986). There appears to be no inherent problem with the mass method, indeed the two methods did not differ in trials on 15 seedlots from four species. The need for testing *Paulownia* seed is no less necessary than for other tree seed; viable seed per gram often differing by thousands between seedlots within species.

Seed of most *Paulownia* species should germinate rapidly when placed in a moist environment at a temperature between 25° and 35°C (Zhao-Hua,1984, Schopmyer,1974). This has not been this author's experience, probably because the test material has been stored rather than fresh seed (Carpenter & Smith,1979). Only one of the seedlots tested, *P.fortunei* ex Japan, had an acceptable dormancy percent i.e.< 5 % (Table 5). Work to reduce dormancy percent on stored seed is in hand and will be presented at a later date.

Conclusions:

Seed of *Paulownia* species should be surface disinfected with 5 % sodium hypochlorite and soaked in a 1:1000 Kelpak 66 solution for one hour to maximise germination before being sown. Seed testing is necessary as the range of viable seed within a species is too large to make averages acceptable. Testing should be by mass and it is recommended that the ISTA rules committee be asked to add this genus to those whose seed may be mass tested.

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EFFECTS OF STORAGE CONDITIONS ON GERMINATION OF FIVE TROPICAL TREE SPECIES

by

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ABSTRACT

The effects of storage conditions on the longevity of seed of Khaya senegalensis, Flindersia brayleyana, Eucalyptus deglupta, E. microtheca and E. camaldulensis were examined. Storage in tightly-closed containers at -15°C was far superior, overall, to placement of seed in similar containers in the cool room (ca. 5°C) and at room temperature (ca. 24°C, RH = 40-60%) for medium to long-term maintenance of viability. The cool room environment is suitable for the short to medium term storage of seed of most species but storage at room temperature, except for E. camaldulensis, is largely unsuitable.

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INTRODUCTION

The five species under consideration in this paper, Khaya senegalensis (Desf.) A. Juss, Flindersia brayleyana F. Muell., Eucalyptus deglupta Blume, E. microtheca F. Muell. and E. camaldulensis Dehnh., are tropical hardwoods used in tree planting projects in various parts of the world. They have orthodox seeds but, with the exception of E. camaldulensis, have a reputation for losing viability rapidly in uncontrolled conditions. There is little or no published information on the effect of storage conditions on seed germination or quantitative data on the rates of decline of germination under different storage regimes with seed of these species.

K. senegalensis is a native of Central Africa and is planted as a shade tree in northern Australia (Hearne and Rance 1975). Freshly collected seed gives on average 90% germination and provides 2900-4300 viable seed per kilogram but does not store well (FAO 1955). Imported seed frequently has low viability, local seed stands are remote, and the immature fruits are heavily predated by parrots. Therefore seed supply can be a problem (L. Brigden pers.comm.). The situation is similar with F. brayleyana, a northern Australian rainforest species, in demand for enrichment of moist forests in tropical zones (Pilasi 1980). In Australia and in Hawaii F. brayleyana seed, which is abundant only at 2-3 year intervals, is sown as soon as it is collected. Germination of fresh seed is about 90% and one kilogram yields 8800 - 10500 germinants (Wick 1974, B. Hyland pers. comm.). Wick (1974) reports, seeds stored in air-tight containers at 2°C lose their viability within a year and seed moisture content appears critical in storage.

E. deglupta is planted in the humid tropics but there is a shortage of seed in some areas. The minute seed requires dry, cool storage (3-5°C) to prevent rapid deterioration in uncontrolled conditions (White and Cameron 1966) but even under refrigerated storage a significant decrease in viability can be expected within two years (Turnbull and Pryor 1984). The viability of fresh seed is 4,030,000 ± 2,900,000 per kilogram of seed and chaff mix (Boland et al. 1980).

E. microtheca is used for fuelwood plantations in dry tropical regions and, with E. camaldulensis, is included in a FAO/IBPGR project on conservation and utilisation of genetic resources (Palmberg 1981). Seed collected for this project is kept in a freezer (-15°C) for long-term storage. The average viability of seed of E. microtheca falls within the range of 377,000 ± 247,000 per kilogram of seed and chaff mix and viability is known to decline rapidly within 2-3 years at room temperature (Boland et al. 1980).

E. camaldulensis seed usually stores well for several years when dry and contained in air-tight containers at room temperature. Viability is within the range of 670,000 ± 465,000 per kilogram of seed and chaff mix (Boland et al. 1980). This species is used widely in the dry tropics now the importance of using tropical provenances is recognized (FAO 1979). It has been recommended that conservation measures, including ex situ conservation/selection stand establishment and long-term seed storage, should be undertaken to ensure the survival and availability of seed of the more productive provenances (FAO 1977).

This paper reports the results of a series of trials established at CSIRO Division of Forest Research (DFR), Canberra during the period 1971 to 1979 to study the effect of storage conditions on seed longevity of these five species.

MATERIALS AND METHODS

Khaya senegalensis

K. senegalensis seed was collected in March 1971 in Uganda (Table 1), air freighted to Australia and fumigated with methyl bromide. On arrival it was tested for moisture content using the standard oven-dry method (ISTA 1976) and then germinated in a cabinet at a constant 30°C with natural light. 100 seeds in each of four replications were placed on moist filter paper over vermiculite and normal germinants were counted and removed successively. The percent germination was calculated from average germination of four replicates. In June 1971, following the initial germination test, seed was placed into the following storage regimes -

1. Room temperature; seed in a galvanised tin with tight-fitting press lid. The air-conditioned room remained at a fairly constant temperature of 24°C while relative humidity ranged between 40 to 60 percent.

2. Cool room; seed in a galvanised tin with tight-fitting press lid. The cool room temperature set at 5°C and the relative humidity is about 95 percent.

3. Cool room; seed in a calico bag.

4. Deep freeze; seed in a galvanised tin with tight-fitting press lid. Temperature set at -15°C.

The germination of seed in each storage regime was monitored at regular intervals, the final tests being carried out after 60 months of storage.

Flindersia brayleyana

Seed of *F. brayleyana* collected during December 1971 in North Queensland (Table 1) was despatched by air and received at DFR in January 1972.

The experimental methods were the same as for *Khaya* except that the germination tests were undertaken at 25°C. The storage trial was established in January 1972 and regular checks on the germination of the stored seed were made for a period of 93 months.

Eucalyptus species

Extracted eucalypt seed, unlike the pure seed of many forest trees, always contains 'chaff' (mainly unfertilized or aborted ovules). Except in the case of the few, larger-seeded eucalypt species, the separation of chaff from full seeds is usually impractical (Boland *et al.* 1980). In the three eucalypts under study, the regular convention of storing and testing eucalypt seedlots as a seed and chaff mix with germination figures presented as the number of germinants per unit weight of the mix was adopted.

E. deglupta

Seed of four seedlots of *E. deglupta* from Papua New Guinea (PNG) were received at DFR in July 1977 two weeks after despatch (Table 1). The seed on arrival was 5 to 7 months old and had been subjected to variable conditions from harvest to cool store in PNG and then through air mail post, quarantine inspection and fumigation with carbon disulphide in Australia. All lots were placed in the cool room (5°C) at DFR for seven weeks until the seed storage trial was set-up.

For the storage trial each seedlot, in turn, was thoroughly mixed using a Gamet Divider and 1 g sub-samples were then placed in each of 30 small glass vials with tight-fitting caps. These sub-samples were separated into groups of 10 in plastic bags and assigned to one of three galvanised tins with tight-fitting press lids. These tins were designated for storage at room temperature (ca 24°C), cool room (5°C) or deep freeze (-15°C).

The moisture content of each seedlot at the time of storage was determined by the oven-dry method (ISTA 1976) and initial germination capacities were recorded in a germination cabinet set at a constant 35°C with 8 hours of light daily. The germination test procedure followed Boland *et al.* (1980). At regular intervals during 115 months of storage, one glass vial of each seedlot was removed from each storage regime and germination redetermined.

E. microtheca

Seedlots from five trees in each of five widely-separated provenances of *E. microtheca* (Table 1) were collected in February-March 1979. The fruits from each tree had been air-dried and the seed extracted placed in calico bags with the identity of individual trees maintained. In April 1979 a portion of each of the 25 seedlots was used as a basis for a seed storage trial following the experimental methods described for *E. deglupta*. While the initial germination tests and those after 17 months of storage were carried out at 30°C, subsequent tests over a 96 month period were run at 35°C, a temperature close to the optimum for the germination of this species (Doran and Boland 1984).

E. camaldulensis

Seed of a tropical provenance of *E. camaldulensis* collected in July 1977 from thirteen trees was received at DFR in August 1977 (Table 1). The fruits had been air dried in the field and the extracted seed placed in calico bags with the identity of individual trees maintained. In September 1977, a portion of each of the thirteen seedlots was used to set up a seed storage trial following the experimental methods described for *E. deglupta*. These lots were retested for germination at a temperature of 30°C at regular intervals over 115 months of storage.

Table 1. Provenance details of the seedlots used in the storage trials.

DFR Seedlot No.	Collection locality	Lat °S	Long °E	Alt (m)	Parentage	Date of harvest mth/yr	Start of storage trial mth/yr	Initial mean moisture content %
Khaya senegalensis								
10053	Uganda	3°40'*	31°45'	280	unknown	3/71	6/71	8.1
Flindersia brayleyana								
10247	Atherton, Qld	17°17'	145°27'	750	unknown	12/71	1/72	7.4
Eucalyptus deglupta								
12322	Keravat, PNG	4°10'	152°40'	-	unknown	11/76	8/77	11.7
12323	Bulolo, PNG	7°10'	146°40'	-	bulk of 3 trees	2/77	8/77	10.1
12324	Bulolo, PNG	7°10'	146°40'	-	single parent	2/77	8/77	9.5
12325	Bulolo, PNG	7°10'	146°40'	-	bulk of 5 trees	2/77	8/77	11.4
Eucalyptus microtheca								
12812	Bourke, NSW	30°03'	145°57'	100	5 trees	2/79	4/79	9.3
12816	Wilcannia, NSW	31°45'	143°11'	100	5 trees	3/79	4/79	10.7
12820	Clayton R.,SA	29°17'	138°23'	20	5 trees	3/79	4/79	10.8
12822	Williams Ck., SA	28°55'	136°19'	60	5 trees	3/79	4/79	10.6
12826	Wallara,NT	24°33'	132°34'	460	5 trees	3/79	4/79	11.0
Eucalyptus camaldulensis								
12346	Gibb R., WA	16°08'	126°30'	430	13 trees	7/77	9/77	8.1

* Latitude °N

RESULTS

K. senegalensis

The results shown in Figure 1(a) confirm that long term storage of K. senegalensis seed is difficult. Loss of viability was very rapid in the calico bag, where the moisture content of the seed was not controlled, and in the closed container at room temperature. Seed in these two treatments had less than 10 percent germination capacity after 12 months and there was complete loss of viability within 18 months.

Storage of the seeds in closed containers at low temperatures reduced the rate of deterioration. In seeds stored at 5° and -15°C germination was close to 30 percent after 24 months storage. However after 42 months the viability of the seedlots in both these temperature regimes had fallen to a low level. Storage in closed containers at -15°C was the superior method for the first 18 months but thereafter was little different from storage at 5°C.

F. brayleyana

Major differences in the rate of decline of germination percentage of F. brayleyana seeds in the different storage regimes are shown in Figure 1(b).

After nearly eight years of storage in a closed tin at -15°C, the seeds had lost little of their original germination capacity. In contrast, loss of viability of the seeds stored in calico bags at 5°C and in a tin at room temperature was very rapid and followed the same pattern observed for K. senegalensis. After six months in these conditions few seeds remained viable.

The viability of seeds stored in a tin at 5°C deteriorated only slowly for 24 months but thereafter declined more quickly. Germination percentage had fallen to 10 percent at 42 months.

E. deglupta

The results highlighting the benefits of sub-freezing storage of E. deglupta seed were very clear-cut in this trial (Figure 1(c)). Significant differences between the three storage regimes appeared within twelve months of storage and increased with time.

At room temperature, all four seedlots showed a decrease in germination in the first twelve months of storage. This decrease was not significant in the case of two seedlots (12323 and 12324). However, by 23 months a marked decline in germination and vigour had occurred in all lots. Seedlot 12323 provided 68 percent of all germinants at 23 months, but by 38 months it too provided almost none.

In the cool room, each seedlot initially increased in germination and thereafter declined rapidly at first and then more gradually to final death during 85 to 115 months of storage. The poor vigour of germinants in assessments after 38 months of storage marked this as the limit for effective storage duration in the cool room environment.

Storage in the deep freezer was clearly the best regime for medium-term storage of E. deglupta seeds. High germination results were maintained for 85 months when the first statistically significant decline in germination over the initial assessment was recorded. Beyond 85 months, average germination has decreased rapidly and by 115 months only two seedlots (12323 and 12324) were producing a substantial number of germinants. The vigour of these germinants was poor and it is doubtful whether they would succeed in a nursery environment.

It is interesting to note that the seedlot by treatment and storage time interactions were significant. Two seedlots, 12323 and 12324, which began storage with the lowest moisture contents and highest germination values proved to maintain viability much better than the others.

E. microtheca

The overall effect of storage regime on longevity of E. microtheca seed is demonstrated in Figure 1(d). Again, freezer and cool room storages are, from the first assessment at 17 months, significantly better than room temperature. In this instance it is not until the 66 month assessment that the cool room germination figures show a significant decline from freezer storage. The reversal of the overall trend of declining germination with time at the 25 month assessment can be explained by the improved vigour and germination response produced by increasing the prescribed temperature of test from 30 to 35°C (Doran and Boland 1984).

After only 17 months of storage at room temperature overall germination of seedlots was reduced by 30 percent and by 47 months this had declined to about half initial viability. Fungal problems, an increasing number of abnormal germinants, and lack of vigour were reported for some lots at 25 months. This trend continued and by 47 months four seedlots gave nil germination and a further six germinated very poorly. At 96 months 11 seedlots failed to germinate and 8 yielded poor results and by 66 months 12 seedlots were dead and the remaining 13 lots had very few healthy germinants.

In the cool room, overall germination and vigour were quite well maintained over the initial 47 months of storage. The first major problems appeared at 66 months when three seedlots germinated very poorly. At 96 months of storage two seedlots gave nil germination, two had very low counts and a further eleven seedlots had fungal problems and lacked vigour.

In the freezer there was relatively little change in germination capacity during 96 months of storage. Unlike in earlier assessments, 16 seedlots in the latest evaluation had to be treated against fungi and there was a marked increase in the numbers of abnormal germinants perhaps indicating the start of a decline in vigour after 8 years of storage.

Individual seedlots within provenances (5 individual-tree seedlots in 5 provenances) differed markedly in their tolerances and responses to the various storage regimes. The situation was most critical at room temperature where from about 2 years of storage onwards two or three seedlots (trees) in each provenance declined rapidly in germinative capacity relative to other seedlots in the same provenance. This is a point worthy of note by potential buyers of bulk E.

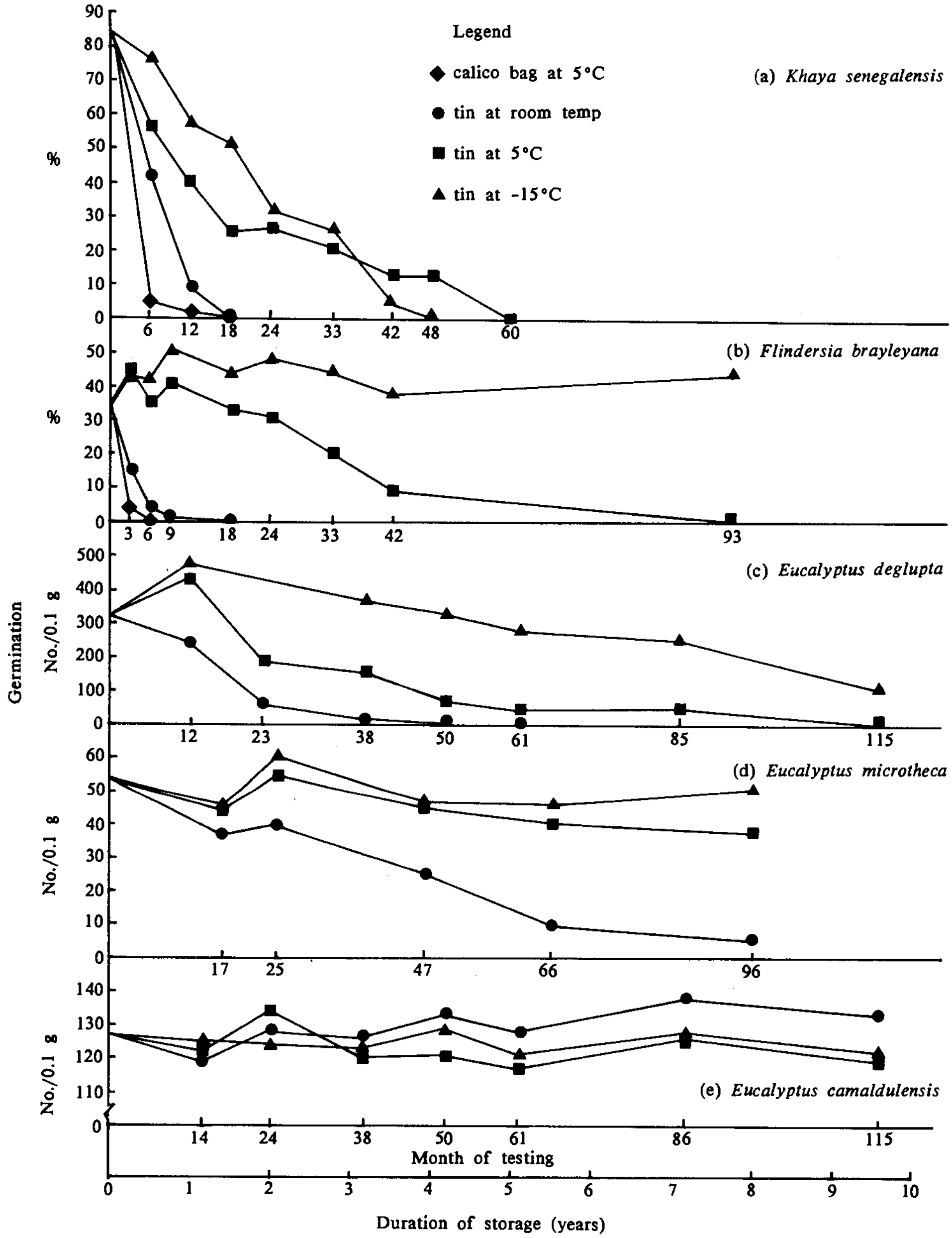

Fig. 1.
Effect of storage conditions over time on seed germination of five tropical tree species.

microtheca seed that has been stored for some time in sub-optimal conditions. The parental composition of the seedlings from the bulk lot may be substantially less genetically diverse than indicated on the seed certificate.

E. camaldulensis

All thirteen E. camaldulensis seedlots stored well with no apparent loss in viability over almost 10 years of storage (Figure 1(e)). The long time span of excellent germination at room temperature is contrary to other findings which indicate a fifty percent reduction in germination can be expected in ten-year-old E. camaldulensis seed (J. Doran unpubl.). The retention of a high level of viability in this trial is most likely related to the original very high quality (nearly double the average germination rate per unit weight for the species) of the seedlots used. An interesting and unexpected trend has been observed also over the last three germination tests in which seedlots in room temperature storage have a significantly higher germination capacity than lots stored at lower temperatures.

CONCLUSIONS

The three eucalypts examined in these trials are already candidates for long-term conservation storage under FAO's Global Programme for Improved Use of Forest Genetic Resources (Palmberg 1981) and it is probable that conservation storage of Khaya and Flindersia may also become an issue in the future. For conservation storage to be effective, it is important to utilize storage environments that minimise the decline in genetic integrity of seed stocks with time thus lengthening replacement intervals and reducing costs. It is clear from these trials that storage in tightly-closed containers at -15°C was far superior, overall, to the other regimes tested for the long-term maintenance of germination and vigour of the species tested.

In the case of K. senegalensis the benefits of low and subfreezing temperatures in storage were only short-term, 18-24 months, and more research is necessary to define better seed storage conditions for this species.

Freezer storage provided excellent maintenance of viability of F. brayleyana seeds throughout the 93 months of this experiment despite the relatively low initial viability (34%) of the seedlot under test. The cool room (5°C), although clearly inferior to freezer storage, provided adequate conditions for the short term maintenance of germination and vigour up to about 18 months. This appears to conflict with experience in Hawaii (Wick 1974) but may be related to the relatively low moisture content (7.4%) of the Australian seedlot when it was placed in storage.

Freezer storage maintained the viability and vigour of the E. deglupta seedlots up to 85 months, before a marked decline occurred. Storage of E. deglupta seed at a sub-freezing temperature (-15°C) is significantly better than the standard practice of storing it in a cool room (ca. 5°C). On the basis of these results the cool room environment cannot be recommended for storage of seed of this species past about 3 years when average germination had declined by 50 per cent.

Storage of E. microtheca seed in a freezer can be safely recommended for maintenance of viability to 8 years and possibly longer while the cool room environment is suitable for medium term (to 4 years) storage. Storage at higher temperatures (ca.24°C) for more than 2 years is ill advised because of rapid decline in the germination and vigour of some seedlots.

At room temperature (ca. 24°C), germination and vigour of high quality E. camaldulensis seedlots were maintained for more than 8 years. Despite this encouraging result, other seedlots of this species are known to have deteriorated significantly in this regime over a similar time span. It would be prudent, therefore, if long term storage of E. camaldulensis seed is the aim, to use air-tight refrigerated storage, and preferably a deep freezer at ca. -15°C, rather than risk the possibility of significant decline at room temperature.

Despite advances in recent years there still remains a serious lack of knowledge on the inter-relationships between temperature, relative humidity, seed moisture content and storage life of seed of numerous tree species and especially those from the tropics. More research effort into studies of these inter-relationships is justified so that seed stores can be better equipped to provide optimum storage conditions for important forest tree germplasm.

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SEED TESTING PROBLEMS OF FOREST SEEDS IN ZIMBABWE

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INTRODUCTION

The understanding of the behaviour of tree seeds comes from results of tests of various kinds. At whatever level of seed trade or exchange it is alsways essential to determine the purity and the degree of viability. Tree seed extractors and dealers find constant testing an intergral feature of their system. Although the practice of seed testing is widepread, the problems experienced vary with areas and regions. This is caused by variations in vegetations hence different tree species. Forestry activities have had a long history in the temperate regions but very recent in the tropics. As a result, the tropical forest species have remained unknown. Their commercial value has only been realised and research into the behaviour of their seed is budding. The International Seed Testing Association whose task is to develop (through various researchers) and standardise testing methods for different seeds haven't yet come up with testing procedures for tropical seeds. Zimbabwe is a tropical country, and although exotic tree species have been introduced to improve the forestry industry the indegenous trees still dominate the natural forest lands. Some of these indegenous species are of significant commercial value hence efforts are underway to counter defforestration through tree planting activities. Most of the trees used in tree planting activities are exotic because of two major reasons: the first reason is that the indegenous species are still unimproved hence their growth rates too slow to cover and protect the soil; the second reason is that little is known about the seed germination requirements and seedling behaviour.

Seed Services, the Government Seed Testing Laboratory has experienced some of the difficulties in testing of tree seeds in Zimbabwe.

Purity testing:

Few problems have been experienced in purity analysis. The major problem being genuineness or trueness (species and variety). The criteria for genuiness are lacking in forest tree seed testing, particularly the indegenous tropical species. Because of the lack of knowledge, experience and equipment the size, **color and** shape have been used to determine genuineness in Zimbabwe. The diagnostically valueable tests of interior characteristics such as texture of the inner seed coverings and embryo have yet to be applied in purity analysis. Efforts are now being made to try and use seedling identification as test for genuineness.

Germination

The major problem faced during testing for viability is dormancy. Extoic species present few problems because the seed behaviour is well understood hence methods of overcoming dormancy without affecting the viability of the seed have been developed. The indegenous species still present dormancy problems during testing. Species such as the indegenous Accacias and other leguminous trees are acid treated to break dormancy. Acid treatment has been recognised as a standard method of overcoming dormancy in the leguminous trees but the effect of this treatment on vigour has not been established. The behaviour and treatment requirements of some seed such as Pterccorpus angolensis is unclear hence viability tests of this species does not provide conclusive or representative results. Comparative test results from different treatments of breaking dormancy have indicated no significant difference among the various treatments. However, there is a general indication of the physiological effects of some treatment on the seed. This is shown by the rate of germination (Gwarazimba V. 1987, unpublished Data).

Although we have managed to germinate most of the species through various technics, the temperature environment is still another problem. The environmental condition currently being applied for tree seed in Zimbabwe are basically on trial and error (Table 1).

Vigour tests

Several uncited reports established that seeds of tropical species can stay for decades in the soil without losing viability. This is attributed to the impermeable and hardseed coats. Artificial treatments such as acid and heat treatment have been used to stimulate germination. But do these treatments simulate natural environments for example do species such Accacia bidiwillii which require raging forest fires which last a few minutes respond equally to oven heat treatment of 75°C for 8hrs. The implication is artificial treatment could have significant effect on seed vigour hence when planted in nurseries the behaviour of seedlings may not be similar to that under natural conditions. The methods and procedures for vigour testing have been established but whether they could be applied in indegenous trees seeds is still another question.

Interpretation of results

Most seed analysists throughout the world have been trained in their fields using agricultural crops. Forest tree seeds have since been introduced into our laboratories, and the analysists are facing serious difficulties in handling and interpreting of test results of indegenous species for example there is a general lack of familiarity with diseases that affect seedlings in indegenous forest trees. Therefore interpretation of abnormality has been of major concern.

The testing period is insufficient to determine abnormalities of radicles and plumule. the analysist is therefore obliged to interpret results of germination from the physiologist'sangle. This interpretation does not provide a general understanding of the amount of seeds that would give rise to abnormal seedlings Table 1.

Table 1 : Germination temperatures for Pteocarpus angolensis (Seed untreated).

Temperature °C	Germination %	Abnormal Growth%	Hard Seed%	Dead Seed %	Fresh ungermina Seed %
20/30	60	0	30	0	10
30	73	0	7	20	0
20	60	0	13	20	7

N/B 20/30 was alternating. 30°C for 16 hours of daylight
20°C for 8 hours of darkness

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ETHNO-BOTANICAL APPROACH TO SEED PROCUREMENT EXPERIENCE FROM BURA, KENYA

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Abstract. This paper presents general considerations concerning the seed supply for arid lands, particularly some preliminary observations on the problem of procurement of indigenous seed as found in the Finnish-supported Bura Forestry Research Project in Kenya. Based on the experience from ethno-botanical studies the paper also focuses on the possibilities to benefit from the local traditional knowledge in research as well as in the implementation of forestry projects.

1. Introduction

The Bura Forestry Research Project started in 1984 as a project funded by the Finnish International Development Agency and the Government of Kenya. It is implemented by the University of Helsinki and the Kenya Forestry Research Institute in connection with the Bura Irrigation Settlement Project in the Tana River District, Kenya. The Research project is a sub-component of the Finnish-funded Bura Fuelwood Plantation Project which aims at ensuring the fuelwood supply for the approximately 20,000 people living in the Scheme area, by establishing about 600 ha of irrigated plantations. In addition, provision of construction wood, amenity trees, windbreaks and trees for soil conservation are among the project objectives. A separate socio-economic research project is also implemented in cooperation between Finnish and Kenyan researchers.

The main objective of the forestry research component is to provide information which can support decision-making in the Bura Fuelwood Plantation Project on various aspects of forestry,including seed procurement and which can lay a foundation for a forestry research programme in the geographical area in question.

The project area is located just south of the Equator in the semi-arid bushland on the west bank of the Tana River. Precipitation is about 350 mm.a-1, very erratic and distributed over two rainy seasons. Temperatures are high throughout the year (annual mean 28° C) with little seasonal variation. The average radiation is 519 cal.cm-2.d-1 and the potential evaporation is 2500 mm.a-1. The project area lies on an old alluvial terrace of the Tana River. The soils consist mainly of Entisols, Aridisols and Vertisols (IBRD 1977). The soils are rather shallow and moderately to strongly alkaline. The Tana River is the only source of irrigation water which is of excellent quality, despite a rather high silt content (FAO 1967).

This paper presents general considerations concerning the seed supply for arid lands, particularly some preliminary observations on the problems of seed procurement of indigenous seed as found in the Bura project in Kenya.

2. Where do the seeds come from ?

The growing awareness of the importance of selecting the right species and provenances for any specific site as well as for any particular purpose has led to an increasing demand for germplasm of well documented sources. This has earlier played an important role in the planning and establishment of industrial plantations, but recently it has become equally important in forestry programmes with a broader range of end uses. Particularly the high demand for multipurpose tree germplasm has revealed an obvious gap between supply and demand.

Another aspect has been the lack of documentation on seed collection, handling, storage, and especially distribution and distributors. The problem has been a topic of meetings and workshops, and a number of organizations such as CSIRO, FAO and ICRAF have published reports to bridge the information gap (Burley 1985; Burley & Carlowitz 1984; Carlowitz 1986; FAO 1975,1980,1985a; Turnbull 1984). Moreover, an increasing number of newsletters with specific target groups or objectives,e.g. the ICRAF Newsletter, the Social Forestry Network Newsletter (Overseas Development Institute), Farm Forestry News (USAID and Winrock International Institute for Agricultural Development), the Nitrogen-Fixing Tree Association Newsletter, have considerably improved the information flow.

However, for the District Forester or researcher out in the field in eastern Kenya the situation has only been partly improved. Kenya, as so many other countries, has been lacking the coordination, facilities as well as documentation needed for a secured forest seed supply. This has been very obvious in the procurement of multipurpose tree seed, and the problem is even more accentuated as far as the seed of indigenous trees is concerned.

In practical work, most forestry projects and organizations have so far been forced to make their own arrangements for seed supply (Buck 1983a, Johansson 1986). In Kenya attempts have been made to coordinate such activities and to increase both the quantity and quality of available tree germplasm (c.f. Buck 1983a,1983b; Odera 1985; Teel 1984). A major step was taken with the establishment of the German supported Kenya Forestry Seed Centre in connection with the Kenya Forestry Research Institute in 1985. The project has examined the current situation, presented possible strategies, as well as provided necessary facilities and equipment for seed collection, handling, storage and distribution (Kenya Forestry Seed Centre 1986a,b,c,d).

However, the identification of seed sources of lesser known indigenous species, especially for marginal areas, is still a problem which calls for closer attention. Efforts have been made by non-governmental organizations, such as KENGO (Kenya Energy Non-Governmental Organizations), but a lot more needs to be done.

3. The forester's choice

Plantation forestry for industrial purposes has been overwhelming in the minds and training of foresters in the past. Due to this economically more easily justified activity, research efforts as well as practical experience has produced a considerable amount of knowledge regarding seed procurement, nursery practices, plantation establishment and management procedures in certain genera e.g. *Pinus*, *Eucalyptus* and *Acacia*. On the other hand, rather little has been done to survey indigenous seed sources and potential species for other than industrial purposes. This informational imbalance and the obvious limited knowledge on available local options often leaves the professional forester with one choice i.e. the use of well-known exotics and predominantly introduced material. One can, for instance, ask whether the recently introduced social or community forestry approaches are any considerable improvements if the major difference is that instead of planting exotics without asking the people concerned we now ask them which exotics they prefer.

Particularly in donor-funded forestry projects there seems to be a tendency for the easy and "safe" species choices. This may be due to the fact that these projects often have a clearly defined time schedule according to which they are supposed to complete their objectives. In such cases the selection of well-known exotics often gets a higher priority as compared to choosing indigenous material, despite the fact that even the exotics often involve time-consuming species and provenance testing.

It is well known that many exotics often grow much faster than the indigenous species.In case of multipurpose tree planting, particularly in community forestry projects, the obvious choice would be to look for species which already are known and the end use of which already is part of the cultural traditions of the people concerned.

The lack of information is, however, not the only factor determining the approach. In many cases foresters are not familiar with the conditions prevailing in the semi-arid and arid areas, because they usually come from high-potential areas where the educational facilities are more readily available. Hence they do not know the local flora, and in multi-lingual societies such as Kenya, they may not even know the local language. In situations like this , which has been the experience in Bura, the only immediate choice is again exotics and introduced germplasm.

4. Traditional knowledge - a "new" source of information

Arid and semi-arid lands are often called marginal, perhaps with reference to their limited economic importance. On the other hand, they have received considerable attention as they constitute the transitional zone where desertification causes the conversion from low-production land to wasteland or desert (Grainger 1982; Hjort 1985; National Research Council 1984). Another aspect is, however, that there often exists an unbroken tradition and an accumulated knowledge related to trees and shrubs and to the environment in general which has been the condition for survival. This knowledge is also often very detailed, with a high degree of distinction (Chambers 1983).

Ethno-botany could be defined as the indigenous people's botany or the local people's knowledge of plants. The ethno-botanical approach, which was adopted in Bura, could offer a novel way to work with the people in projects dealing with rural development. Although people's participation has become the current code word even in forestry projects, it seems that there is a lack of a deeper perception of the concept that would transform the people from mere actors to agents in the development process (Chambers 1983; FAO 1978, 1985b, 1985c, 1986).

5. Ethno-botany and seed procurement in Bura

In the Bura Irrigation Settlement Project most of the factors mentioned above were present. The project area is remote, it is situated in the marginal arid and semi-arid area in eastern Kenya, and consequently most of the professional staff, including the foresters, are from the more developed parts of the country. Also the choice of seed available for different purposes was limited and consisted mainly of the standard set of exotics for arid and semi-arid lands. When it became apparent that fuelwood could not be provided based on irrigation only, (due to severe constraints in the water supply), a broader approach had to be adopted. This would include a variety of methods such as the use of rainfed plantations, canalside plantations, village afforestation with multipurpose species, soil conservation plantations, windbreaks etc.

The problems in Bura associated with seed supply through normal centralized channels, combined with the fact that the introduced material still had to be tested directed the attention towards the possibilities to better utilize the local flora. In connection with the drought in 1983-84, local pastoralists were engaged in the forestry project with World Food Programme assistance. A team of them were involved in collection of local seed for research purposes in 1985. Difficulties, however, arouse since the species could only be identified according to their local vernacular names, i.e. in the Malakote, Orma and Somali languages.

Simultaneously other activities in the project also called for proper identification of the indigenous trees and shrubs. In 1986, a botanist from KEFRI was engaged in conducting a botanical survey with a team of local people, representing both the sedentary agriculturalists along the Tana River (Malakote) as well as the pastoralists (Orma and Somali). The objective was to survey the woody vegetation and compile a check-list with botanical and vernacular names which could be used, for instance, in seed collection.

During the botanical study it was realized that the local people could easily identify the plants in their own languages, and in particular in their own sphere of living i.e. in the riverine forest (Malakote) or the dry bushland (Orma and Somali). Apart from identification, they could also specify the uses of the species, phenology, the location of stands, soil preferences etc. Based on this, it was decided that a specific study on the traditional knowledge on trees and shrubs could provide the forestry project with information which would have required much more time and funds to establish using a convential forestry research approach.

The study was conducted in 1986-87. The research team consisted of a sociologist, a botanist and a representative group from among those Malakote and Orma people who already had participated in the botanical survey. The methodology was based on interview sessions using a preliminary species list as the basic material. During these sessions, all aspects regarding the species were discussed. These included the use of trees for household utensils or other material items, building purposes firewood, food, medicine, as well as ritual and religious practices. The use of plants as indicators was also discussed. The interviews were supplemented with frequent field visits, so as to confirm the species and to collect specimens for final identification.

In addition, a team consisting of two Malakote and two Orma informants was trained to conduct interviews in the villages within the study area according to a questionnaire. The aim was to supplement and counter-check the information obtained during the formal interview sessions.

6. Some preliminary observations

A total of about 230 different species, including a few sub-species, were identified in the riverine forest or the dry bushland. What was remarkable in the botanical survey was that the local people's plant classification included a very high degree of distinction, down to the sub-species level. The local people also had no difficulties in making distinctions within such genera as Commiphora, which is known to be difficult even for professional taxonomists. Apart from the different vernacular names, the local informants could usually in great detail specify the distinctions, for instance, according to morphological characteristics.

The local knowledge also included a rather clear picture on the distribution of various species within the area frequented by the people. It was possible to locate exceptionally large stands of certain species or forest patches in the riverine forest or in the bushland which were fairly undisturbed and which were potential conservation stands or seed collection areas. Also in this respect there was a high degree of distinction so that even single trees of desired kind could be located when the team was in the field confirming the presence of a species or collecting botanical specimens.

Phenological features were also part of local kowledge. Especially flowering and seed setting phases are observed, and also the possibility to find out relationships between plants and their pollen vectors or seed dispersers was noted. In the case of pastoralists, the knowledge of the period of the onset of vegetative growth or leaf shedding is of utmost importance.

The study on traditional uses revealed quite a detailed and delicate network of interaction between the society and the environment and which involved the most frequently available tree species in particular. With very few exeptions, each species had a clearly defined place in the life of the society either through its material value or its religious or ritual meaning. In certain forms of utilization such as the medical use both of these aspects were involved. The study also enabled an evaluation on the priorities concerning the species as well as on the qualities of the species for any particular use, such as the use as firewood or building material or in honey production etc. It also became obvious that, to some extent, changes in the uses or in the occurence of plants were part of local knowledge. Obviously, this data base is relevant as information on endangered species and environmental disruptions.

The informants in the research team were selected due to their good knowledge on the uses of trees and shrubs as judged by some of their own people. They did not, however, have any particular position in their own societies in this respect. During the work it became obvious that there were a number of specialists in these societies who possessed a deep knowledge in their particular own field. Among such specialists were the herbalists and the masters consulted in religious and ritual matters who knew the spiritual or material aspects of plant utilization. On the other hand, there were the more practically oriented specialists such as those involved with handicrafts or carpentry,

The methodology used and developed during the field studies proved to be satisfactory in the prevailing circumstances. Some points are, however, worth additional emphasis. The informants had a positive attitude towards forestry because the forestry project had offered them employment and supported the local people who had suffered during severe drought in 1983-84. Some of the informants were selected among people who were either already employed by the project or who were covered by the World Food Programme support, whereas others were employed for specifically the study. All informants were employed during the course of the Fieldwork and, if possible, they were retained within the project after the completion of the work. Despite some initial doubts, the presence of different ethnic groups in the team and the interviews was a positive factor rather than a constraint. The two main ethnic groups (agriculturalists and pastoralists) were mutually inspired by the exchange of experience and knowledge, as well as by the opportunity to learn about the details of the everyday life in the two rather contrasting societies. It was also obvious that the interviews evoked a "new" interest in the cultural heritage among the informants. Simultaneously, an awareness and a pride over the discovery of the importance of their traditional knowledge became apparent.

One of the major factors contributing to the success of the study was that both the government administrators in the area and the traditional leaders were involved and they wholly embraced the objectives of the study. Faced with the great and potentially threatening changes induced by the new settlement project they realized that the indigenous tradition should be documented and made available both for administrative as well as educational purposes. Another important aspect may be the recent government policy under the slogan "District focus for rural development" which emphasizes the importance of local knowledge and indigenous solutions, for instance, in forestry.

7. Lessons from local knowledge.

Basic research on the flowering characteristics of even important tropical species is still needed as well as studies on population genetic factors whenever strategies for seed procurement or gene conservation are outlined and implemented. This particularly true regarding lesser known indigenous species (Baker 1983, Luukkanen 1984, Marsh 1978). In this respect local knowledge and experience has often been overlooked and discarded in research as well as in the development process despite the fact that it often includes a very high degree of discrimination regarding agricultural, pastoral and environmental factors (Chambers 1983, Peterson 1986). Also in practical seed procurement the ethno-botanical appraoch may have something to offer. Local knowledge is not likely to come with all and ready formulated answers but it may definitely provide supplementary information and offer a short cut when indigenous ecosystems are studied.

There are a number of specific situations where the use of local knowledge may offer assistance for studies on seed problems or for practical seed procurement. They can be summarized as follows:

(1) The most evident benefits from using the local knowledge are achieved in conducting botanical surveys and in botanical identification; the local plant classification can be in many cases more discriminating than traditional taxonomy (Chambers 1983).

(2) The ethno-botanical approach can provide a short-cut in the planning of field collections and in surveys of potential seed collection sites. The local knowledge of the distribution of species, geographical location of stands and even in finding stands with clearly defined qualities can reduce the time and the costs required in seed procurement.

(3) Research on phenology, particularly in connection with flowering and seed setting, is also an area where direct benefits can be achieved by adopting this type of approach. The observations made by the local people, for instance, on the relations of trees with their pollen vectors or seed dispersers are partly confirmed by Marsh (1978) in his study on tree phenology in the gallery forest along the Tana River.

(4) In situ gene conservation is another field which requires attention. The task of conservation often lies within the powers of those who implement projects. The more important the relationship between the local people and the surrounding environment is the greater is also the resposibility of those

who implement a project which affects the surrounding environment. Another observation made during the present study was that the local people had rather precise information on the environment. For instance, they could point out areas of undisturbed vegetation or areas which had been subjected to various degrees of disturbance.

(5) Tropical forest management is a field which is relatively unexplored in research as well as implementation. As far as the natural forests are concerned the local knowledge can often act as a rather precise guide in selecting stands and areas for research, as was the case in Bura when a number of permanent monitoring plots were established. The local information can thus assist in developing management methods. On the other hand studies on traditional uses can assist in the search for new species for plantation forestry or for multipurpose tree planting (Baumer 1983, National Academy of Sciences 1975, 1979; Prescott-Allen 1983).

(6) From a methodological point of view, the ethno-botanical approach offers new solutions for projects dealing with rural development. It both involves as well as depends on the participation and knowledge of people and hence provides a tool to deal with the rural environment.

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STUDIES ON SEED OF PINUS ELLIOTTII BY X-RAY CONTRAST METHOD

by

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ABSTRACT

The investigation deals with the determination of the germinability of *Pinus elliottii* Engelm. seed by the x-ray contrast method. Seven seed samples were used for the experiments. The specifications of the samples are given in Table 1. Sodium iodide was used as the contrast agent. The results (Table 2) showed that there was a close correspondence between the germinability values of the samples by the x-ray contrast method and their germination values on Jacobsen apparatus; the latter were taken as the standard. The x-ray contrast method can therefore be reliably used for determining the germinability of the seed of this species. Some suggestions concerning the use of the x-ray contrast method are made.

INTRODUCTION

Pinus elliottii Engelm., slash pine, occurs naturally in parts of United States of America (Coastal Plains from southern South Carolina to southern and central Florida and west to southeastern Louisiana), Cuba and parts of Central America (FAO 1955, Critchfield and Little 1966, USDA 1974). Two geographical varieties are recognized in USA: Pinus elliottii Engelm. var. elliottii and P. elliottii var. densa Little and Dorman. Outside its natural range, slash pine is grown as an introduced species in several tropical countries, e.g. India, Tanzania, Zimbabwe, Argentina, Colombia, etc. (Kamra 1974a). Slash pine thrives best on moist, fertile, low-lying ground at low elevations. It is also planted in swampy areas (FAO 1955). The wood of slash pine is used as lumber, pulpwood and for resin production.

In USA the male and female strobili of Pinus elliottii emerge from buds from January to April, the cones ripen in August-September, and the seed dispersal takes place from September to November. The seed bearing age varies from 7-10 years for var. elliottii and from 8-12 years for var. densa.

Seed is the link between two generations, the existing one which produced it, and the new one which it gives rise to. With the exception of the species propagated vegetatively, forest trees are usually raised from seed. Consequently, afforestation and reforestation programmes have to start with seed. Since good plants arise from good seed only, the genetical and the technical qualities of the seed have to be high. The genetical quality refers to the genetical characteristics of the seed. The technical quality describes such characteristics as purity, germination, diseases and pests, etc. X-ray radiography has proved to be useful for determining some of these technical aspects of seed (Kamra 1964, 1974b, 1976, Seward 1980, Willan 1985).

The x-ray contrast method is a rapid technique for determining the germinability value of a sample. Several investigations have confirmed its reliability on various species (e.g. Simak 1957, Kamra 1971, 1984, 1985, Devillez & Guertechin 1973, Leadem 1981, 1984, etc).

The present investigation was undertaken to find out, if x-ray contrast method can be used to determine the germinability of the seed of Pinus elliottii. The results are reported in this paper.

Material

Seven samples of Pinus elliottii Engelm. were used for the experiments. The specifications of the samples are given in Table 1.

Table 1: Locality and country of origin, latitude, longitude, altitude and year of collection of the samples investigated.

Sample No.	Locality and country from where obtained	Latitude	Longitude	Altitude m	Year of collection
1	Melsetter, Zimbabwe	19° 54'S	32° 53'E	1483	1977
2	Tanginyana, Zimbabwe	20° 24'S	32° 43'E	1050	1978
3	Melsetter, Zimbabwe	19° 54'S	32° 53'E	1483	1978
4	Tanginyana, Zimbabwe	20° 24'S	32° 43'E	1050	1981
5	Mukandi, Zimbabwe	18° 43'S	32° 51'E	1268	1982
6	Tanginyana, Zimbabwe	20° 24'S	32° 43'E	1050	1982
7	USA	----------Not known----------			1974

Note: The supply of seed samples from Zimbabwe by Mr. B.R.T. Seward, Forest Research centre, Harare, is gratefully acknowledged.

METHODS

(a) Germination on Jacobsen apparatus:

To study seed development and to determine the number of empty seeds (and insect-attacked ones, if any) in the material, each sample was radiographed using soft x-rays before the germination tests. No contrast agent was used. The conditions for radiography were the same as those described below under the x-ray contrast method, except that the time of exposure was 7.5 seconds, as the seeds were spread directly on the envelope containing the film. The procedure for processing the films was the same as described below.

For the germination tests as well as for the x-ray contrast method, the percentage of the germinable seeds of each sample was calculated on the basis of the number of fully developed seeds only. For this purpose, the number of empty (and insect-attacked seeds, if any) and incompletely developed seeds (classes I, II and III according to Simak and Gustafsson 1954 for Pinus silvestris) was counted and subtracted from the total number of seeds of the sample on the x-ray film, thus giving the number of fully developed seeds only. Consequently, the results of the germination tests and those of the tests by the x-ray contrast method are comparable with each other.

Pure seed (8 x 50) of each sample was used for the germination tests carried out according to the ISTA Rules (1985). Thus an alternating temperature of 20-30°C was used (20°C for 16 hours and 30°C for 8 hours). Light was supplied by fluorescent tubes (Type Warm White) for 8 hours daily when the temperature was 30°C. The intensity of light on the seed bed was about 2000 lux. Since in the case of Jacobsen apparatus, the distance between water level and seed bed affects the moisture level of the seed bed, this distance was kept constant at 14 cm. No fungicide treatment was given to the seeds before putting them for germination.

The germinated seeds were counted on the same day on which their germination started. This counting was done every day during the first ten days and every other day thereafter. The germinated seeds were removed from the seed bed. A seed was considered as germinated, when the length of the root was at least equal to that of the seed itself. This criterion has been found to be dependable in the case of Pinus silvestris and Picea abies in experiments where the germinated seeds are checked every day.

(b) Germinability by the x-ray contrast method:

A representative portion of each sample containing about 200 seeds was soaked in water for 16 hours at room temperature. After draining off the water, the seeds were dried superficially with a filter paper. Thereafter the seeds were treated with a 40 per cent aqueous solution of sodium iodide for one hour. Since sodium iodide is sensitive to light, the solution was kept in the dark (in a cupboard) during the treatment. Afterwards, the seeds were washed with slowly running tap water for about 1.5 minutes. The extra water was wiped off the seeds and they were then dried in a thermostatically controlled oven at 70°C for 90 minutes. Thereafter, the seeds were allowed to cool for a few minutes and then put in plastic patterns, one seed in each hole. The seeds were then radiographed using the following conditions: kV = 14, mA = 5, focus-film distance = 50 cm, time of exposure = 9 seconds. The x-ray industrial films, type "Structurix D7", manufactured by Agfa-Gevaert, Antwerpen, Belgium, were used. They were developed in Structurix Developer G-127 and fixed in Universal Fixative G-321, manufactured by the same company.

In order to classify a seed as germinable or non-germinable by the x-ray contrast method, the criteria worked out by Simak (1957) on Pinus silvestris and by Kamra (1971) on Picea abies were used. According to these criteria, a seed with embryo free of impregnation and with impregnation in the endosperm not exceeding 25 per cent of its total projected area on the x-ray film is considered germinable. Conversely, a seed with impregnation in the endosperm alone (embryo not impregnated) in more than 25 per cent of the total projected area of the endosperm on the x-ray film or with partial or complete impregnation in the embryo alone, or with partial or complete impregnation in both the embryo and the endosperm, is considered as non-germinable. On the basis of the above criteria, a seed in which both the embryo and the endosperm remain free of impregnation is regarded as germinable.

RESULTS

(a) Rates of germination:

When one examines the rates of germination of the samples investigated (Fig. 1), one finds that they all, except samples 1 and 2, begin their germination on the same (6th) day. Sample 5 germinates slightly faster than sample 6 up to the 9th day, but after the 10th day sample 6 is faster than sample 5. Up to the 12th day sample 5 shows a more rapid rate than no 7, but after the 14th day, the reverse is true. Sample 1 has a somewhat similar germination rate as sample 7 up to the 8th day, but slower thereafter. Out of samples 3 and 4, no. 3 has a more rapid rate right from the start. Sample 2 does not begin to germinate until the 24th day and shows the slowest rate of all the samples.

Comparing the rates of germination of the samples of the same year of harvest, for example 1982, nos. 5 and 6, one observes that sample 6 after the 10th day germinates not only faster than no. 5, but is also the fastest of all the samples. The two samples of 1978 (nos. 2 and 3) show a great difference between themselves. Sample 2 is not only far slower than no 3, but it is also the slowest of all the samples in the germination rate. Of the three remaining samples, no. 7 of 1974 germinates faster than no. 1 of 1977 which in turn is more rapid than no. 4 of 1981 (cf. Fig. 1).

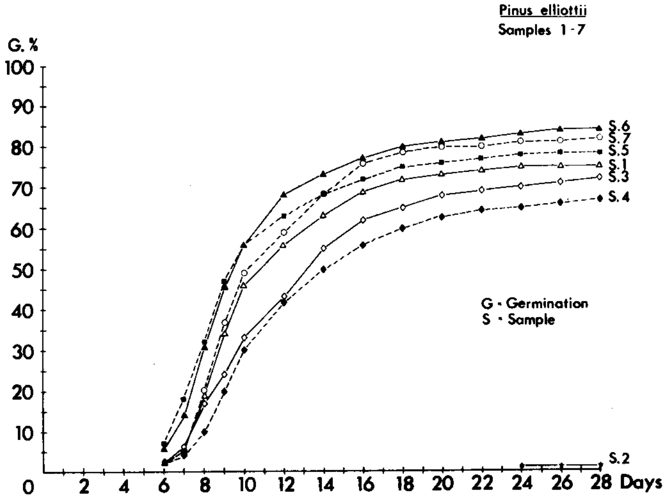

Figure 1. Rates of germination of the samples investigated.

(b) Germinability and germination percentages:

In Table 2 the germinability values of the samples by the x-ray contrast method using sodium iodide as contrast agent are compared with their germination values on Jacobsen apparatus. As is apparent from the Table, the values correspond well with each other. The differences between the values of germinability and of germination of the samples are significant at the $\alpha = 0.05$ level but not at the $\alpha = 0.01$ level, according to Wilcoxon's test for matched samples. However, such small differences in the values can be considered negligible in practice. The values in Table 2 are based on the number of fully developed seeds in each sample. The poorly developed seeds were totally absent in four of the samples, and occurred only between 1-2 % in the remaining three samples.

Fungal attack:

Towards the end of the germination tests, a heavy fungal attack was observed on samples 1, 2, 3, 5, 6 and 7 and a medium one on sample 4.

Table 2: Comparison of germinability and germination values of Pinus elliottii samples investigated.

Sample No.	Germinability per cent by x-ray contrast method	Germination per cent on Jacobsen apparatus
1	74	75
2	3	1
3	74	72
4	70	67
5	81	78
6	85	84
7	84	82

The patterns of impregnation by sodium iodide in seeds of Pinus elliottii were very similar to those found earlier in seeds of some other pines and of Norway spruce (cf. Simak and Kamra 1963, Kamra 1971). Some of the impregnation patterns observed in seeds of Pinus elliottii are shown in Figure 2.

Figure 2

Pictures 1-10:

1. A fully developed not-impregnated seed. a. seed coat. b. cavity between seed coat and endosperm. c. endosperm. d. embryo cavity. e. radicle. f. cotyledons.
2. An empty seed. Note the endosperm remains (not impregnated).
3. Seed showing a single impregnation patch in the endosperm.
4. Seed with partial impregnation in the endosperm near the radicle end, embryo not impregnated.
5. Seed showing three impregnation patches in the endosperm.

6-7. Seeds with partial impregnation in the endosperms, embryos not impregnated.

8. Partial impregnation of the embryo, endosperm not impregnated.
9. Complete impregnation of the embryo, endosperm not impregnated.
10. Complete impregnation of the embryo and the endosperm.

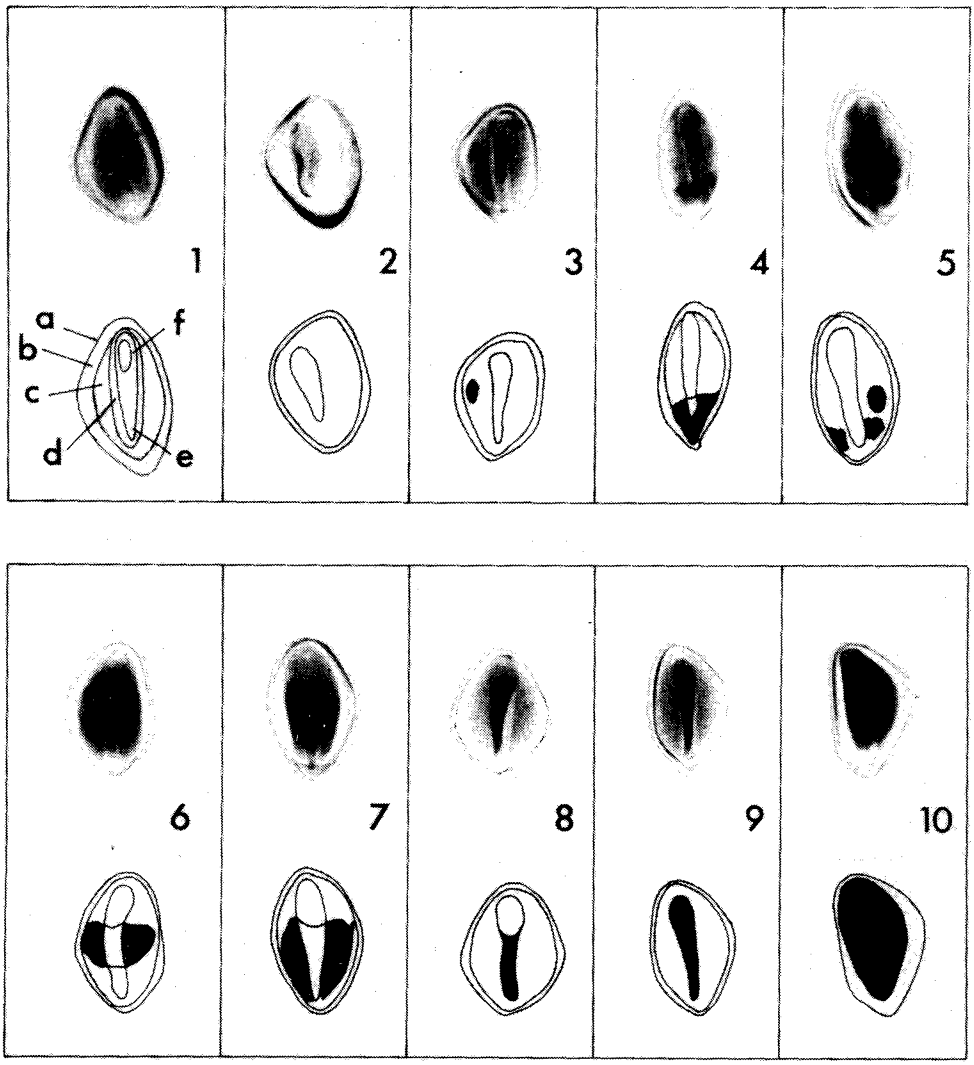

Figure 2. Pinus elliottii: Radiographs (above) and drawings (below) of seeds without and with different degrees of impregnation with sodium iodide. (Further explanation on previous page).

DISCUSSION

When one comapres the values of germinability of the samples by the x-ray contrast method with their germination values on Jacobsen apparatus (Table 2), one finds that they correspond well with each other. This shows that the x-ray contrast method gives reliable results of the germinability of Pinus elliottii seed. Consequently, the criteria described under the Methods for judgement of the germinability of seed by the x-ray contrast method are dependable. In view of the above, the x-ray contrast method can be reliably used to determine the germinability of the seed of Pinus elliottii.

During the germination tests, all the samples showed fungal attack (cf. Results). As is well known, fungal growth is quite common during the germination of seed with reduced viability or dead seed. Like the earlier investigations on Pinus merkusii, P. kesiya and Pinus oocarpa (Kamra, 1984, 1985), also in this study no fungicidal treatment was given to the seed. The reason for this was the experience of Magini (1962). He reported that several experiments carried out by different methods of disinfecting the seeds just before or during germination did not show any reliable improvement in germination percentage. Moreover, it cannot always be excluded that a fungicide may even have an adverse effect on the germination of some types of seeds.

While using sodium iodide solution, it should not be forgotten that it is sensitive to light. Consequently, it should not be exposed to strong light before or during the treatment of the seeds. Despite this, it is not necessary to work in total darkness. Treatment of seeds with sodium iodide can be carried out in weak diffused light. Of course, if the solution of sodium iodide has to be stored for a long period, it should be kept in darkness.

Water absorbs x-rays and therefore moist seeds can absorb more x-rays than dry ones. Consequently, moist seeds may appear lighter on the x-ray film than dry seeds. Moreover, there are some natural differences in the absorption of x-rays by individual seeds of a sample. As a result, some seeds appear dark and the others bright on an x-ray film, even though no treatment with a contrast agent has been given to the sample. It is therefore necessary to become acquainted with such differences in the intensity of brightness of the seeds on a radiograph, so as not to confuse the bright, unimpregnated seeds with the impregnated ones, where both kinds occur on an x-ray film. The proper way of doing this is to use a few seeds (about 25 to 50) as the control. They are soaked in water overnight along with the seeds which are to be treated with the contrast agent, but are separated before treatment and are kept soaked in water for the same period for which the others are treated with the contrast agent. Thereafter, these two portions of a sample are dried in separate petri dishes but simultaneously and under the same conditions. While taking the radiograph of the sample, the control seeds should be placed separately in a corner of the film and marked as "control", and the treated seeds placed on the rest of the film. In this way, the control and the treated seeds of a sample on a radiograph receive the same exposure and the same processing treatment. The control seeds thus serve as a reliable reference for distinguishing the unimpregnated and the impregnated seeds on the x-ray film, and consequently reduce the chances of confusing the bright unimpregnated seeds with the impregnated ones on a radiograph.

While washing seeds with water after treatment with a contrast agent, it is helpful to remember that if they are not washed thoroughly, the remaining chemical on the surface of the seed can cause misleading impregnation artefacts. However, too long washing of seeds is not desirable, as in this case the contrast agent from the impregnated areas inside the seed can be washed off, if the testa for some reason (e.g. mechanical damage, etc.) allows water to enter the seed. Usually washing the seeds with slowly running tap water for about 1,5 to 2 minutes gives satisfactory results for pine seeds. For further details of seed radiography and x-ray contrast method, see Kamra 1964 & 1974b.

In some cases, the contrast agent with which the seeds are treated, is able to enter the seed coat for some reason (e.g. mechanically damaged testa), but stops just under the testa and does not impregnate the endosperm or the embryo. Such seeds should not be confused with the impregnated ones, as here the endosperm and the embryo remain free of impregnation.

Regarding the processing of the x-ray films, it is important to remember that the films should not become too light or too dark, as in both cases the distinction between the impregnated and the unimpregnated seeds is difficult to make. The films processed to a medium darkness are usually satisfactory for evaluating the impregnated and the unimpregnated seeds.

The suggestions given above will be found useful while working with the x-ray contrast method. A thorough understanding of the principles involved and a delibrate use of the method will give dependable results.

Whether the seed of Pinus elliottii should be stratified or not is a debated question. The main purpose of stratification is to shorten the germination period by overcoming seed dormancy. A shorter germination period has the advantages that it helps to obtain a more or less simultaneous germination of the seed and also reduces chances of attack by fungi. Seed of Pinus elliottii sometimes has an inherent dormancy at maturity which may be accentuated during extraction and storage (Swofford 1958). This would naturally justify the stratification of the seed.

However, Wakeley (1954) observed that stratification of all seed lots of a species lead to no beneficial effect in some and to actual reduction in germination in others. Therefore he recommended that only those seed lots should be stratified which show a beneficial result in parallel tests of stratified and unstratified seed.

Swafford (1958) carried out such parallel tests of stratified and unstratified seed of slash pine and found that only 15 per cent of the seed lots benefitted from stratification, whereas 54 per cent were injured and 31 per cent remained unaffected. He is therefore of the opinion that stratification of all seed lots is not justified and that the need for stratification can only be determined by comparative tests of unstratified and stratified seed.

Forrest (1964) found a higher germination percentage in stratified as compared to unstratified slash pine seed in a test for 28 days. He obtained maximum total germination and maximum germination rates either by soaking slash pine seed in water for 60 hours or by soaking in water for 8 hours followed by cold storage at 40°F (= 4.4°C) in sealed plastic packets for 15 days.

Concerning seeds of Pinus species, the USDA handbook (1974) (p. 624) states: "Seeds of many species ordinarily germinate satisfactorily without pretreatment, but germination is greatly improved and hastened by first subjecting the seeds to cold stratification, especially if the seeds have been stored". This handbook recommends no stratification in case of fresh seed of Pinus elliottii var. elliottii but a stratification for 15-60 days at 0-5°C for stored seed. However, for Pinus elliottii var. densa the above handbook recommends a stratification for 30 days at 0-5°C both for fresh and stored seed.

Unlike the USDA handbook, the International Rules for Seed Testing (1976 and 1985) do not require stratification of slash pine seed. Since in the present investigation, the germination tests were carried out according to the ISTA Rules, the seed samples were not stratified. The close correspondence between the results of germination and those of germinability by the x-ray contrast method indicates that the procedure followed was correct.

One of the advantages of the x-ray contrast method is that it works well both on stratified and unstratified seed and can therefore be utilized without knowing the status of the seed sample. In cases where one compares the results of the x-ray contrast method with those of the germination tests, it is important to remember that both kinds of tests have to be carried out on the same material which has been treated in exactly the same way.

The x-ray contrast method is simple, rapid and gives reliable results. However, knowledge and experience are as valuable in this case, as they are everywhere else in scientific work.

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FOREST SEED IN INDIA : RESEARCH AND PROBLEMS

by

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ABSTRACT

India is a very large country having several extremes of climatic conditions. Afforestation and/or reforestation programmes in these conditions have forced the forest scientists to find out those tree species which can very well establish themselves in any geographical area under some of these conditions. In the last few years, provenance trials of several useful tree species have been done and a number of species suitable for each type of climate, viz. temperate, tropical, subtropical and arid etc. have been selected. Nursery techniques have also been standardized for several tree species and seedlings are being raised to be planted in saline, alkaline, dry and moist soils of even very special localities like coalmine and bauxite mine overburdens, lime-stone and effluent rich soils etc. Viability periods of seeds of a large number of species during storage have been determined. Seed production areas and seed orchards are being developed for certain tree species. However, there are many problems related to the collection, handling, processing, testing, certification and storage of seeds which are still unsolved. The most important of them is the shortage of well trained seed scientists who should supervise at all steps viz. from seed collection to the planting of seedlings in the field.

INTRODUCTION

The importance of forests for mankind is as old as the history of man himself. Even then, sufficient attention to forest management was not given in the old days in India. The use of forests was aimed at their exploitation for timber, fuel and grazing etc. However, the present approach of administration and management of forests has become conservation and regeneration oriented. Since, forests in India form only 1.6 per cent of the gross domestic product, only their periodic increment is proposed to be used whereas the capital is not being touched.

In view of the ambitious plan for increasing the fastly shrinking forest area through wasteland afforestation, research in forestry has nowadays obtained new horizons. Forestry research in India was primarily the responsibility of the Forest Research Institute, Dehra Dun. But, several additional centres viz. Regional Forestry Research Centres, State Forest Research Institutes and Departments of Forestry in many Agricultural Universities have been established to conduct research, training and education in various aspects of forest science.

These units undertook fragmentary projects but ultimately the results can be well integrated. Inventory of those tree species has been prepared which are useful in some or the other way, and are fast growing. Suitability of these species to various soil and climatic conditions is being determined. Period of viability of seeds of a large number of species has also been determined through different viability tests. Nursery techniques have also been standardized for getting the maximum germination of seeds with the least investments. However, there are certain problems related to the shortage of quality seeds of some species and lack of trained seed technologists for which ways and means are being developed.

Suitability of species for different types of soils

India, being a very big country, possesses a number of botanical regions, i.e. habitats for the growth of natural forests. There are extremely cold mountains of Himalayas on one hand and extremely xeric and hot deserts of Rajasthan on the other. There are extensive mangrove forests on the seashore in the south and simultaneously there are maximum rainfed areas of the world like Assam. The trees in these varied climatic zones behave very differently and so do the seeds of these trees too.

The government of India has proposed various afforestation and reforestation programmes like social-forestry, farm-forestry, agro-forestry, environmental-forestry, urban-forestry and fuelwood-forestry etc. for the reclamation of wasteland of roadsides, canal banks and along railway tract etc. The wasteland Development Board of India has put emphasis on the plantation of those tree species which can of use to some purpose. Since selection of suitable plant species for a particular area is the first and the most important need in any plantation programme as the success or failure largely depends on it, the forest scientists were bound to study the germination behaviour of the seeds of a large number of tree species in different types of soils. After screening, following species were found suitable for establishing themselves in the soils and specialized localities given below in order of their performance :

+ Coalmine overburdens - Eucalyptus hybrid, Acacia auriculiformis, Dalbergia sissoo, Albizzia sps., Acacia sps. (Prasad and Shukla, 1985).

+ Bauxite mine overburdens - Eucalyptus camaldulensis, Acacia auriculiformis, Grevillea robusta, G. pteridifolia, Pinus caribaea, P. roxburghii, (Prasad and Pandey, 1985).

+ Saline or alkaline soils - Acacia arabica, Butea monosperma, Tamarix aphylla, Azadirachta indica, Albizzia lebbek, A. procera, Pongamia pinnata, Tamarindus indica, Terminalia arjuna, Salvadora oleoides, S. persica, Prosopis juliflora.

+ Coastal sandy soils - Casuarina equisetifolia, Calophyllum inophyllum, Borasus plabellifer, Eucalyptus hybrids, Anacardium occidantale, Manilakara littoralis, Pithecellobium dulce.

+ Sand dunes - Acacia tortilis, Colophospermum mopane, Prosopis cineraria, Zizyphus rotundifolia (Shankernarayan and Kumar, 1986).

+ Dairy effluent area - Syzygium cumini (Chaturvedi, 1985).

+ Limestone soil - Bauhinia retusa, (Gupta, 1978).

Viability periods of seeds of different species

A sincere and useful work done in the last few years is the determination of viability spans of the seeds of several species so that they can be stored in the good seed years and can be used for plantation at the proper time. Also, the specific ways and containers are determined for the storage of seeds. Such informations are regularly published and circulated among the field foresters so that they can make use of them (Prasad and Kulkarni, 1986). Some of the important findings are the following :

2 weeks - Madhuca indica, Shorea robusta, Michelia champaca, Syzygium cumini, Soymida febrifuga, Dipterocarpus, Hopea, Aegle marmelos, Anogeissus latifolia, A. pendula, Azadirachta indica, etc.

3 months - *Chloroxylon*, *Mangifera*, *Chukrasia*, *Podocarpus*.

1 year - *Artocarpus heterophyllum*, *Cedrella toona*, *Mesua ferrea*, *Terminalia tomentosa*, *T. belerica*, *Bambusa bambus*, *Semecarpus anacardium*, *Pongamia pinnata*, *Prosopis juliflora*, *Pterocarpus marsupium*, *Largerstroemia parviflora*, *Lannea coromandelica*, *Diospyros melanoxylon*, *Garuga pinnata*, *Buchanania latifolia*.

2 years or more - *Acacia arabica*, *A. decurrens*, *Albizzia lebbek*, *A. procera*, *Dalbergia sissoo*, *Eucalyptus tereticornis*, *Cassia fistula*, *Anthocephalus cadamba*, *Tectona grandis*.

Standardization of nursery techniques

After selecting tree species for particular soil and climatic conditions, provenance trials for the selection of improved varieties of various species are done. This sort of work is being done in some centres of India. Misra *et al*.(1983) studied the performance of 14 species of *Acacia* in different pot conditions whereas Mathur *et al*. (1984) performed a selection programme for 18 provenances of *Acacia nilotica* subspecies *indica*. They screened 12 presowing treatments for their suitability to the seeds of these provenances.

Since, much research work was not done on the forest seeds in India in the past, proper and standardized methods for collection, handling and storage of seeds of several desired species were not known. In the last few years, exact reasons for low percentage of seed germination in a large number of species used in extension forestry programmes have been found out and nursery technique for a series of species have been standardized (Date 1985a, b, 1986a, b, c, d). The main object of such studies is to evolve those methods of seed germination which have the least wasteful nursery practice. Germination media, method and time of seed sowing and any pretreatment required are specified through these methods. Similarly, several cheap and easily available agents for hastening the seed germination were also found through these trials.

Such work has pointed out that special care is needed for the handling of seeds of mangrove seeds, which can not be stored for longer periods than a few days. They ripe mostly during July and should be collected during flow and ebb tides, from July to September. Sowing should be done from middle of August till the end of September.

During the studies for standardisation of nursery techniques for the handling of tropical pine seeds, six germination media (100% river sand, 75% river sand + 25% forest soil, 50% river sand + 50% forest soil, 25% river sand + 75% forest soil, 100% forest soil and acidified sawdust of mango wood soaked in 1 N HCl for 24 hours, then washed and mixed with 25% amount of forest soil) were tested for their suitability to the seeds of *Pinus caribaea* var. *hondurensis* and *P. patula*. The effect of germination media was reflected in the germination percentage as well as mortality percentage and finally in the plant percentage. Sand was found to be the best suitable medium. Moreover, it is cheapest and easily available. However, if the seedlings are retained for a long time in this medium, there is an apprehension. The poor moisture and nutrient retention capacity of sand may create certain deficiencies by limiting nutritional uptake. However, lifting up the seedling is much smoother in the sandy medium thus damage during the transfer operation is minimised (Ghosh et al.1974a,b).

With a view to determine the optimum environmental conditions suitable for the germination of Dendrocalamus strictus seeds, Gupta and Kumar (1977) studied the effect of five constant and three alternating temperatures viz. 20, 25, 30, 35 and 40°C; 20-30, 25-35 and 30-40°C, in combination with five moisture levels of the substratum viz. 25%, 50%, 75%, 100% and 125% on the germination of D. strictus seeds. It was observed that 30°C temperature is the ideal for germination as it brings out the maximum and quickest germination. Moisture status of the substrarum was found to be a controlling factor and 50% to 75% moisture level was found to be the optimum.

Like sal, Pisa (Actinodaphne hookeri) is a very good source of non-edible seed-oil but this plant is not found in large number. Due to its higher percentage (48.4) of solid fat in the seed, this moderate sized tree is being grown artificially. However, germination of seeds was a problem. Only in last few years (Joshi, 1978) methods could be standardized to obtain 90% germination in it.

Standardization of methods of seed testing for different species

Seed testing is a tool in the hands of tree planters to ensure that seeds of only approved source and quality conforming to certification standards are used in plantation programmes. In order to make this possible, seeds should be collected from selected superior mother trees and extracted, processed and stored in a scientific manner. From the storage, seed samples should be sent to the seed testing laboratory for determination of purity, germination, viability, vigour and disease-free condition. These tests are performed with the help of rules framed by research laboratories on the principles laid down by ISTA. In order to maintain uniformity in evaluation of seeds throughout the country, it is compulsory to follow a standard pattern of testing. Gupta et al. (1975) were the first to make certain rules and standardize the methods for testing the seeds of 53 tree species of Indian forests belonging to 32 genera. This work has helped a lot to make the proper use of seeds and to obtain the optimum crop from them.

While framing the rules for testing the seed germination, several factors (seed characteristics, presowing treatments, environmental factors, germination media and depth of sowing etc.) are kept in mind as the germination behaviour changes considerably with change in any of the factors.

Effect of seed characteristics

The origin of seed has any effect on the germination and subsequent growth or not was first realized and experimented in India by Kadambi (1945). A national progress report on seed and seed problems of teak was presented by Seth (1956). Gopal (1968) first emphasised the significance of seed testing and certification in several Indian tree species. Gupta and Balara (1972) studied the germination behaviour of two exotics in Rajasthan - *Prosopis julifera* and *Acacia nilotica* whereas Gupta *et al.* (1973) observed the germination behaviour in 4 species of *Acacia*. There are several papers of this kind on a single or few species considering one or more factors, viz. Ghosh *et al.* (1974a, b) on *Pinus caribaea* var. *hondurensis* and *P. patula*; Gupta and Pattnath (1975) on teak of 18 origins, Kumar and Bhatnagar (1976) on *Dalbergia sissoo* etc. Pathak *et al.* (1974) noticed polymorphism in the seeds of *Leucaena leucocephala* and studied its effect on their germination whereas Gupta and Pattnath (1976) studied the germination behaviour of the seeds of 20 species (4 Gymnosperms and 16 Angiosperms including representatives of temperate, tropical, subtropical and arid climates) as influenced by temperature, metabolic energy in the form of seed vigour and ionic environment as supplied by the growing media. Ghosh *et al.* (1976) investigated the effect of seed grading by size on germination and growth of pine seedlings while Kandya *et al.*(1978) found certain seed- and seedling characteristics as the indicators of geographical variation in *Pinus caribaea* provenances. They found that trees of this species in drier areas produce heavier and bigger seeds which, because of their greater endosperm nutrient pool, support the seedling during the initial phase of growth under conditions of deficient water supply. Kandya (1978) also found significant correlations of seed weight with some growth parameters in *Pinus oocarpa*, and according to him seed weight in this species can be used to predict the seedling growth rates in nursery phase of development. Such understandings help in selecting provenances of tropical pines for planting in different localities. Pathak *et al.*(1978) performed their trials on germination behaviour of *Robinia pseudoacacia* whereas Chauhan and Raina (1980) on *Pinus roxburghii*.

Thapaliyal and Gupta (1980) observed the effect of seed source on the germination of deodar seeds whereas Pathak *et al.* (1981) obtained positive and significant correlations among the seed weight and several seedling characteristics of *Leucaena leucocephala*. In 32 populations, seed weight varied from 18.8 to 69.1 mg. and on the whole, bigger and heavier seeds were found to produce healthier seedlings. This characteristic was ascribed to the relatively higher storage of food materials in the cotyledons. Recently, Kandya and Ogino (1986) found that reserve dry weight of seed is a more significant factor governing the germination potential of seeds specially in certain conifers.

Effect of various presowing treatments

During the last decade, maximum work has been done on finding out suitable pre-germination treatments for the seeds of different forest tree species. Rai (1976, 1978, 1979) found the presowing treatments for hastening the germination in *Acrocarpus fraxinifolius*, *Albizzia falcata*, *A. chinensis*, *A. richardiana* and *Calamus thwaitesii*. Nagaveni and Srimathi (1980, 1981) found suitable pretreatment to prolong the viability period of *Santalum album* seeds. Dnyansagar and Kothekar (1982) recommended to expose teak seeds to gamma rays at 15 KR to enhance the germination percentage whereas Madhwa Raje (1982) improved the germination percentage and shortened the germination period of *Pinus caribaea* var. *hondurensis* seeds by stratification. Babelay and Kandya (1985a, b) obtained the pretreatments for the seeds of *Acacia catechu* and *Leucaena leucocephala*, whereas Babelay *et al*. (1986) obtained better germination in *Albizzia lebbek* by physical scarification.

Interpretation of viability of seeds was done in several species by tetrazolium staining of seeds (Gopal and Thapaliyal, 1969; Gupta and Raturi, 1975; Kumar and Sharma, 1982; Kandya and Babeley, 1984; Yadav *et al*. 1986a; Babeley and Kandya, 1986a and Rai *et al*. 1986). Babeley and Kandya (1986b) also used the excised embryo test for determining the seed viability of six dry deciduous tree species whereas Kandya and Ogino (1987) assesed the germination velocity indices of the excised embryos of three pine species.

While investigating the impact of various environmental factors on the germination of seeds of different species, it was found that there are several species whose seeds are indifferent to light (*Acacia leucophloea*, *Dalbergia sissoo*, *D. latifolia*, *Emblica officinalis* and *Schleichera oleosa* etc.) however, there are many whose seeds can not start germination unless get some stimulus from light (*Albizzia procera*, *Cassia fistula*, *Hardwickia binata*, *Pterocarpus dalbergioides* and *Pinus merkusii* etc.).

Temperature and substratum play a very important role in the germination of seeds which require a constant temperature in some species while alternating temperature in some others. Three substrates, 5 constant temperatures and 10 conditions of alternating temperatures were studied for the germination of *Dalbergia sissoo* seeds, by Kumar and Bhatnagar (1976). Maximum and quicker germination was obtained at 30°C, between the germination papers. Alternating temperatures between 20-30, 25-35 and 30-40°C were also found equally effective.

Similarly, depth of seed sowing is also one important factor affecting the seed germination. Thus, some workers studied in certain species, the effect of depth of sowing so that optimum depth could be determined. Singh *et al*. (1973) found that 15 mm depth is the best for sowing the seeds of *Pinus wallichiana* as maximum germination percentage can be obtained at this level. Not only this, they also evaluated the force of emergence plus the length of plumule to decide the depth at which the seeds should be sown. Singh *et al*. (1975) studied the same aspect in *Picea smithiana*, where they found that seeds should be sown as shallow as possible. Germination percentage decreased as the depth of sowing was increased. Singh *et al*. (1985) also found in *Populus ciliata* that sowing on the surface gives maximum germination. Deep sowings delay the commencement of germination. Tripathi and Bajpai (1985) also studied this aspect in Anogeissus pendula and it was proved that depth of sowing is a very important factor governing the germination potential of seeds, and should be carefully decided for every species.

A few specific aspects affecting the germination behaviour of seeds have also been investigated by some workers. For example, Pinus roxburghii trees are tapped extensively for resin. Lohani and Kureel (1973) studied the effect of tapping on cone and seed production and seed characteristics, for 16 years using trees of 9 origins. No effect of tapping was found on seed size. Production of cones and seeds was also not affected adversely. Chandra and Chauhan (1976) studied the effect of gibberellic acid on the germination of seeds in Picea smithiana and found that soaking of seeds in 500, 750 and 1000 ppm solution of GA gave almostsimilar enhancement in seed germination. Yadav et al.(1982) studied the effect of 15 potting media (different combinations of black soil, sand and sawdust) on the germination of seeds and growth performance of teak seedlings. A similar study was done on Populus deltoides by Mathur et al.(1983), whereas Yadav et al.(1986b) observed the effect of tree girth on seed viability and germination in Shorea robusta.

Singh and Singh (1983) observed the effect of moisture stress on the germination of Populus ciliata seeds whereas Kumar et al.(1984) studied the effect of complete solar eclipse on the germination of Dalbergia sissoo and Toona ciliata seeds.

Some of the workers are also interested in entirely different aspects of seeds than their germination behaviour etc. For example, production of large quantities of sal seeds is being used for extracting seed-oil which became a significant and regular foreign exchange earner for India from 1974-75 with its addition to the list of items for export. There has been a steady increase in its export and at present it is of substantial value to the foreign trade of India. Japan has been one of the major importers of sal seed oil. It was pointed out by Japanese interpreuners that quality of the different lots of sal seed oil received from India showed varying properties. It was analysed by Sharma and Jain (1981) that seed oil extracted after the storage of seeds for 4-5 months showed increased amount of free fatty acids (FFA) and hydroxy-glyceride. Since this drawback may pose a threat to the sal seed oil export, experiments are being conducted for finding out those conditions of storage of sal seeds in which the oil properties should not change. However, it was found that sal kernels containing 12.25% moisture when stored in a room, they were found to have been infected by Penicillium sp. Dewinged seeds with 13.1% moisture were also found infected with Aspergillus flavus. These fungi commonly found under humid conditions, hence, to avoid fungal attack, it is necessary to dry the seeds properly and to store them in such a way that they do not absorb the moisture again.

Similar to this, Beri et al.(1982) studied the chemical composition of the seeds of *Prosopis cineraria* and measured quantitatively various organic substances like protein, starch, tannins, crude fibres and total carbohydrates etc. Such studies sometimes give relevant information related to the medicinal use of seeds. Another paper of this kind (Soni *et al*. 1984) reported that seeds of *Leucaena leucocephala* which are produced abundantly (1307 kg/ha) can be used as a source of gum. They isolated this gum from the seeds of K-8 variety in the form of a powder, in 29% yield, using a spray drier.

Unsolved problems

Even after so many, multifarious studies, there are certain problems related to the seeds of some tree species, which are unsolved. Some of them are structural while others are circumstantial. A few of them are policy originated whereas some others are due to the ignorence of persons working in the forests.

The chief problem regarding the forest seeds in India is their need in extremely large quantities (Srimathi and Emmanuel, 1986) which makes it compulsory to collect all available seeds, both of good and poor quality. Since seed setting is not regular in most of the species, usually there is a shortage of seeds, enforcing the forest managers to use all available seeds, however, not a reasonably good outcome is received from such a seed stock. More and more seed orchards and seed production areas are needed to solve this problem however, it will take its own time.

Another reason for getting low quality seeds is that, in view of providing year round wages and incident income to the very poor tribals and villagers, the forest department gives the work of collection of forest tree seeds to them who have no scientific understanding of good and bad seeds. They are also not guided properly and are normally illiterate thus can not keep the record of collection data. Lack of such information does not permit the researchers to correlate the performance of seeds with any of the factors related to their origin. To solve this problem, seed collectors have to be trained and guided carefully to distinguish ripe and good seeds specially in small fruited *Terminalias*, *Adina* and *Altingia* etc. with which mistakes are easily made, but not easily detected, till too late.

Investigations done in the last few years have determined the exact dates for a large number of species when their seeds ripe. Khosla *et al*. (1982) found that in *Pinus roxburghii*, cones can be collected when they are still green.

It has also been well established that dry fruits such as cones of pines, capsules of *Lagerstroemia*, legumes of *Bauhinias* and capitula of *Adina* require appropriate treatment to extract their seeds, (Babeley, 1985). The commonest procedure used in India for several species is to spread the fruits in the sun until they open up because it is the cheapest and the simplest way. Special drying klins and ancillary mechanised seiving for this purpose are not much used. However, certain attempts are being done in this direction. For example, sun-drying of cones in _Pinus roxburghii_ is very slow and takes about 3 weeks to release the seeds. Thus, Maithani _et al_. (1986) made a trial to extract the seeds by drying the cones in ovens at various temperatures viz. 45, 60, 75, 90, 105, 120 and 135°C. The time of drying the cones at 45°C came down to only 4 days while at 90°C it could be reduced to only 2.5 hrs. It was observed that the seeds do not deteriorate if the cones are dried at 45 to 105°C temp. and the germination percentage also remains highest. Such seeds were also found to have low moisture content thus they could be stored for longer periods than the normal seeds.

Finding out a satisfactory pre-germination treatment for teak seeds specially from less moist and dry areas has been almost a century-old problem. Most of the conventional approaches aim at hastening the process of weathering of the impermeable woody endocarp and the felty mesocarp. Such approaches include methods like alternate wetting and drying, bengal-pit method, treatment with hot sand, use of acids or alkalies, treating the fruits with a mixture of lime water and cow-dung etc. But, the serious drawback of these methods is that a large proportion of seeds are rendered useless when they come in contact with the treatment media. Some workers made efforts to open the woody fruits by mechanical methods to expose or to make free the seeds to facilitate early germination. Such efforts resulted into wastage of seeds due to mechanical injury. Dabral(1976) suggested a very simple instrument (modification of traditional nut cutter) to cut the fruits individually. With this method, he found sufficiently higher percentage of germination of the extracted seeds (50 to 79%). Although, this method of extracting the seeds is time consuming (one man, on an average, cuts 0.5 Kg fruits in about six hours) but very little wastage of seeds is noticed with this method. It was calculated that seeds extracted from 1 Kg fruit were sufficient for plantation in 0.4 ha plot where normally 10 Kg fruits were being used. However, number of seeds and fruits in a Kg. was not very different (Sample 1 - Fruits 2290, seeds 2542; Sample 2 - Fruits 2646, Seeds 2287). The reason is well known that not all loculi of the fruit contain seeds, many of them are empty. Usually, a single, fully mature, sound seed is found in a drupe (Prasad and Jalil, 1986). By the frequent germination tests of the extracted seeds, it was also found out that the seeds should not be sown before the after-ripening period is complete. Success of germination of teak seeds depends upon the relative absence of the fungal attack during different months. Seeds germinate over a wide range of temperature (25 to 40°C) but 30°C has been found to yield better results. Too wet conditions cause decay of seeds thus soaking of seeds in water before sowing was found to be harmful.

A traditional problem is existing with pulpy fruits which require the removal of pulp for releasing the seeds. When the seeds are very small (_Morus_, _Anthocephalua_) separation of pulp becomes a problem. However, this is sometimes done by the Nature, i.e. through animal action or quick decay on the ground. If this is not checked, a serious drop in the germination capacity occurs, eg. _Azadirachta indica_. Bains (1980) determined that in thos seeds which are easily damaged, kneading in water is done in which, the pulpy material floats on the water and seeds sink down.

Sometimes, there are certain structural problems too. For example, in Millingtonia hortensis extensive flowering occurs every year but not a single seed is formed. The reason is found to be natural. The style of the ovary is so long that no pollen tube reaches the ovule and no fertilization takes place (Yadav, 1983).

There are several plant species whose seeds are eaten by different animals. But, this phenomenon is not always harmful for the seeds, rather, it is extremely beneficial at occasions as the seeds become capable to germinate only when they pass through the gut of a specific animal. The digestive juices secreted in the intestine of these animals induce some physiological activity or soften the hard seed coat and make the seed germinable. Examples of such forest tree species are : Prosopis juliflora, Acacia arabica, Santalum album, Azadirachta indica, Diospyros sp., Carya sp., Magnolia sp., Quercus sp., and Juniper sp. etc. The biochemical changes occuring du the natural conditioning in the body of the animal are not at all understood thus seeds of some of the above described species do not give a satisfactory germination in the field even after certain presowing treatments.

Another natural problem has been observed in the seeds of Populus ciliata which are short lived. The reason was investigated and it was found that the seeds in nature are dispersed in June which is the period of onset of pre-monsoon showers. The seeds thus face alternate wetting and drying conditions and ultimately the moisture stress. This creates the moisture deficit in the seeds below the threshold which leads to the degradation and inactivation of the essential hydrolytic and other groups of enzymes (Singh and Singh, 1983).

In Boswellia serreta, it has been recorded that very few trees flower every year. Furthermore, very few of them make fruits. Thus, very few seeds are produced each year. The problem of seed collection becomes more acute due to the seed structure. With light weight and big wings, the seed flows with air current and rarely stabilizes at a place. In this way, the natural as well as artificial regeneration of this important species whose pulp is extensively used for paper making, are very poor.

Sometimes the problems are man made and due to improper handling of seeds. A good example of this is the aerial seeding of the Chambal ravines in Madhya Pradesh. Without determining the quality, i.e. viability and purity, a huge amount of seeds of different species was spread over 12500 ha of land, from 1980 to 1984. The number of seedlings recorded in different areas ranged from 0 to 15900 per hectate (Sharma, 1985). These results are not satisfactory and the reason attributed for them is the washing away of seeds by rain water as the soil is very loose and the area is very precipitous.

Shorea robusta faces a circumstantial problem of seeds. This species in nature, regenerates by seeds only. Large scale collection of seeds from forest areas affects adversely the natural regeneration of this species. The effect is more pronounced in poor seed years when sufficient seeds are not left behind for regeneration.

With the increasing demand of vegetable oils in the country, oil producing trees assumed great importance in India. Although, the oil obtained from these is not edible and is used for non-edible purposes like lubricants, soap making, rocket propellant, shoe polishes and medicinal purposes. Out of all the oil-seeds of tree origin, Shorea robusta stands foremost due to its gregarious occurrence over large areas. However, collection of seeds in this species is associated with the following field problems :

1. Presence of bushes - Forests of sal possess a dense undergrowth of bushes due to which the labourer is not able to move over the area freely and collect the seeds fallen in the bushes.

2. Presence of leaf litter - The leaf shedding in sal precedes seed production. Therefore, large quantity of leaf litter accumulates on the forest floor and the seeds remain covered under it. Removal of litter from over large areas is not practicable.

3. Short duration - The collection period for sal seeds is very short, extending over ca 3 weeks only. Pre-monsoon showers during seedfall season hamper seed collection and early break of monsoon puts an end to it as the seed germination starts immediately on getting moisture.

4. Transport - Transport of collected seeds from interior of the forests in the absence of proper roads is also a problem as the fair weather forest roads are closed at the onset of rains (Verma and Sharma, 1978).

In several desirable species whose seeds are not available in required amounts alternative means of getting large number of seedlings without seeds have been achieved with a considerable success. For example, in Pinus roxburghii, this is done by splitting the seedling into two from tip to the root and plant them in polypots. 50 to 80% splitted (half) seedlings were found to establish themselves after two months, if splitting was done in July which was found to be the most suitable month for splitting (Chandra, 1976).

Planting material in large quantities by technique of tree tissue culture from callus has also been obtained in Cryptomeria japonica, Pinus tadea, Tectona grandis, Dalbergia sissoo, Santalum album, Betula pendula, Eucalyptus, Populus sp., Coffea sp., and Putranjiva roxburghii etc. These species are being regenerated in culture from plant segments like hypocotyls, cotyledons, and buds through callus differentiation, embryogenesis and organogenesis. Millions of plants have been produced in test tubes, however, further progress was not satisfactory (Prasad and Kulkarni, 1986).

The most recent technique used to get the optimum crop from a seed-lot is the application of biofertilizers to the seeds in a variety of ways. Biofertilizers are pure, artificially cultured, solid-based or frozen concentrate dizotrophs, phosphomicrobiales, sulpher-oxidizers, nutrient solubilizers, mineralizers, mycorrhizal fungi or other beneficial microbes which make available various nutrients for plant use which are locked into complex compounds. Seed inoculation is normally done by the following four ways :

1. Powder method - Dry seeds are sprinkled with 10% sugar solution or 30-40% solution of water soluble gum just to wet entire surface of seeds and then dry powder of biofertilizer is mixed for complete coating of seed surface. Immediately after the inoculation, seeds should be sown.

2. Slurry method - In an adhesive solution like sugar, gum or molasses, powder of biofertilizers is mixed to prepare a slurry which is poured into dry seeds and mixed for complete coating of seed surface. Inoculated seeds are dried in shade and sown after 8 to 10 hours.

3. Seed pelleting - Adhesive solution is poured on the seeds and then some pelleting material like powdered limestone, rock phosphate or basic slag is thoroughly mixed with seeds. These coated seeds are inoculated with moist peat-based inoculum just before sowing.

4. Seed coating - One of the difficulties with pelleted seeds is that the pelleting material tends to take-off particularly if pelleting is done several weeks in advance or when the seeds are sown by airplane. To ensure the flaking, polyvinyl alcohol, polyvinyl acetate or poly-urea varnishes or resins dissolved in chemical solvents are used to bond the seed coat and coating material such as charcoal, calcium silicate etc. After coating, *Rhizobium* inoculation is done as usual just before sowing. (Mohammad and Prasad, 1986).

Conclusion

In India, the use of certified seeds in forestry is rare. Seeds are collected from malformed, diseased, too young, too old, inferior or poor quality trees. To improve the situation, some organisations like the SFRIs (State Forest Research Institutes) and/or RFRCs (Regional Forestry Research Centres) should control the seed collection rather than simply purchasing them from the villagers and tribals and no private agency should be allowed to collect seeds.

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EFFECTS OF PRESOWING TREATMENTS ON SEED GERMINATION OF FOUR IMPORTANT TREE SPECIES IN KENYA

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SUMMARY

The effects of several pretreatment methods on seed germination of four important tree species to Kenyan forestry, Acacia xanthophloea, Trachylobium verrucosum, Cassia siamea and Maesopsis eminii were examined. In trials with the 'hard' seeded legumes, A. xanthophloea and T. verrucosum, nicking gave significantly better enhancement of germination than the other pretreatments tested. Some of the sulphuric acid and boiled water pretreatments were reasonably effective and far superior to several obviously inappropriate methods that ranked close to control (no pretreatment). Although nicking was not tested, sulphuric acid and boiled water gave reasonable enhancement of germination of the hard coated C. siamea.

The trials with M. eminii indicated that presowing treatment may not be necessary for seeds of this species. The poor germination results with the seedlot tested might be attributable to loss of viability during seed processing.

INTRODUCTION

The four species under examination in this paper, Acacia xanthophloea Benth., Trachylobium verrucosum (Gaertn.) Oliv. and Cassia siamea Britt. of the family Leguminosae and Maesopsis eminii Engl. of the family Rhamnaceae are important agroforestry and timber species in Kenya. All species except C. siamea, an exotic from Asia, are indigenous to Kenya.

A. xanthophloea and C. siamea are medium-sized trees used principally for fuelwood while T. verrucosum and M. eminii are large-sized trees which produce useful timber. M. eminii has the further distinction of being one of the few indigenous species cultivated in plantations and, when open grown, provides a good shade crop for coffee and tea.

While some seeds of the leguminous species germinate readily when first collected (Kobmoo and Hellum 1984, Teel 1984) they quickly develop a 'hard' seedcoat which even under conditions favourable for germination excludes the absorption of water and air and effectively inhibits germination (Rolston 1978, Gunn 1981, Doran and Gunn 1986). For successful germination in the laboratory, glasshouse or nursery, some form of artificial pretreatment must be applied to render the hard seedcoats permeable to water. M. eminii fruits must be collected when fresh, the fruit should be removed and seeds dried in order to obtain high germination percentages (Teel 1984).

In this paper the effects of several pretreatments on subsequent germination of seeds of each of these species are described. While the tests on seeds of A. xanthophloea and T. verrucosum were well-replicated under carefully controlled conditions, the same precision was not possible with C. siamea and M. eminii. The data on these species should be regarded as preliminary.

MATERIALS AND METHODS

Acacia xanthophloea and Trachylobium verrucosum

The A. xanthophloea seedlot was collected from Kibwezi and the T. verrucosum seedlot from Gede. Both were bulk collections, extracted by hand from the fruits and transported by air to Fredericton, NB, Canada. In Canada the seeds were sealed in polyethylene bags and stored in a cool room (1-4°C) for 6-8 months prior to the experiments being undertaken.

The seeds were divided into four replicates of 100 seeds in each of 13 pretreatments. All the seeds were sterilized before pretreatment by first soaking in 30 to 35% hydrogen peroxide for one hour and then thoroughly rinsed in sterile water. All the pretreatments were conducted under a laminar-flow hood.

Except for the control, the selected pretreatments were known to enhance germination in some leguminous species. The pretreatments used were:

1) Control. The seeds were kept dry, except for sterilization with hydrogen peroxide, until they were sown.

2) Nicking. The seedcoat was nicked at the micropylar end with sharp cutting pliers, extreme care was taken not to damage the seeds internal structures.

3) Dry abrasing. Seeds were abrased for 12 hours using a Tumblex-finishing apparatus with Tumbler T9 (Anonymous 1970). The abrasive material was aluminium oxide in the form of triangles (1 cm x 1 cm x 1 cm).

4) Wet abrasing. The seeds were abrased as in (3) but a small amount of water was added.

5,6 and 7). Soaking in boiled water for 6,12 and 24 hours, respectively. Seeds were immersed in water just taken off the boil and left to cool for the time period indicated.

8,9 and 10). Soaking in concentrated sulphuric acid (sp. gr. 1.84) at room temperature (23-25°C), for 8, 16 and 32 minutes, respectively.

11, 12 and 13). Soaking in xylene for 8, 16 and 32 minutes, respectively.

Following the pretreatments the seeds were rinsed thoroughly with sterile water. They were then placed (4 x 100 seeds for each pretreatment) on moist sterilized Kimpak (cellulose wadding) in sterilized (autoclaved for 20 minutes at 121°C and 105 kPa) polycarbonate Spencer-lemaire germination boxes (Wang and Ackerman 1983). Each box was sealed with Parafilm after autoclaving, until used under the laminar-flow hood. To each box, 200 ml of distilled water was added. Each seed-loaded germination box was then placed randomly in one of two Conviron G30 germinators at constant 20°C with a daily 16 hours fluorescent-light photoperiod and 8 hours of dark. The relative humidity in the germinators was maintained at over 85%.

Germination counts were made after first germination was observed and then every other day. The criterion for successful germination was that the radicle had protruded normally from the seedcoat and had achieved an exposed length equivalent to that of the longest dimension of the seed. The germination tests ran for 28 days.

After 28 days the ungerminated seeds were sectioned and classified according to the character of the content. Firm and white contents were considered viable, soft and discoloured contents were dead and empty seedcoats were classified as empty.

Cassia siamea

A bulked seedlot was extracted manually from fruits collected at Kibwezi in 1985. It was stored temporarily at the field station under room temperature conditions (25°C), until transport by road to the Kenya Tree Seed Centre. The seed was then placed in the cool room (3 - 5°C) until preparations for this experiment began.

The seeds were divided into two replicates each with 100 seeds in each of five pretreatments. The pretreatments applied were:

1) Control. No pretreatment, the seeds were kept dry until they were placed for germination.

2) Soaking in cold/tepid water (tap water) for 48 hours.

3) Soaking in boiled water and let to cool.

4) Soaking in boiled water and let to cool and imbibe overnight.

5) Soaking in concentrated sulphuric acid for 5-15 minutes. After pretreatment the seeds were thoroughly rinsed under cold running tap water.

The seeds were sown in two different locations, in a glasshouse and a nursery. The glasshouse had higher and more constant temperatures compared to the nursery. The germination medium in the nursery was forest soil covered with a thin layer of sand while in the glasshouse sand was used.

The criterion for successful germination was the emergence of the hypocotyl and cotyledons above the sand level. The germination tests ran for 60 days.

Maesopsis eminii

Bulked fruits of M. eminii were collected from Kakamega in 1985. The seedlot was stored temporarily at the station of collection, under room temperature conditions (25°C) until transported by road to the Kenya Tree Seed Centre. The seedlot underwent further processing before storage at 3 - 5°C. It remained there until required for the pretreatment experiments.

Seeds were divided into one replicate of 100 seeds in each of 5 pretreatments. The pretreatments selected are known to enhance germination in some tropical tree species. The pretreatments used were:

1) Control. No pretreatment, the seeds were kept dry until they were placed for germination.

2) Soaking in cold/tepid water for 12 hours.

3) Soaking in cold/tepid water for 18 hours.

4) Alternate wet/dry. Soaking in cold/tepid water for 2 days alternating with 2 days drying.

5) Soaking in concentrated sulphuric acid for 2 hours followed by thorough rinsing in cold tap water.

Seeds were sown in the same two locations and under the same conditions as the C. siamea seeds.

The criterion for successful germination was the emergence of the hypocotyl above the sand level. The germination tests ran for 60 days.

Statistical analysis

The statistical analysis of the data on A. xanthophloea and T. verrucosum germination was conducted by application of analysis of variance and the Scott-Knott test (Scott and Knott 1974, Zar 1984).

RESULTS AND DISCUSSION

Graphs indicating the mean cumulative germination percentage versus pretreatment over time were given in Figures 1 to 4. In Figures 1 and 2 the results of Scott-Knott mean separation tests on the final data are indicated, the mean percentage germination values with the same letter were not significantly different at 5% level.

The results with the legumes, A. xanthophloea, T. verrucosum and C. siamea confirmed that the seeds of these species require some form of pretreatment in order to get high germination percentages. Seeds of A. xanthophloea and T. verrucosum germinated best, 77% and 97% respectively, when their seedcoats were nicked at the micropylar end. Other studies on leguminous seeds have shown that the percentage germination following nicking may be taken as a close approximation to the germination capacity of a seedlot and is useful for comparison when assessing effectiveness of other pretreatments (Clemens et al 1977, Tran and Cavanagh 1979, Doran et al 1983). Although nicking was not conducted in the C. siamea trial, other studies on this species (Kobmoo and Hellum 1984) show that germination is enhanced.

Seeds immersed in boiling water then allowed to soak for various periods of time has been effective with many hard-coated seeds, but the results have sometimes been erratic (e.g. Cavanagh 1980, Doran et al 1983, Tran and Cavanagh 1984). In these experiments, the three boiled water pretreatments were effective in enhancing germination of seeds of A. xanthophloea (between 53% and 62%) but the same treatments were ineffective when applied to T. verrucosum. The two boiled water pretreatments of the C. siamea seedlot enhanced germination, especially in the glasshouse (61% and 75% - see Figure 3). Kobmoo and Hellum (1984) also demonstrated this in their study of the effects of hot-water pretreatments on C. siamea.

Recent studies on Acacia species in Australia have shown that immersing seeds for 1 or 2 minutes in boiling water gave reliable and effective enhancement of germination for most of the species tested (Doran and Gunn 1986). It would be interesting to apply this harsher heat pretreatment in future germination studies of legume species in Kenya.

Sulphuric acid is frequently used to enhance germination of leguminous seeds (Rolston 1978, Doran et al. 1983, Kobmoo and Hellum 1984, Bebawi and Mohamed 1985) and the results of these tests confirm the usefulness of this technique. Pretreatment for 32 minutes in concentrated sulphuric acid led to a high response and, for shorter periods, a lesser but positive response in seeds of A. xanthophloea (Figure 1) and T. verrucosum (Figure 2). The pretreatment of C. siamea seeds with concentrated sulphuric acid for 5-15 minutes enhanced germination, especially in the nursery (Figure 3).

The M. eminii seedlot did not respond well to any of the pretreatments. The best germination percentage achieved was a low 39% (Figure 4). The control performed as well as the best of the pretreatments indicating that presowing treatment is not a prerequisite for germination of this species. The time lag between sowing and commencement of germination (34 days in the glasshouse and 41 days in the nursery) was substantially longer than the normal 14 to 28 days reported for this species (Teel 1984). It is speculated that the poor germination performance of this seedlot may be a result of overmaturity at time of collection. Mahdi and Coto (1985) state that the M. eminii fruit maturity stage is related to germination percentage, highest germination is achieved from fruits before they turn purple.

CONCLUSIONS

From the results of this series of experiments, it is recommend that small quantitities of seeds of *A. xanthophloea* and *T. verrucosum* required to be germinated for research purposes should be manually nicked at the micropylar end. Concentrated sulphuric acid pretreatment is also recommended for research purposes on the seeds of *A. xanthophloea*, *T. verrucosum* and *C. siamea*.

Further studies should be conducted on appropriate pretreatment schedules for large quantities of seed of the leguminous species including scarification, heat and more detailed evaluation of concentrated sulphuric acid. Trials on the collection and processing of *M. eminii* fruits and seeds should be conducted to determine the factors leading to low germination percentage.

ACKNOWLEDGEMENTS

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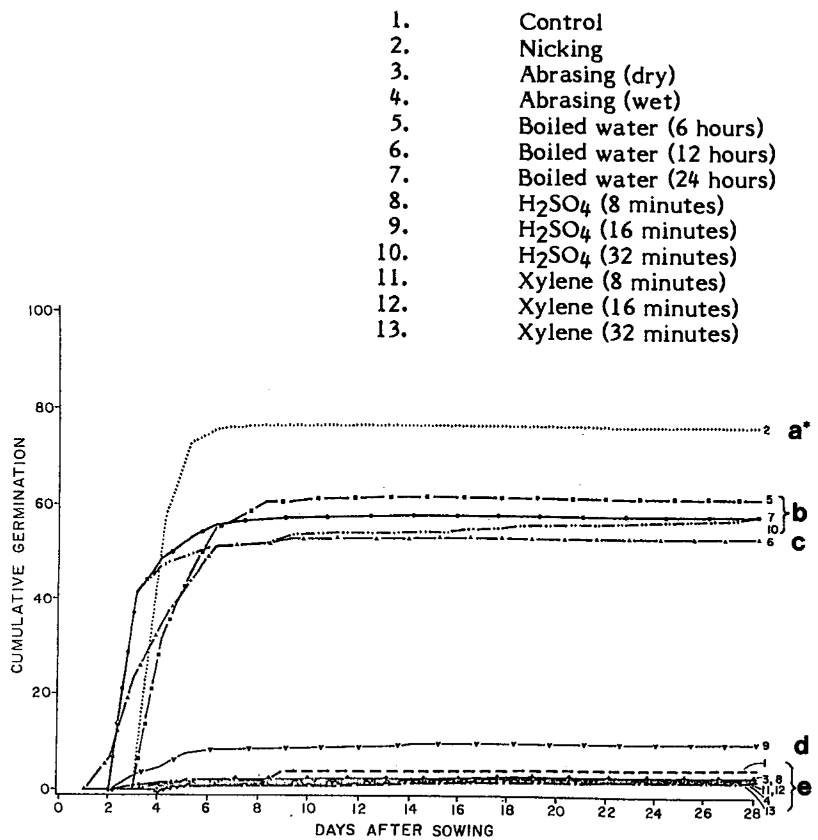


Figure 1 Mean cumulative germination percentages by pretreatment and time for <u>Acacia xanthophloea</u>

* Mean percentage germination values followed by the same letter as not significantly different at P = 0.05 according to Scott-Knott mean-separation test (Scott and Knott, 1974).

1. Control
2. Nicking
3. Abrasing (dry)
4. Abrasing (wet)
5. Boiled water (6 hours)
6. Boiled water (12 hours)
7. Boiled water (24 hours)
8. H_2SO_4 (8 minutes)
9. H_2SO_4 (16 minutes)
10. H_2SO_4 (32 minutes)
11. Xylene (8 minutes)
12. Xylene (16 minutes)
13. Xylene (32 minutes)

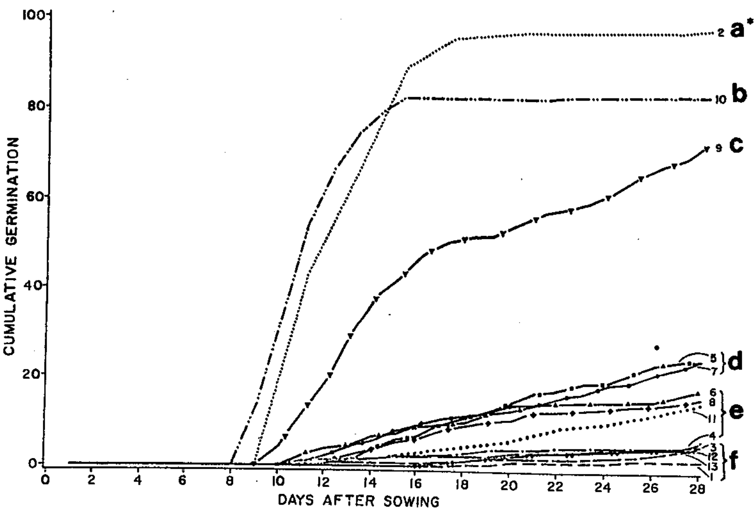
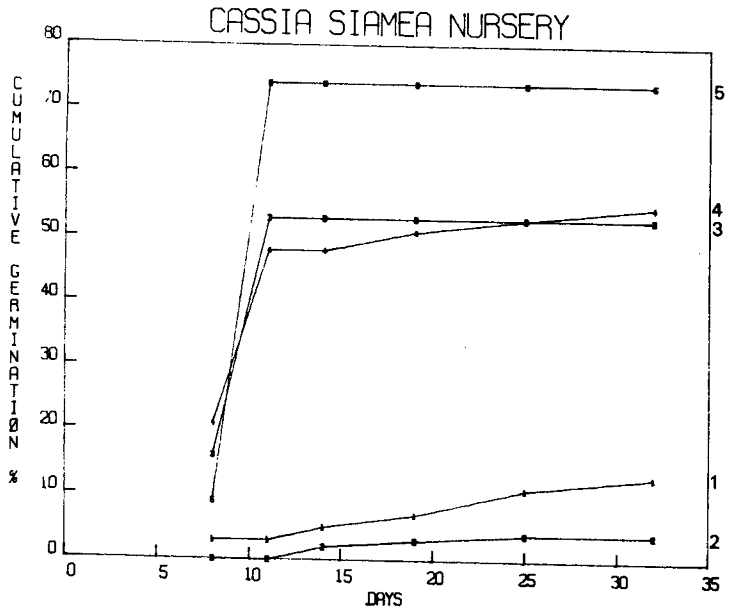
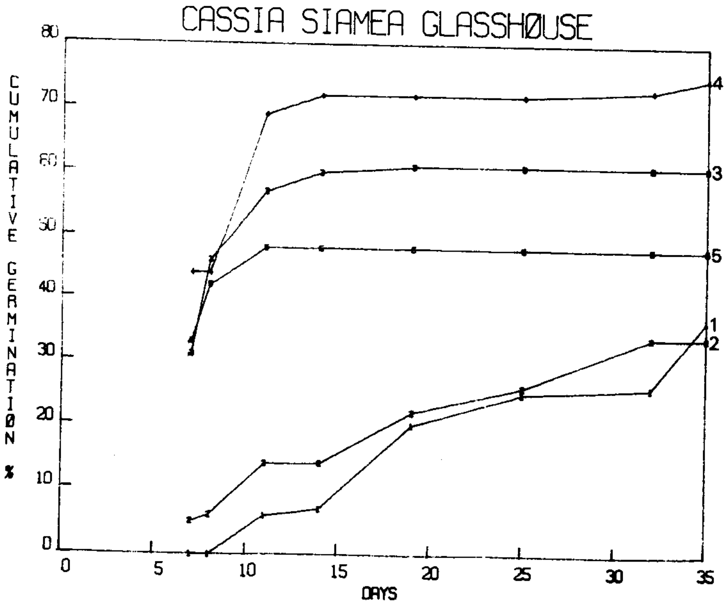


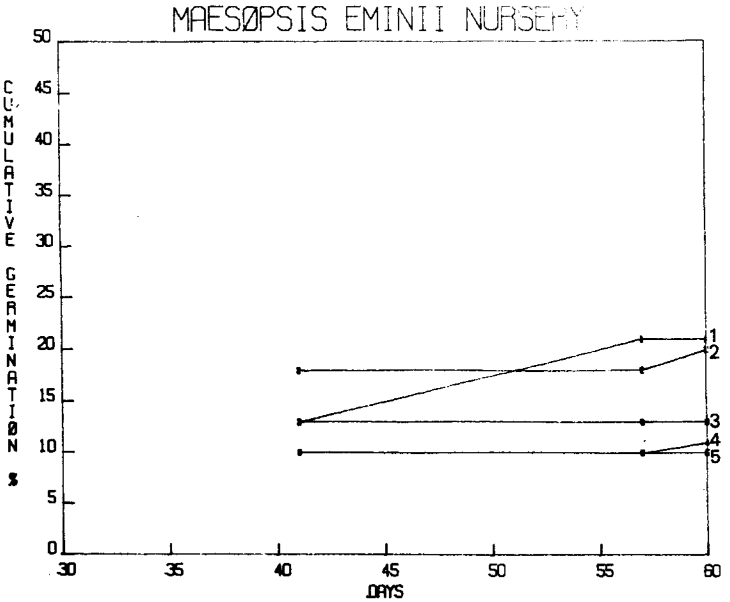
Figure 2 Mean cumulative germination percentages by pretreatment and time for Trachylobium verrucosum.

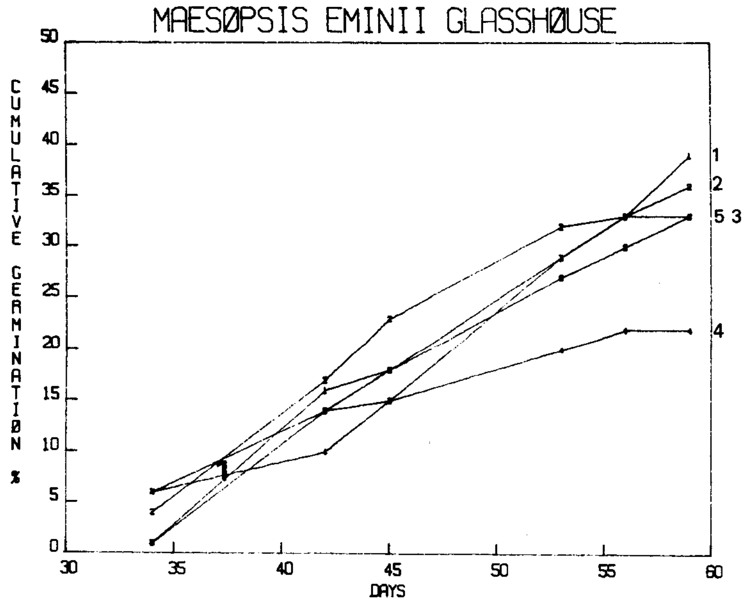




1. Control
2. Cold/tepid water (48 hours)
3. Boiled water and let to cool
4. Boiled water and let to cool overnight
5. H_2SO_4 (5-15 minutes)

Figure 3 Mean cumulative germination percentages by pretreatment and time for Cassia siamea seed sown in the nursery and glasshouse.





1. Control
2. Cold/tepid water (12 hours)
3. Cold/tepid water (18 hours)
4. Alternate wet/dry
5. H_2SO_4 (2 hours)

Figure 4 Mean cumulative germination percentages by pretreatment and time for Maesopsis eminii seed sown in the nursery and glasshouse.

COLLECTION, GERMINATION AND STORAGE OF SHOREA ROBUSTA GAERTN F. SEEDS

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SUMMARY

The present paper deals with the storage of freshly collected seed of Shorea robusta Gaertn f. at a wide range of temperature under closed and partial vacuum conditions. Results indicate that critical moisture content for storage is the initial moisture content of seeds at the time of collection. Ventillated closed conditions and partial vacuum storage are suitable to keep the seeds viable for 50 days.

Key words: Recalcitrant storage physiology, critical moisture content, Shorea Robusta.

INTRODUCTION

Shorea robusta Gaertn f. ('Sal') is one of the most important timber tree species distributed in Asian humid tropics. It is a typical dipterocarp species and is subjected to gregarious fruiting at an interval of 4 years (Ng, 1981). Seeds of Shorea robusta are inseparable from fruits and short lived under natural conditions. Therefore, storage and transport problems to distant places have hindered establishment of plantations and species trials.

Roberts (1973) separated seeds into two broad categories; "orthodox" seeds, which can be dried to about 5 % moisture content without damage and can be stored at low temperatures, and "recalcitrant" seed, which can not be safely dried below a relatively high moisture content and must consequently be stored moist. Earlier studies on storage methods of S. robusta seeds are those of Purohit et. al., (1982) and Tompsett (1985). Results of these studies indicate that the species has "recalcitrant" seed storage physiology. Tompsett (1985) recommended 40 % seed moisture content and 21°C temperature conditions for successful storage of seeds in closed containers subjected to periodic ventillation. The time of collection of seeds was not mentioned in this study.

The present paper deals with the storage of freshly collected seeds of S. robusta during peak fruiting period, without desiccation at a wide range of temperatures in closed containers and in partial vacuum conditions.

MATERIALS AND METHODS

In this paper Shorea fruits are referred to as "seeds" throughout.

Seed collection

Normally in Madhya Pradesh, India, fruiting in S. robusta begins from first week of May and continues until the first week of July. The peak time of fruiting is during the first 15 days of June. Fresh seeds were collected from selected trees from Motinala forest range, M.P., India, during the peak time of fruiting. The forest floor under selected trees was cleaned, mature seeds were shaken from the branches and collected on 16.6. 1985. These seeds were brought to laboratory in polyethylene bags and stored within 48 hours. Sample of 400 seeds was examined for insect infestation and emptyness. No diseased and empty seeds were found.

Assessment of viability and moisture content

Viability was assessed both by 1 % tetrazolium chloride test and germination at 25 ± 2°C in a seed germination incubator by placing seeds on moistened filter papers. Two replicates of 100 seeds were taken for this purpose. Radicle emergance was considered as an index of seed germination. In some storage experiments, however, pregermination of some seeds occurred. Number of pregerminated seeds was added to post germinated seeds, yielding a combined viability estimate.

Moisture content of seeds was determined after drying 100 x 2 seeds in an oven at 103 ± 2°C for 17 hours. Moisture content was expressed as percentage on a wet-weight basis.

Storage methods

Seeds were placed in two storage conditions i.e., in closed containers and partial vacuum. Glass bottles of 1000 cm^3 size with glass stopper were taken as closed containers. Vacuum desiccators of 254 mm internal diameter and 375 mm height were taken to create vacuum. After filling with seeds vacuum was created by rotary vacuum pump 'GEVIVAK' compressor 1/4 hp. 220/240 volt 28 "Hg and the desiccators were dry sealed.

Both closed containers and vacuum desiccators were placed at room temperature, 15, 10, 0 and -10°C temperatures. Observations were taken at an interval of 7 days till the seeds died.

Factorial analysis for interactions of different storage conditions, time of storage and storage period on seed viability was followed after Mather (1966).

RESULTS AND DISCUSSION

Results of the present study are based on the fresh seed, collected directly from the selected tree species during the peak fruiting period. Fresh seeds showed 28.2 % moisture content with 100 % germination. Loss of germination and viability in different storage conditions and temperatures, varied considerably after 15 days of storage (Table 1). Except in closed and partial vacuum conditions at 15°C, seeds kept at all other temperatures did not show any germination, however, positive test for viability was still observed with tetrazolium chloride. Observations indicate that tetrazolium colouration test appears to be unreliable in this species and overestimates viability. Loss of viability in seeds kept at low temperatures can be attributed to the susceptibility to damage by intracellular ice formation due to its "recalcitrant" storage physiology (King and Roberts, 1979). Similarly, storage of seeds at higher temperatures resulted in rapid loss of viability. Hence, after 15 days, observations were confined to storage at 15°C. However, seeds kept at room temperature and at 10°C remained viable upto two weeks but lost germination considerably (Table 1).

Seeds stored at 15°C showed a gradual decline in germination till 50 days after which viability was completely lost. Comparison of storage conditions showed that seeds kept at partial vacuum showed higher percentage germination than those kept in closed glass bottles.

Results of analysis of variance and interactions of storage time (D), temperature (T) and storage conditions (C) is given in Table 2. The main effects (D, T and C) mean squares were significant. Similarly interactions D x T and T x C were also significant. However, interaction D x C was not found significant. The differences between the germination of seeds kept in closed containers and in partial vacuum conditions were also found significant.

Tompsett 81985) recommended periodic ventillation for storage of S. robusta seeds kept in closed containers. In the present study, it seems that glass bottles with stoppers provided ventillation to the seeds and they were not completely impervious for the exchange of air. Further, storage of these seeds was done in vacuum conditions for the first time and was found better than the closed, periodic ventillated storage conditions.

Earlier, critical high value of moisture content for storage of S. robusta seeds given by Tompsett (1985) was 40 %. In the present study it comes to about 30 %, the differences can be attributed to the habitat from where the seeds were collected. It is possible that seeds in the present case may be derived from less moister environment than those used by Tompsett (1985). For "recalcitrant" seeds like S. robusta it can be said that critical high value of moisture content for storage could be the moisture content present in seeds at the time of collection. Similarly the range of storage temperature seems to be 15 - 21°C. Besides, recommendations for possible storage of these seeds, it is also suggested from the results of the present study that seeds from different environments should be considered for experimentation for the generalization of data.

CONCLUSIONS

The present study concludes that temperature has a considerable effect on storage of S. robusta seeds besides the type of containers and storage environment. Critical high value of moisture for storage should be the initial moisture content of seeds at the time of collection. This value varies due to the environment from where the seeds have been derived. Proper attention should be given for ventillation of seeds if stored in closed impervious containers. Partial vacuum conditions seem to be better for storage.

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Table 1. Average percentage germination of Shorea robusta seeds after different storage periods at 5 temperatures in two storage conditions.

Temperature/ Storage periods/(days)		14	21	28	35	42	49
Room Temp.	C	23	0	0	0	0	0
	V	27.3	0	0	0	0	0
15°C	C	65	60	57.67	50.67	45.33	42.00
	V	81	67.33	65.00	60.33	57.00	54.33
10°C	C	40	0	0	0	0	0
	V	20.1	0	0	0	0	0
0°C	C	0	0	0	0	0	0
	V	0	0	0	0	0	0
-10°C	C	0	0	0	0	0	0
	V	0	0	0	0	0	0

C - Closed containers

V - Partial vacuum conditions

Table 2. Analysis of variance for seed germination in Shorea robusta.

	Item	Sum of squares	Degree of freedom	Mean square	Variance ratio	Probability
Main effects	Storage days (D)	1808.4	5	361.63	78.96	0.001
	Temperature (T)	30908.95	4	7727.24	1687.17	0.001
	Storage condition (C)	39.56	1	39.56	8.64	0.01
First order interaction	D x T	1570.61	20	78.93	17.23	0.001
	D x C	9.36	5	1.87	-	-
	T x C	339.7	4	84.93	18.54	0.001
Second order interaction	D x T x C (Error)	91.59	20	4.58		
	Total	34775.91	59			

BREAKING SEED DORMANCY OF PINUS BUNGEANA ZUCC. WITH MICROORGANISMS

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ABSTRACT

Seeds of pinus bungeana are very dormant due to the impermeability of their seed coat. we have found that treatment with microorganisms can effectively soften the seed coats and thus promote germination. Therefore we can select various miroorganisms to treat the seeds of pinus bungeana.

Key words; Seed coat, microorganism, pine, germination power (GP) , germination percent (P) .

INTRODUCTION

Pinus bungeana Zucc. is valuable as a landscope species and as a forestation species for most cities of north China. It is indigenous to China.

The seeds of pinus bungeana are very dormant. According to research for dormant reason, we have observed that one of the main reasons for dormancy of P. bungeana seeds is the tough, impermeable, seed coat. For increasing the permeability of seed coat, the authors have treated the seeds with a microorganism—Trichoderma-4030. The result is very significant. The paper about this test will be published in "New Forestry" No 3,1987. On the basis of this test, we treated seeds of P. bungeana with spore solution of Aspergillus niger V. Tiegh. Its result is very good too. Then we treated seeds by different funguses, made a preliminary study to the enzyme produced by the funguses and its decomposing power to seed coat respectively.

MATERIALS AND METHODS

Materials

(1) Seeds, *pinus bungeana* seeds were collected from Beijing in 1986. The thousand-seed weight was 137.42g. Seed viability was estimated to be 83,0 percent by staining with 0·5 percent tetrazolium chloride.

(2) *Aspergillus niger V. Tiegh* and produced enzymes by it , This fungus was cultured and supplied by Mr. Yao pei-xin in The Microorganism Institute of Shaanxi province, China. It is a culture type of high productive pectin enzyme.

Methods

1. Treating seeds with spore solution of *Aspergillus niger*

Aspergillus niger was cultured on POA culture medium. When the colour of hypha on POA turned to black and even black particle was presented on the culture medium, we rinsed spore out of culture medium with disinfeted water, and made spore solution. The concentration of spore solution is 28×10^{4} spore/ml.

Treatments were divided into five groups, each group was set up with four replications, each containing 50 seeds as follows,

Group A_1 , First seeds were soaked in tap water at 29℃ for 5 days. The soaking water changed daily. Then the seeds were sparayed and mixed evenly with spore solution for 5 days at 29℃ too. On the third day, the seeds were rinsed with water once and again mixed evenly with spore solution.

Group A_2 , This proup was treated as same as group A_1. The only difference between group A_1 and group A_2 the seeds of group A_2 were soaked in tap water for 2 days.

Group A_3 : The seeds were soaked beforehand in tap water at 29℃ for 2 days. The soaking water was changed daily. Then the seeds were soaked in spore solution at 29℃ for 5 days.

Group A_4 : This group was treated as same group A_1, but before treatment they were not soaked.

During germinative time,we had sprayed suitable spore solution on the seed bads two times.

Group A_4 ,This group was treated as group A_3. But the seed bads of group A_4 were absorbent cotton soaked with enough spore solution of Aspergillus niger.

The seeds were randomly sampled, and were full rised by tap water before sowing. The seeds were illuminated 8 hours a day, and the germination temperature was kept at 25±1℃. During course of germination, the seed beds were kept moist.

Control Treatments,

(1) Pinus bungeana seeds soaked in tap water for 2 days at 29℃ were regarded as the control 1.

(2) Pinus bungeana seeds soaked in tap water for 5 days at 29℃ were regarded as the control 2.

Each control was seted up eight replications, and each containing 50 seeds. The soaking tap water was changed daily.

Germination (G) was expressed as the percent of filled seeds germinating in the 40 days period,

$$G(\%) = \frac{n}{N} \times 100$$

where n=number of germination seeds

N=total number of seeds

Germination energy (GP) was expressed as the precent germination at the peak of germination (20 days) .

2. Methods for determination of seed coat degrading ability with spore solution of Trichderma-4030, Aspergillus niger and with cellulase and pentinase enzyme preparation.

(1) Seed coat 2g of Pinus bungeana were soaked in different concentration spore solution of Trichoderma-4030, Aspergillus niger.

(2) Seed coat 2g of Pinus bungeana were soaked in different enzym-activity unit (U) solution of cellulase and pectinase enzyme.

The above treated seed coats were soaked for 5 days, afterwards, the enzyme activity was killed by boilling water for 5 minutes. we had determined soluble sugar of soaking solution by Ultraviolet spectrophotometer and had determined organic acids by 0.1N NaOH titration.

RESULTS AND DISCUSSION

1. Testing results of breaking seed dormancy of Pinus bungeana with spore solution of Aspergillus niger.

Table 1 Germination of P. bungeana seeds treated by Aspergillus niger. Each value is the mean of 4 or 8 replication.

	Treatment Methods						
	A_1	A_2	A_3	A_4	A_5	control 1.	control 2.
GP (%)	21.5**	32**	6.5	1	1	9.8	7.5
G (%)	43.5**	67**	30.5**	15	2	16.8	14.5

1/ ** = significant difference at p=0.01 from control 1

It will be seen that the effect of treatment by Aspergillus niger is signifcant. Its spore solution can softer the seedcoats and thus improve their germination.

2. Results of seed coat degradation with spore solution of Trichoderma-4030, Aspergillus niger, and celluase and pentinase enzyme preparation.

Tracing the changes in the concentration of intermediate products ---soluble sugar and organic acids in hydrolizing the pectin and cellulose of the seed coat, The result shows the degradation of the seed coats by those fungi and their enzymes.

Table 2 Changes in concentration of sollutble sugar (mg/100ml) in soaked solution of different concentration.

	Concentration of spore solution					
Fungus	n	$\frac{1}{2}n$	$\frac{1}{3}n$	$\frac{1}{4}n$	$\frac{1}{5}n$	0 (control)
Aspergillus niger	19.05	15.75	15.22	12.75	11.73	0.00
Trichoderma -4030	68.36	30.31	16.99	12.82	7.25	0.00

In spore solution of Aspergillus niger $n=28\times10^6$ spore/ml and in spore solution of Trichoderma-4030 $n=400\times10^6$ spore/ml.

Table 3 ml of 0.1N NaOH used per 100ml different U soaked solution

Fungus	Concentration of spore solution					
	n	$\frac{1}{2}n$	$\frac{1}{3}n$	$\frac{1}{4}n$	$\frac{1}{5}n$	0 (control)
Aspergillus niger	1.50	0.83	0.53	0.53	0.26	0.071
Trichoderma -4030	25.00	10.00	6.20	5.70	4.00	0.071

Table 4 Changes in concentration of soluble sugar (mg/100ml) in different enzyme U soaked solution

Enzyme	Enzyme activity unit (U)					
	5	10	15	20	25	0
pectin	0.02	0.07	0.15	0.20	0.26	0.06
Collulose	0.24	0.26	0.255	/	/	0.06

From those results, it will be seen that the content of soluble sugar in soaked solution ml of 0.1N NaOH used in titration increased as concentration of spore solution and U of two enzymes preparation increase. It show that the spore solution of Trichoderma-4030, Aspergillus niger and their enzyme preparation had significantion decomposing action of pectin, cellulose and other materials of the seedcoats of Pinus bungeana. This decomposing action certainly improves permeability of the seeds and promotes germination of the seeds.

CONCLUSION

Tests show that microorganism for breaking seed dormancy of hard seedcoat is various. Therefore we can select one or more of them from the various microorganisms to treat seeds.

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THE ROLE OF THE FORESTRY ASSOCIATION OF BOTSWANA IN THE NATIONAL TREE SEED COLLECTION PROGRAMME

by

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ABSTRACT

A rapidly increasing population, drought and overgrazing are exerting increasing pressures on the natural woodlands in Botswana. The result is a shortage of wood for fuel, fencing and poles. The Government Forestry Unit is substantially understaffed and does not have the resources to address Botswana's immediate forestry needs. This paper outlines how the Forestry Association of Botswana (FAB), a non-government organisation, has tackled some of these problems by, among other things, establishing Botswana's first tree seed collection programme.

INTRODUCTION

Until early 1987 there was no systematic tree seed collection programme in Botswana. At that time the Forestry Association of Botswana (FAB), a Non-Government Organisation (NGO) was funded by NORAD to carry out such a programme. The object of this paper is to give a brief review of tree seed collection in Botswana and to show how FAB has initiated a programme which can link into any Government of Botswana (GoB), Southern African Development Cooperation Conference (SADCC) or other international programmes.

BACKGROUND

Botswana is a landlocked country on the Tropic of Capricorn and between 20 and 30 degrees east. The mean altitude is 1000 metres above sea level. Approximately eighty percent of the country is the Kalahari Desert with semi-arid tree and scrub savanna. Mean annual rainfull, which varies between 200 and 650 millimetres, is sporadic and occurs between September and April.

The population is just over one million, concentrated in the east of the country and is forecast to double by the year 2000.

Livestock plays an important economic and cultural role in this country. The national cattle herd is estimated at 2.9 million cattle with nearly one million goats and sheep.

The main types of woodland are Zambezi teak, or mukusi, (Baikiaea plurijuga) with Kiaat, or mukwa, (Pterocarpus angolensis) in the north and north east with a small area of miombo on the Zimbabwe border. South and west of the teak forest is mophane woodland with Acacia/Combretum/Terminalia savanna in the remainder of the country.

These indigenous woodlands in Botswana are declining around population centres as a result of lack of management and overcutting for fuel, poles and fencing materials. Rapid deterioration of fuelwood supplies is expected to occur within 10-50 km of towns and major villages. The needs of urban dwellers for fuelwood supplies are a key factor in creating shortages, especially in the south east of the country (ELR 1985). The development of the firewood trade has contributed to this decline. Poorer people, who cannot afford to buy firewood, are now forced to walk great distances to gather wood for cooking. In the past, people collected only dead wood, but cutting living trees is now becoming more frequent and as a result, many of the preferred fuelwood species are disappearing from the more densely populated areas. For the large majority of people in rural Botswana there is no economic alternative to fuelwood.

In the Chobe District in the north east of Botswana, timber is being extracted commercially from the Zambezi teak forest mainly for export to Zimbabwe and the Republic of South Africa. Little is known about the conditions necessary for the regeneration of these forests which are subject to frequent fires as well as exploitation (Millar, 1987).

The GoB does not yet have a clear policy to address the exploitation and degeneration of natural woodland. It is substantially understaffed in terms of trained manpower to support any improvement in forestry necessary to meet the demand for wood or to prevent further rapid decline in wood resources. Much of the responsibility has therefore fallen on NGOs who have until recently conducted small, un-coordinated programmes.

At present there are approximately 200 hectares of Government plantations and 200 hectares of NGO woodlots in Botswana. Most of these consist of a small number of exotic species, mainly eucalypts. Plantations established over the last 30 to 40 years have in general not been successful. Provenance and species suitability have been largely ignored during species selection. Lack of management and recurrent drought have also contributed to their failure. It was the failure of many such plantations which prompted the FAB to examine the use of indigenous species in plantations.

WHAT IS FAB?

The Forestry Association of Botswana is a non-government, non-profit making organisation. It was started in 1983 by a group of individuals concerned about environmental degradation caused by overcutting of natural woodlands surrounding the populated areas. The aim of FAB is to further forestry interests in Botswana and this is being achieved by liason and cooperation with both government and NGO foresters. We also advise GoB ministries on forestry matters and promote forestry education at all levels. In addition, FAB has developed a nationwide forestry extension service and is conducting a forestry research programme of which the seed collection programme is a par

THE NEED FOR SEED

It has become clear that a major deficiency in GoB, NGO and FAB forestry programmes is in the supply of suitable seeds of both indigenous and exotic species. This problem is not unique to Botswana, but is well documented for many developing countries, (Burley 1985, Doran et.al. 1983; IDRC 1985).

In Botswana, seed is acquired for forestry purposes from a variety of sources, but mainly from Australia through the Regional Forest Seed Centre (RFSC) in Harare. Seed from this source, and seed purchased from the Republic of South Africa, are usually well documented but untried in Botswana.

Small amounts of indigenous seed have been collected locally, but not on a systematic basis. There are no registered seed trees or stands supplying selected or improved seeds.

It is acknowledged that a fundamental requirement of any successful forestry programme involving the planting of trees is access to the best quality planting stock available grown from the best quality seeds.

SOME SEED COLLECTION PROBLEMS

Most of the technical and biological problems pertaining to seed collection in the sub-tropics are applicable to Botswana. Such problems are well documented (Burley 1985; Doran 1983; IDRC 1985), and the difficulties of embarking on such a project on a limited budget are also obvious.

The main difficulty in establishing a seed collection programme in Botswana is the lack of institutional infrastructure. Although there is a Forestry Section of the Ministry of Agriculture, an organised seed collection programme is lacking. Much of the basic information required to start a collection programme, which would normally be acquired by consulting field foresters, is therefore not available.

There is also little available information about the flowering and fruiting times of indigenous species in Botswana. Reliable phenological information is essential for effective planning of seed collecting operations, and gathering such information is a high priority for our seed collection staff.

Little is known about the most effective way to collect, extract and handle the seed of many species indigenous to Botswana. We are at present trying different approaches as a means of overcoming some of these problems in the field.

THE FAB SEED COLLECTION PROJECT

FAB's approach to these problems has been a cautous one. We did not have the staff or resources to set up a full scale programme. In late 1986, however, FAB sought and obtained funds from NORAD, (the Royal Norwegian Embassy Development and Cooperation Programme) to establish a modest seed collecting, handling and storage facility in Botswana.

Our programme includes:

- o Documenting superior seed sources within Botswana.
- o Recording flowering and fruiting times of selected tree species.
- o Developing suitable techniques for seed collection, extraction and storage.
- o Establishing procedures for routine pest control prior to and during seed storage.
- o Accurately documenting seed provenances.
- o Training Botswana nationals in the activities listed above.

The aim of this programme is to provide high quality seed of known origin. The seed will be used initially by FAB Research Branch but, as stocks increase, seed will also be used in plantation establishment, natural woodland enrichment and village plantings. In the longer term we envisage exporting surpluses, either through the RFSC in Harare, or directly to countries on request.

Capital equipment paid for with the grant includes a four wheel drive vehicle, seed collection tools and equipment and an interim seed store complete with storage and testing equipment.

The NORAD grant includes salaries for a graduate Research Assistant and a part-time field assistant for a two year period. These people will be trained by staff from the FAB and RFSC. The FAB Training Officer (Senior author) has experience in tree seed collection in Australia, both in government and private enterprise, and will use this experience to help set up a programme in Botswana. Provision of training in seed collection for Botswana nationals is an important feature of our programme.

Initially we have concentrated on the immediate tree seed requirements of FAB's research and extension sections. To date we have collected seeds on an opportunistic basis from good sources as they come to our attention. We are planning to conduct regular observation and collection trips in different regions in the country so that phenological data can be collected in a systematic way. Government foresters will be encouraged to record and collect in their Districts and to join our mobile seed collection unit for short periods.

COOPERATION WITH OTHER ORGANISATIONS

There is also a shortage of information about the best way to treat seeds prior to sowing for maximum germination. The National Institute of Development Research and Documentation (NIR) in Botswana is doing some work on seed germination, but little has been published. We are cooperating with NIR by sharing results of our joint investigations into pre and post-germination treatments for optimum seedling production.

FAB cooperated directly with the GoB Forestry Unit in recent discussions with the CIDA-funded SADCC consultancy into the possibility of satellite seed centres in selected SADCC countries. As a result of this consultancy, the GoB Forestry Unit has proposed to SADCC the construction of a seed centre near the Botswana capital Gaborone. If constructed, the Centre will operate as a satellite of the RFSC in Harare. It is expected that FAB's seed collection programme will, in due course, be absorbed into a more comprehensive GoB programme.

CONCLUSIONS

The FAB has been funded to implement the first systematic tree seed collection programme in Botswana. Our role is mainly to provide training and guidance in the procedures of systematic seed collection and documentation. We are hoping to achieve our objectives with the assistance of institutions such as the RFSC in Harare.

We intend to provide a working seed handling infrastructure within two years. By that time we hope that the Forestry section of the Ministry of Agriculture will be able to assume responsibility for the collection of tree seed in Botswana.

ACKNOWLEDGEMENTS

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FAB is also endebted to NORAD for their ready support for the seed collection programme from their funds for enviornmental projects.

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TREE SEED PROBLEMS CONSTRAINING THE DEVELOPMENT OF DRYLAND AFFORESTATION SYSTEMS IN KENYA

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ABSTRACT

Increased attention to Planting of trees and shrubs and more emphasis than ever before to indigenous multi-purpose species has opened up a whole new range of species for trial. These new developments have also introduced new opportunities and problems in seed collection, handling and germination.

Forest renewal by outplanting of seedlings and the anticipated increase in demand for forest products indicate that seed will become a major, and perhaps a limiting factor in reforestation. The reason for this is that published accounts of tropical experience with tree seeds are scattered and incomplete. Research on tropical tree seed is inadequate in comparison with both the severity of the problems and the large number of species of potential value for plantation. Much has still to be learned and a first step to this is acquiring a clear understanding of the natural reproductive biology of potential tree species.

The biggest problem Kenya is encountering in reforestation of arid and semi-arid areas is poor establishment and survival. Most planting activities are concentrated on the type of tree species for which seeds are readily available. Gaps between listings of species for reforestation and availability of hard data on their performance under different climatic conditions are common. This paper reviews background information on the problem of tree seeds in arid and smei-arid Kenya; variability in supply, quality and germination. Each topic includes a description of the problem based on whatever limited local experience exists and also suggestions for solving the problems are given.

INTRODUCTION

Woody plants are grown and conserved for socio-economic and ecological reasons. These fall under the "productive" category (for production of wood, fuel, fodder, food, medicine, etc.), or the "protective" category, aiming at the protection or improvement of the environment (erosion control, maintenance of soil fertility, shade and shelter, etc.). In arid and semi-arid Kenya, trees and shrubs usually combine productive and protective functions, and have a range of uses: they are almost always multi-purpose.

Kenya has a total area of 580,000 km^2 and two thirds of this is arid to semi-arid (Pratt et al. 1966). These areas currently support 20-25% of the total population (Midgley 1983; Hauveldop et al 1982). Since the consumption of wood for various purposes is expected to increase considerably in the near future, this may induce serious ecological and economic consequences unless tree planting is kept instep with deforestation. As a result, Kenya's President Daniel arap Moi has directed that: soil erosion be eliminated by practicing conservation measures, increase land productivity by intensifying agriculture and better use of marginal lands, and 200 million tree seedlings be planted each year to stop deforestation (Buck 1983). To implement these directives, over 200 million tree seeds are required each year for reforestation across Kenya.

ENVIRONMENTAL LIMITATIONS.

Arid and semi-arid areas are characterized by an average annual rainfall of less than 800 mm and a dry season lasting six months or more. The areas are also subject to a number of constraints such as
(a) relatively scarce resources (soil nutrients, water),
(b) high exposure to adverse, climatic condition: dry winds, wide temperature differences between day and night, etc.,
(c) great fragility (susceptibility to erosion and precarious equilibrium of natural plant formations), and (d) considerable fluctuations in a major production factor: rainfall (Souvannavong and Cossalter 1986). In view of these vast extents of arid to semi-arid lands, their history is well stocked with records on drought, crop failures and widespread human suffering. The reason for this is that past development efforts, particularly within the agricultural sector, have largely focussed on more productive lands. Such policies must be re-examined and efforts to introduce appropriate land management and development systems in low-rainfall areas be made. Trees and shrubs have a major role to play in this development.

Experience from West Africa in trying to alleviate existing problems has shown that under arid and semi-arid conditions a crucial step consists of defining and implementing production systems, that by their nature, safeguard the long-term potential of the resources and the resource base. In respect to tree planting in dry-zones, experience clearly show that long-term requriements can best be met by land utilization systems which combine farm crops, perennials, multi-purpose woody species and animal husbandry. If species promoted can serve a number of different purposes simultaneously, then they will be more easily accepted by local people. Thus timber and wood should be considered to be only one of the many products, sometimes only by-products. Availability of quality seed have a big effect on translation of these goals to reality. It is within this context of rapidly and horizontally expanding interest in community level and on-farm multi-purpose tree planting that tree seed problems constraining dryland afforestation in Kenya is explored.

TREE SEED SUPPLY

Communities that have or intend to engage in nursery establishment require tree seeds. Most that have considered raising seedlings have come to recognize that seed of suitable species which promise to meet the specifications of project participant/beneficiaries is an essential input, but not easy to obtain (Buck 1983).

Since 1986 a specialized Tree Seed Centre within the Kenya Forestry Research Institute (KEFRI) was opened (with the support of GTZ) to help supply the highest possible quality reproductive material, taking into account all available knowledge of the species in use (selecting seed stands in the right provenances, establishment of seed orchards and high collection standards). Judging from papers presented in a workshop addressing ways of improving seed supply of forest and multi-purpose tree species in December 1986, it is clear that Kenya is able to satisfy seed supply for industrial plantation forestry. However, it is still ill-equipped to adequately satisfy demand for seed of multi-purpose tree species especially for those that have recently been included on lists for reforestation of arid lands. The reason for this is due to lack of sufficient information on reproductive Seasonal patterns of the species.

Nevertheless over the last six years, some information have accumulated that throws some light on various aspects of seed problems. As a result, systematic collection of indigenous seed has been encouraged for the majority of species. However, observations indicate that there is great variability in seed production from year to year and as well as in timing of seed ripening throughout the year.

The highly drought resistant species, such as Acacia reficiens Wawr and Peyr., A. nubica Benth. and Salvadora persica L., seem to economize their seed production with very few seeds during drought years. Large trees of A. tortilis (Forsk.), which occupy a variety of sites release their pods slowly during a period of several months, while some other species such as Cadaba rotundifolia Forsk. (Zumer-linder 1983) and Melia volkensii Gurke., (Milimo 1986) do not have a seasonal pattern in regard to seed maturity. The fruit bearing species, such as Zizyphus mauritania Lam., Diospyros sp., Balanites aegyptaca (L.) Del., and Dobera glabra (Forsk.) R. Br., have a rather well defined collection season, although their seed viability declines rapidly compared to the majority of Acacia species.

Lack of knowledge on various aspects of reproductive biology make forecasting and planning for seed harvest difficult. In depth embryological investigations, chemical compound quantification at various stages of development and histochemistry have remained neglected. If seed problems, especially for arid and semi-arid lands have to be solved, future forest research priorities must include specific studies as, methods of artificial flower induction, fertilization, embryogenesis and description of development and histochemistry of the ovule in families of interest. Studies along these lines would be useful in: (a) determining the basis of viability and dormancy in seeds (Pollock and Olnay 1958, Olney and Pollock 1960), (b) getting an indication of particular stages of ovule development, and (c) helping the genetist, economic botanist and forester in the identification and improvement of strains for industrial use (Grobe 1957, Isley 1961).

Q U A L I T Y

Information of species distribution, ecology of the native ancestral populations and variations between populations based on geographic, elevational, or provenance differences associated with major differences in the environments of native populations in Kenya is lacking. This does not permit a clear understanding of the diversity in potentials for the species we have chosen to work with. Also it is uncertain that the gene packages of the plant material that have been chosen are the best for the perceived end uses. To solve this problem the following are recommended: a survey of the original variability within species (this will involve two operations - selection of the desired trees or genes, and packaging of those genes in the plants to be used) and benefit capture to convert those gene packages into growing trees which will be harvested as a renewable resource (Libby 1973).

Since little is known about genetic variability, most planting activities have been concentrated on the type of trees for which seeds are readily available. Thus the choice of species is largely determined by the availability of seed (Herlocker et al. 1981) resulting into high mortality, particularly among the less drought resistant species, like *Delonix regia* and *Jacaranda mimosfolia*. It is common to observe an obvious gap between listing of species for reforestation and availability of hard data on performance of such species under different climatic conditions (Midgley 1983).

During seed collection of indigenous species, little attention has been paid to any of the recommended sampling or to sufficient representation of the geographical and individual variability ranges (Doran et al. 1983). Seeds have been simply collected where and when available to be used as quickly as possible. Whenever indigenous seeds were purchased from local collectors, very little information was usually included (Zumer-Linder 1982). Documentation on seed lots used is often not available, making future procurement of seed form those provenances well-adapted and to avoiding those with undersirable characteristics difficult, in this latter case a species was often considered non-suitable, as a whole; which might be a complete wrong conclusion.

As far as collecting seed of indigenous species is concerned, the sampling procedures are expected to improve with the assistance of better trained and more reliable local staff than have been available. On the other hand, it will continue to be difficult to obtain reliable information on the origin and correct identity of some of the introduced species, such as Prosopis, Eucalyptus, Cassia siamea Lam., Azadirachta indica (A. Juss), and Grevillea robusta A. Cunn. To make matters worse a few of the successful survivals from earlier plantings of these species have been used repeatedly as seed sources for raising seedlings (Zumer-Linder 1983). As a result the majority of outplanted trees of these species originated from a narrow genetic base with the potential danger of in-breeding and gradually reducing growth performance (Doran et al. 1983). These problems can only be avoided if nurseries concerned obtained seeds through reliable channels such as the Seed Centre at KEFRI.

Seed damage by insects is a major problem in a number of species. A good example of this is in the genus Acacia and Belanites which are usually damaged by Bruchid lavae. Inspite application of insecticides, it is difficult to protect seeds from further damage either in the open or in airtight containers. The lavae are already in the seed when collected and therefore storage condition manipulation have little effect. To solve this problem, it is necessary that a clear understanding of the ecology and reproductive biology of both the insects and the plants be acquired.

SEED GERMINATION

Little or no information is yet available on the performance of dryland indigenous species which today are receiving increased attention as providers of goods and services for rural communities. Therefore, the importance of testing their germination capacity simultaneously with the preparation of instructions for seed pretreatment and routines of recording is emphasised. Apart from few laboratory tests at KEFRI's Seed Centre, elsewhere germination is recorded at the nurseries, simply as a ratio of germinated seeds to number/amount of seeds sown for the production of seedlings. In most nurseries, pretreatment currently consists of soaking and boiling seeds, and in others the pretreatment is rarely applied. Lack of necessary tools and inadequate information is the main reason given for the practice (Zumer-Linder 1983). Species with hard seed coats have been observed to germinate more quickly and completely following scarification (Barrow 1981, Herlocker et al. 1981). When the seeds are pretreated by soaking and boiling, germination often extends over several weeks in some species such as Acacia nubica and A. segegal (L.) Willd. This treatment causes the smallest seeds to germinate first. French studies in West Africa have shown that boiling water treatment is frequently ineffective for African Acacias. Boiling of Australian Acacias on the other hand is suspected to destroy some 20% of the seed (Zumer-Linder 1983), or the treatment is simply not effective. High elevation at Muguga of of about 2000 m above sea level is suspected to influence germination by lowering the boiling point of water (Milimo and Kaumi, unpublished).

Seed germination of tree species indigenous to Kenya's drylands vary greatly. A few of them have failed to germinate, these include Cadaba rotundifolia (a valuable sand dune stabilizer), Bosia coriacea Pax, B. angustifolia A. Rich., Some other species, such as Sterculia astenocarpa H. Winkler, Grewia bicolor Juss., and Dobera glabra have given low germination percentages. It is not clear yet whether this is caused by poor seed quality or some other limitations (e.g., dormancy of seeds). Rather specific germination problems are associated with seeds of Hyphaena coriacea Gaertn. (Doum palm) and Populus ilicifolia (Engl.) Rouleau and Melia volkensii Gurke.

Doum palm is confirmed to shores of Lake Turkana, on the coast and at Taveta. It is also riparian along the Tarkwell river (Dale and Greenway 1961). In Turkana, thickets have been extensively cut for building material, thatching, basketry, rafts and for fuel. Their nuts are also burned for smocking fish. At some places especially along the lake shores at Kalokol, regeneration has been greatly reduced with the disappearance of mature fruit producing trees and burning of fruits for fish smocking. With the current drying up of Lake Turkana, the population on the shores are also disappearing. Dry doum palm seeds take about a year to reach 5% germination when sown approximately 10 cm deep in the sand (Zumer-Linder 1983). Preliminary results of studies into ways of how to improve germinative rate indicate that pealed (cutting off outer slivers that are edible) or crushed nuts germinate more easily; that planting deeper into the sand generally increase the survival rate of seedlings. However, it still remains to be determined whether the seed pretreatment and planting depth has any effect on the rate of germination and survival of seedlings (Zumer-Linder 1983).

CONCLUSIONS

Tree seed research must be extended to cover the following areas:

1. Flowering biology and seed development, methods of pre-germination treatment, methods of improving seed collection, extraction and storage, and control of seed disease. This information will aid improvement of seed collection feasibility (seed stand selection, establishment of seed stands, etc.), and planning. It will also improve seed collection and utilization of seed sources by activation of more flexibility of organizations and personnel involved in seed collection.

2. While planning for seed collection, efforts should be made to ensure that sufficient representation of geographical and individual variability ranges have been taken into account.

3. Seed collectors and nursery headmen should be trained especially in regard to seed documentation.

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STUDIES OF THE STRUCTURE AND DEVELOPMENT OF SEEDS OF MELIA VOLKENSII[1]

BY

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ABSTRACT

In order to determine factors which cause and maintain seed dormancy and conditions that lead to its release, a study to describe flower and fruit external morphology and structure of the ovule was undertaken.

Seeds of *Melia volkensii* mature in 11 to 13 months, but phase of fruit development lack a seasonal pattern.

Lignification and cutinization of interguments, their growth to form a caruncle start early in ontogeny. However, major structural changes that characterize mature seeds occur late in ontogeny.

Key words: Germination, interguments, perisperm and endosperm.

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INTRODUCTION

The genus *Melia* belongs to the family Meliaceae. The genus has eight species, most of them indigenous to Asia and Australia. Among them, *M. azedarach* L. has been most widely introduced to other parts of the tropics (Moore 1981). In Africa, apart from *M. azedarach* which is exotic (Dale and Greenway 1961), *M. volkensii* Gurke., and *M. bambolo* Melw. are the only known members of the genus recognized as truly indigenous. The former is native to East Africa (Dale and Greenway 1961) and the latter to Angola (Mabberley 1984).

M. volkensii is highly prized in Kenya's semi-arid areas. It coppices readily, is fast-growing, produces durable, strong and termite-resistant timber which is also easy to work. The large fruits, twigs and leaves provide fodder for goats, cattle and sheep. The species is among five most important forage plants for giraffe in Tsavo East National Park, Kenya (Leuthold and Leuthold 1972).

From fruits of *Azedarachta indica* (A. Juss) and *M. azedarach*, three commercially important chemical compounds have been isolated. These are: azidirachtin (Butterworth and Morgan 1971), salanin (Herderson et al. 1964) and meliantriol (Levie et al. 1967). Fruits of *M. volkensii* contain an insect anti-feedant (Mwangi 1982) which may be of economical value.

Efforts to germinate seeds of *M. volkensii* in the past have been unsuccessful. At the beginning of this study, little was known about how to germinate them and as a result, various germination studies were carried out to try and determine the type of seed dormancy involved. Results indicated that integuments, perisperm or endorsperm inhibited germination by: (a) limiting the amount of water to the embryo; and (b) mechanically restricting the radicle from protruding.

MATERIALS AND METHODS

Existing bud, flower and fruit phases of development were identified and classified using Todorov's (1977) guidelines. Three sites in Machakos district were chosen for study between May to August, 1984. These were: Kinyambo, Kalulini and Kibwezi Forestry Research Station. Six trees, two per site, were selected and twenty plastic labels used to tag phases of fruit development. Classification was based on visual inspection, but sometimes a hand lens (x10) was used. Also, fruits were cut radially to determine pericarp and stony endocarp hardness. Visual observations included the texture and structure of fruits and seeds; the degree of cork deposition and colour of the fruit surface; length and width of the fruits using hand calipers and the distance from the fruit stock attachment on the branch to the branch tip. Phases of development recorded were vegetative buds, reproductive buds, extended and unopened flowers, and senescent flowers. Bud and flower observations were made every other day and fruits were monitored once each month.

Seed Structure:

Ovaries of unopened flowers, seven month old fruits, and mature fruits were collected in late January 1985 at Kibwezi, Kenya. These were immediately fixed in formalin-Aceto-Alcohol (FAA) (Johansen 1940) for seven days and the FAA drained. Fruits were wrapped in paper towels soaked in FAA and were then sealed in polythene bags and mailed by air to the University of Alberta, Canada where they were stored at 3°C. The three methods used in tissue preparation were: (1) the paraffin method for flowers, immature seeds, embryos, and the endosperm of mature seeds (Johansen 1940, Jensen 1962, Sass 1940, and O'Brien and McCully 1981); (2) a freezing microtome method (Model C Reichert Wien No. 2832) for whole sections of mature Seed (Farris 1982), and; (3) LKB2218-500 Historesin procedure.

In the paraffin wax method, seeds were separated into embryo, endosperm and integuments. The integuments were boiled for 10 minutes in tap water before fixing in FAA. These were dehydrated and infiltrated with Paraffin (Paraplast Plus, MP 56-57°C) each step taking 24 hours. Four changes were made for the embryos and endosperm during infiltration, but ten changes for the integuments because of poor infiltration due to high lignin content. Embedding, block making and trimming followed Johansen's (1940) procedures. Sections were cut at 7-14 μm thick.

Slides were deparaffinzed in xylene and stained in Periodic Acid Schiff's (PAS)/Light Green (LG); Safranin O/Johansen's Fast Green (FG), and mounted in Clearmount for light microscopy (O'Brien and McCully 1981); (Jensen 1962).

In the freezing microtome method, seeds were fixed in FAA and softened in "Aerosol O.T." (Fisher Scientific). These were then oriented on a freezing device attached to a sliding microtome and flooded with "Tissue-TEK II Compound" (Farris 1982). To prevent sections from sticking onto the blade, paraffin oil and "Lab Freeze" (Nutritional Biochemical Corporation) were applied frequently. Sections were cut at 21-27 μm thick.

Tissue preparation for the LKB Historesin method involved boiling intact seeds in tap water for 10 minutes, cutting them into very small pieces and fixing them in 3% glutaraldehyde in sodium-cacodylate buffer (at pH 7 overnight in 15 psi vacuum). These were then washed in tap water for about 30 minutes, and dehydrated in 30, 50, 60, 70 and 95% ethanol for about 30 minutes at 4°C each. Dehydration was followed with a change to a 1.1 95% ethanol and Historesin plus a catalyst at room temperature, 100% Historesin plus a catalyst at 15 psi in a vacuum overnight and 100% Historesin plus a catalyst for 4 hours in a vacuum.

Tissues were then imbedded (in a mixture of a Historesin, a catalyst and a hardener) in Beem Capsules size 00. These were then left to polymerize (15 ml of Historesin, catalyst and 1 ml hardener) overnight at room temperature, protected from dust. Blocks were cut at 2 μm on an ultramicrotome equipped with a glass knife. Sections were stained in Aniline Blue Black (ABB) and PAS/Johansen's Fast Green (O'Brien and McCully 1981, Johansen 1940 and Jensen 1962).

RESULTS

Flower and Fruit Phenology:

Reproductive buds develop only in terminal branch positions in *M. volkensii*. They are generally larger than vegetative buds. There is considerable variation among trees in development of both buds and flowers. The stalks of the flower buds become extended before flowers finally develop or before they open. Within six weeks of first being identified as flower buds, flowers begin to wither and petals start to fall off.

After petals fall, tiny fruits (3 to 5 mm in diameter) remain behind. This stage of fruit development was called the "candle stage" (Figure 1.6). In about seven months from the time of flower appearance, the fruits grow to reach 15 to 20 mm in diameter. This stage of fruit development was called "fruit soft" (Figure 1.7). The fruits are light green in colour with a semi-hard endocarp, and a colourless jelly-like substance inside the integuments (Figure 1.7a). Fruits continued to increase in size reaching about 30 mm in diameter at 10 months after fertilization (Figure 1.8). This stage of development was called "fruit hard". It is characterized by exocarp and fruit stalk changing in colour to greyish-green due to the deposit of cork. The mesocarp is firm, the endocarp fully developed and hard, and the outer integument is dark-brown in colour.

Fruits normally ripen 12 to 13 months from the time of flowering. This final stage of fruit development was called "ripe" (Figure 1.9). Ripe fruits are similar in size to those of the "fruit hard" stage. They are distinguished from hard fruits by the soft mesocarp (pulp) and the yellowish-green colour of the exocarp. Fruits at this stage may be completely covered with cork. Endocarps are very hard and brittle, the outer integument is black in colour and brittle (Figure 1.9a), and abscission rings on fruit stalks are fully developed, allowing the fruit to fall off when lightly disturbed.

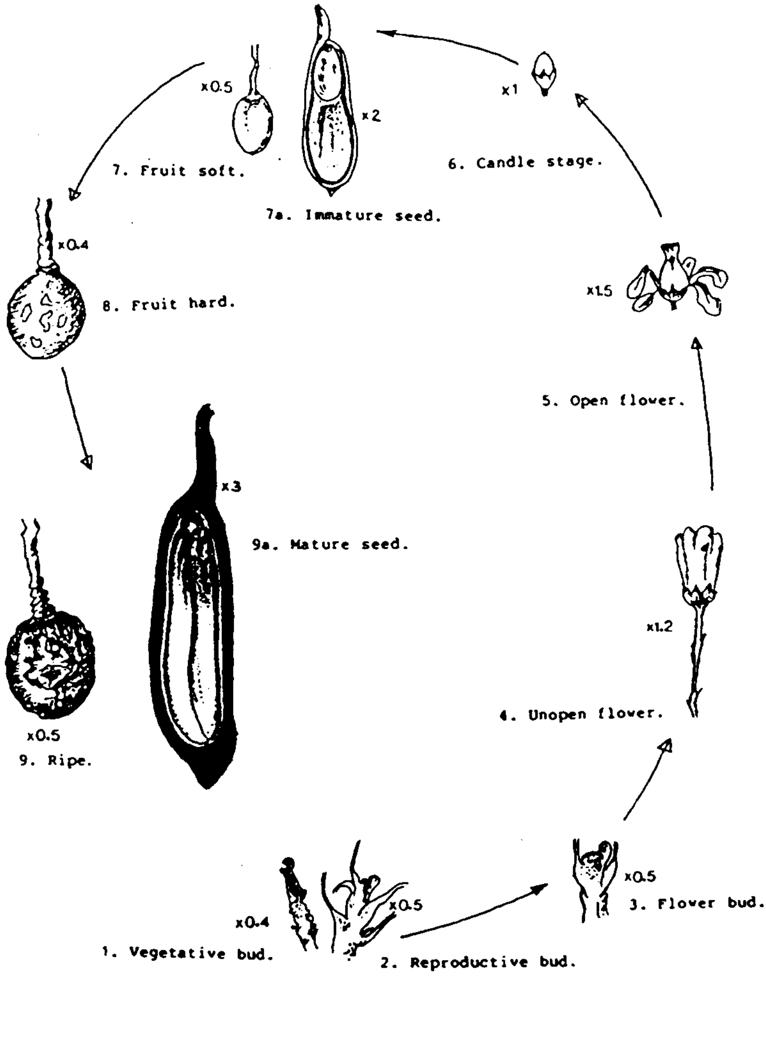

Figure 1. The reproductive cycle of *M. volkensii*. (drawing by P.B. Milimo.)

Occurrence of any one particular stage of development varied from branch to branch even within trees. Some trees did not produce fruits, while others had one (Figure 3) or all the stages. This type of plant development is considered to be without a seasonal pattern (Todorov 1977). In cases where more than two stages of fruit development occur, they emerge from a location corresponding to a specific part of the growing season, the youngest emerging closest to the branch tip and the oldest farthese from the tip.

Seed Structure:

The ovule of M. volkensii grows from the placenta as a round protuberance. At origin, the ovule has a symmetrical growth, the funiculus and micropyle have a straight orientation, the ovule is said to be "orthotropous". But during development, the body of the ovule bends (Figure 6) and becomes completely inverted (Figure 8), bringing the micropyle close to the funiculus. This condition is described as "anatropous" (Maheshwari 1950). In the course of maturation various tissues change in thickness, and the tip of the integuments develop to form a caruncle. Late in ontogeny the embryo and endosperm start to accumulate storage material. Although the micropylar end is a small part of the total surface of the seed, it is one area which commonly causes germination inhibition and therefore the degree of its specialization justifies special consideration in this investigation.

Embryo:

The mature embryo of M. volkensii seed consists of two fleshly cotyledons and an axis bearing the plumule and a radicle (Figure 4).

At "fruit soft" stage, cell walls are thin and have no nutrient reserves (Figure 11). At maturity, a root cap is well developed (Figure 13). The cytoplasm and vascular bundles are filled with storage material: proteins, lipids and probably starch (Figure 17). Cell walls stain a light brick-red in PAS and a light blue in ABB as does the storage material.

Integuments:

The integuments begin to differentiate before fertilization. The inner integument starts to develop first followed by the outer integument (Figure 6). The outer integument of the pre-fertilization stage is four to six cells thick and the inner integument four cells. Both, however, are much thicker at the micropylar end (Figure 8). The ground tissue at this stage is parenchymatic. The epidermal layer of the outer integument and cells of the inner integument at the chalazal end are vacuolate. The inner cells of the outer

Plate 1.

Figure 2. A M. volkensii tree with a goat foraging on the fallen fruits. 0.0007

Figure 3. Immature and mature fruits located on the same branch. x0.4

Figure 4. LS of a stony endocarp showing seeds and the micropylar orifice. x4.1

Figure 5. TS of a stony endocarp showing locules and vascular bundles in the centre. x4.1

Key to Abbreviations: En, endosperm; CR, caruncle[4]; Em, embryo; Im, immature fruit; Ma, mature fruit; TS Transverse section, and; LS, longitudinal section.

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4 The growth of integuments into a protuberance at the microphyla end of the seed; Esau (1977); Maheshwari (1950).


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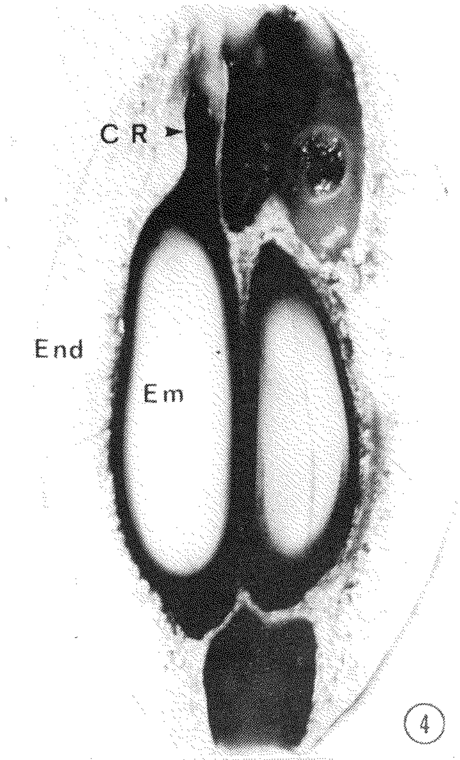
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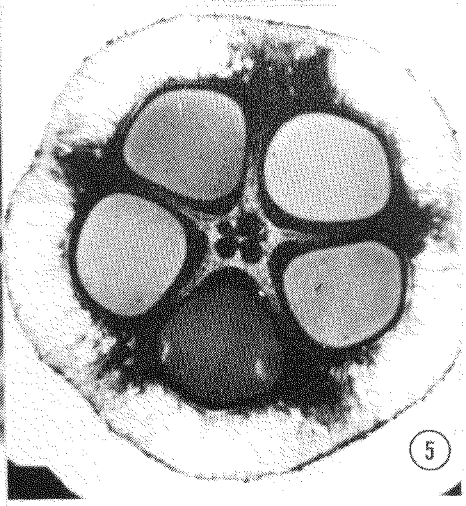
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Plate 2

Figure 6. TS showing an early stage of ovule differentiation. x500.

Figure 7. TS of ovule at the same stage of development as in Figure 20, stained in PAS/FG. x600.

Figure 8. LS of unfertilized ovary stained in PAS/FG. x70.

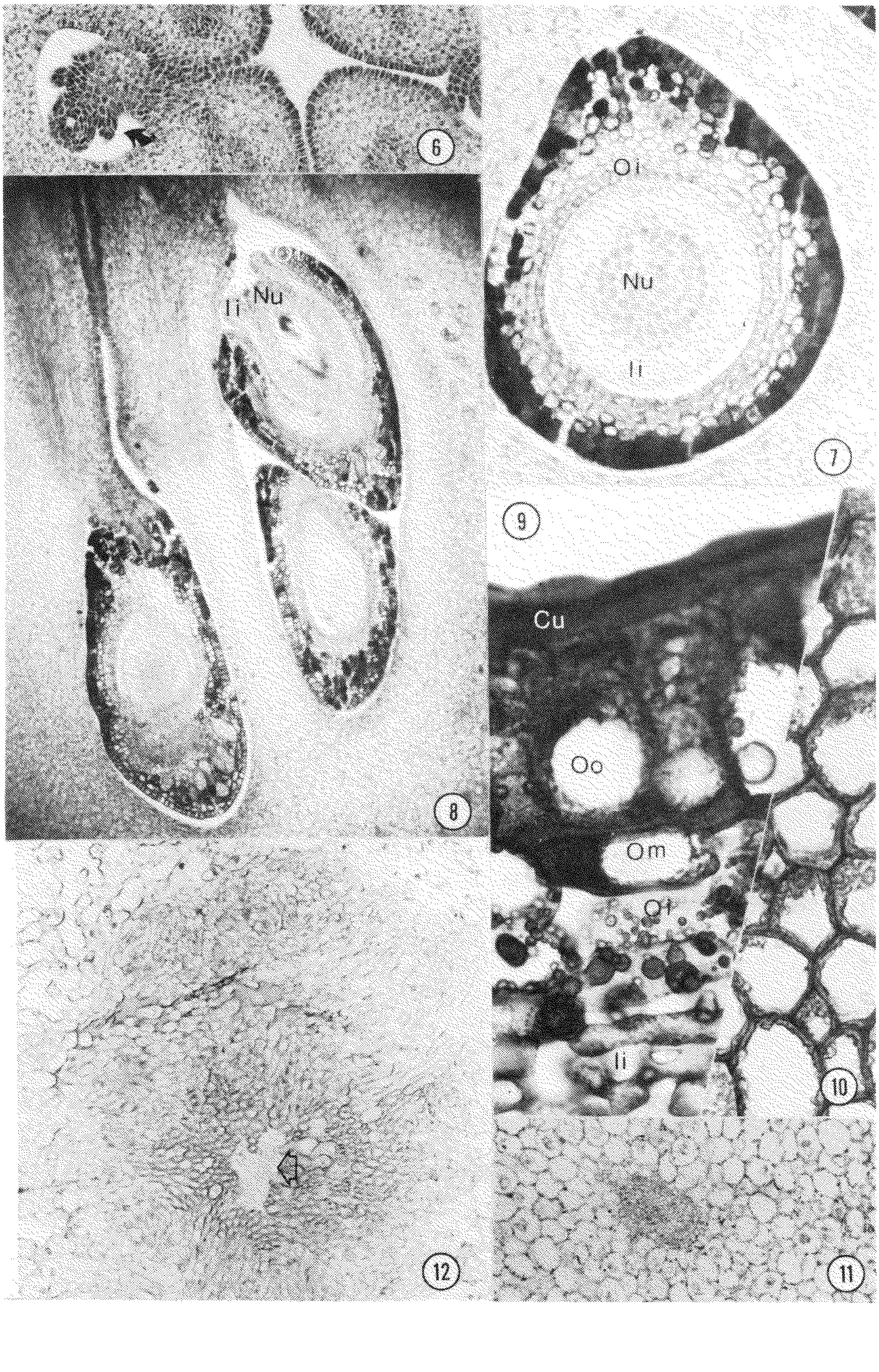
Figure 9. TS taken from the.chalazal end, showing the outer and inner integument layers of immature seeds stained in PAS/FG. x650.

Figure 10. LS of the outer integument at the same stage of development as in Figure 9, stained in PAS/FG. x450.

Figure 11. TS of immature cotyledon tissue, stained in PAS/FG. x500.

Figure 12. TS through the vascular bundle situated in the caruncle of an immature seed showing an open canal. x500.

Key to Abbreviations: Nu, nucellus; Ii, inner integument; Oi, inner cell-layer of outer integument; Cu, cuticle; Oo, outer cell-layer of outer integument, and; Om, middle cell layer of outer integument.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Oi
Nu
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10
12
11

Plate 3.

Figure 13. LS of a semi-thick section at the micropylar end, unstained, mature and heavily lignified seed, cut by the freezing microtome. x 26.

Figure 14. LS showing the endosperm, nucellus and a layer of granular deposits at the micropylar end at seven months after fertilization, stained in PAS/FG. x 108.

Figure 15. TS of the integuments from mature seeds prepared by the Historesin procedure, sectioned at 2 μm and stained in ABB. x 150.

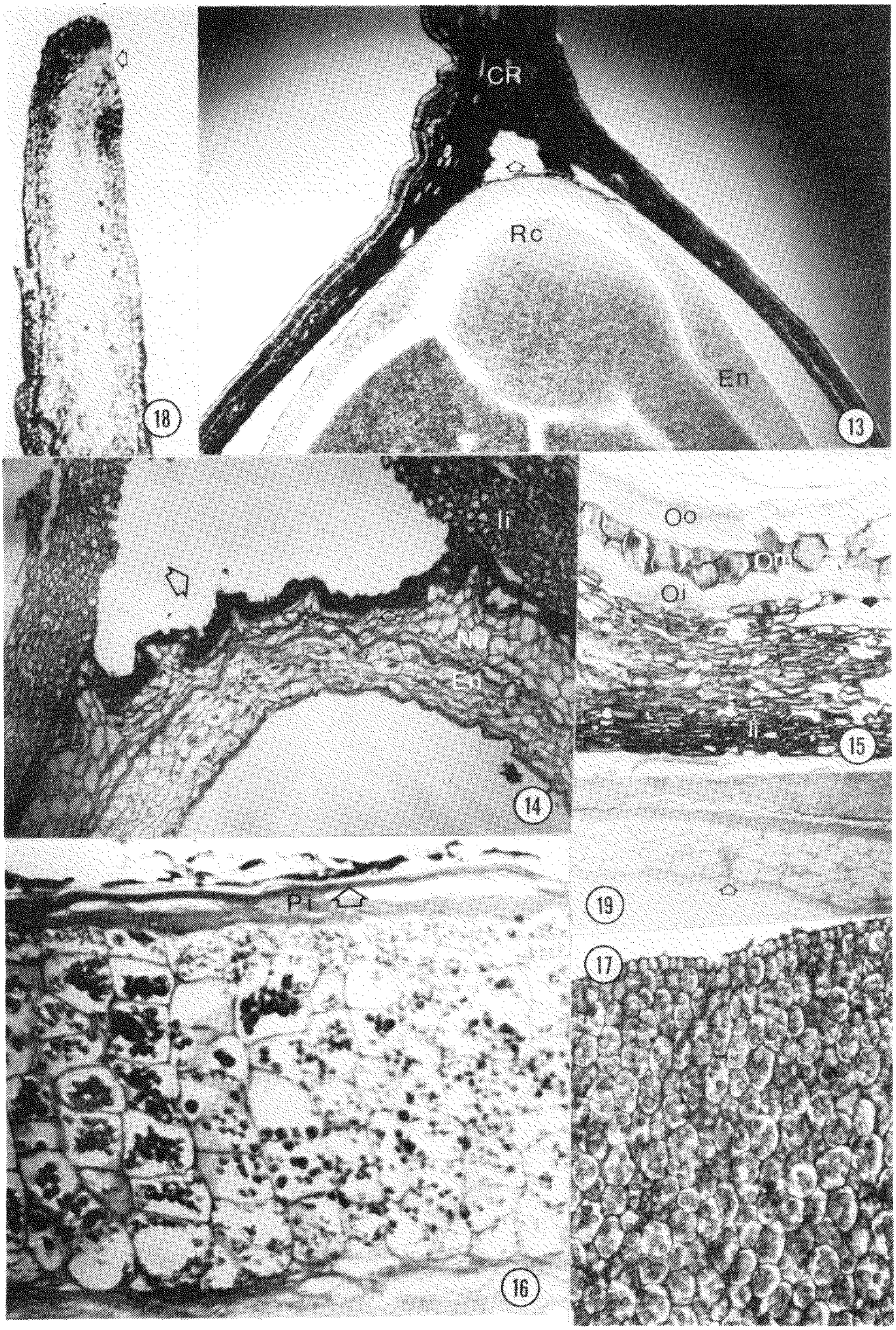
Figure 16. TS by Nomarski-interference optics; showing perisperm and the endosperm, stained in PAS/FG. x 210.

Figure 17. TS showing stored material and thin cell walls in the cotyledon of a mature seed, stained in PAS/FG. x 500.

Figure 18. LS through the caruncle of an immature seed; showing the micropyle. x 75.

Figure 19. TS showing the endosperm, the nucellus and a portion of the mucilage layer of a mature seed stained in PAS. x 800.

Key to Abbreviations: CR, caruncle; Rc. root cap; En. endosperm; li, inner integument; Nu, nucellus; Oo, outer cell-layer of the outer integument; Om, middle cell-layer of the outer integument; Oi, inner cell-layer of outer integument, and; Pi, compressed perisperm layer.


CR
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integument and the micropylar end of the inner integument are cytoplasmic. Cell walls of the outer integument at the chalazal end stain brownish-red in PAS/FG, while most of those at the micropylar end show an intense green after treatment with PAS and Fast Green. The former is a reaction identifying starch and sometimes lignin (O'Brien and McCully 1981). All cells of the inner integument and those of the nucellus stain a light green with PAS and Fast Green.

There is no evidence of a cuticle layer on the outer integument during the pre-fertilization phase.

Epidermal cells of the outer integument are anticlinally elongated, but those of inner cell layers and of the inner integuments are periclinally elongated. This cell orientation does not change much during ovule development, except for two inner cell layers of the outer integument which later become isodiametric (Figure 15).

Seven months after fertilization, integument cells increase in size, develop large vacuoles and a cuticle (Figure 9). Cell walls of the outer integument are thick and have deposits of crystalline material (Figure 10), while the inner integument is composed of thick spongy parenchyma tissue (Figure 9). The formation of the caruncle is such that the inner integument tips fuse at some distance from the nucellar tip, thus creating a space between integuments and nucellus (Figure 13 and 14).

Figure 13 and 14 represent integument tissue of a mature seed. The two inner cell layers of the outer integument have changed orientation from periclinal to isodiametric, and outer integument cells are more closely packed. The middle cell layer of the outer integument and cells of the inner integument stain light brick-red in PAS and light blue in ABB, reactions identifying lignin, or starch and proteins respectively.

The inner integument tissue also has numerous large oval-shaped secretory cells which do not react with either PAS or ABB. These cells look like enlarged parenchyma cells (Figure 15).

Nucellus:

The nucellus is the inner part of an ovule in which the embryo sac develops. The nucellus in *M. volkensii* is well developed and is many cells thick, a state referred to as "crassinucellate"; this state is also considered to be primitive (Singh 1964). The pre-fertilization stage of ovule development is characterized by variable nucellar cell thickness, about seven to nine cells thick at the micropylar end (Figure 8). It is fused with integuments at the chalazal end. The prefertilization structure, the histochemistry and cell orientation of the nucellus is similar to that of the inner integument.

Post-fertilization changes of the nucellus involve a reduction in cell thickness, reduction in cell wall size, loss of cytoplasm and development of a one-cell-thick cuticular layer. Above the cuticle, but below the inner integument, is a one-cell-thick layer of irregular, sometimes branched, thick walled-cells deposited with a crystalline material (Figure 14) that stained deep-red in Safranin O. On the lower side of the nucellus and bordering the endosperm, is a thick layer of cells probably marking the beginning of compression to be completed before or by maturity.

In Sections of a mature seed, the nucellus cuticle and the irregular thick-walled cell layer above it still persist (Figure 15 and 16).

Endosperm:

The first stage of endosperm described here is represented by ovules at the "fruit soft" stage (Figure 1.7 and 1.7a). The endosperm cell-walls have distinct nuclei and cytoplasm (Figure 8), but deposits of nutrient reserves, characteristic of cells in mature seed, are not evident. Cell-walls of mature endosperm are thick (Figure 19) and cells contain proteins, starch and lipids. Although a histochemical test to localize lipids was not done, chemical analysis results have shown that the endosperm is rich in crude fat. Between the endosperm and the embryo tissues, a band of mucilage equivalent to several cells thick (Figure 19) stained positive for starch and proteins. Endosperm thickness is variable at maturity. It is only four cells thick at the micropylar end (Figure 13) and below the raphe (Figure 19), but up to nine cells thick elsewhere in the seed (Figure 16). The sequence of events leading to the reduction in thickness of the endosperm layer are not clear.

DISCUSSION

Seed and fruit development in M. volkensii in Kenya is without a seasonal pattern. They take up to 13 months to mature (Figure 1). Many reproductive stages of development can be found on a single branch of the same tree at most times of the year. This makes it difficult to ensure that only mature fruits are collected in bulk for germination purposes. But different exocarp colour and mesocarp structure may serve as indicators of stages of maturity. Accordingly, when exocarp colour changes from green to yellowish-green this is a fairly reliable indicator of maturity (based on seed germinability). However, fruit colour at maturity also depends on the amount of cork on the fruit. When the deposition is heavy, fruit colour varies from greyish-yellow to grey. As a result, the ability to distinguish between mature and immature fruits is dependent on the knowledge of the reproductive cycle, and the morphological characteristics pertinent to each of these phases. The ovule structure appears to be closely correlated to the external development of the fruit.

Some of the striking features of the ovule development are growth of the integument to form a caruncle, the persistence and crushing of the nucellus, the reduction in the thickness of the cell layers of the endosperm at the micropylar end and below the raphe, and the deposition of nutrient reserves in the endosperm and embryo tissue.

The development of a caruncle, its lignification and cutinization are initiated and completed early in ontogeny of the ovule. That the micropyle is crushed during the caruncle formation is inferred from the fact that a continuous micropyle is not evident in mature seeds. At the time when the caruncle development is complete, the micropyle is formed by the spongy parenchyma cells of the inner integument. The inner integument tissue is arranged such that it fills the central core of the caruncle from base to tip and the outer integument covers it (Figure 18). A canal running the full length of the seed is evident within the raphe (Figure 12). This may serve as a direct avenue for the entry of gases and water.

During the development of the embryo sac and embryo, the nucellus is partly re-absorbed and crushed. In a mature seed it persists as a thick layer of compressed perisperm having a distinct cuticle.

Accumulation of nutrient reserves in the endosperm and embryo, and the development of a mucilaginous layer between the endosperm and the embryo start after the "fruit soft" stage. If the assumption that these changes are the major factors underlying the dormancy mechanism in the species, then there may be a period in the course of ovule development when seeds may be collected and made to germinate without a pre-germination requirement.

CONCLUSION

Seeds take 11 to 13 months to reach maturity. Stages of fruit development lack a seasonal pattern, as a result it is difficult to differentiate mature from immature fruits. However, this study has shown that change in fruit colour from yellowish-green and sometimes grey or greyish-yellow is a reliable indicator of maturity.

During transformation into seed, the ovule undergoes changes in form, structure and histochemistry. All these changes occur in ontogeny of the ovule. They include: endosperm cell wall thickening, compression and persistence of the nucellar tissue with its distinctive cuticle in mature seed and the accumulation of insoluble, non-polar and non-swelling storage material in the embryo and endosperm.

Against this background, it is therefore inferred that: (a) much of the water that needs to be imbibed by the seed for it to germinate is prevented entry by the perisperm, endosperm, or both; (b) the embryo does not acquire sufficient imbibition pressure to overcome the mechanical restrictions of integuments, perisperm and endosperm; and, (c) a chemical weakening of the perisperm and/or endosperm in addition to the imbibition force of the embryo is needed.

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A DATABASE SYSTEM FOR THE MANAGEMENT OF SEED STOCKS and Related Information.

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What is a Database System?.

1. A Database is a set of logically related Files, organised so that ACCESS to the Data is improved and REDUNDANCY is minimised.

2. A System must exist to manage the Database.

3. Implicitly: the Database is NEEDED by a number of users, probably on an intermittent basis.

4. Central control is essential in Defining and Developing the Database and the System.

5. The Database must be made easily usable, and must be secure from misuse and corruption.

The NEED for a COMPUTERISED DATABASE at the Forest Research Centre, Zimbabwe?.

1. A Register of Seed acquisitions and stocks was begun in 1936.

2. Similarly, over the years other Records have been kept of Trials, Introduction Plots, and the many other activities of the Research Program.
   All have been maintained in a multitude of Files, and on Index cards, etc.

3. This hand-organised and managed Database was well designed, and even now is excellent in many respects.

4. However, in addition to the problems created by the ever-increasing size of the Database with the consequent heavy labour demand for its upkeep, added difficulties have arisen due to such factors as staff shortage and change. Newer staff members find difficulty in seeking necessary information, and the problem of cross-referencing is virtually insurmountable.

The Current Size of the Database.

1. In the Seed Register the most recent Stock Number is approaching 17000.

2. Certain Seedlots are available for sale and distribution to customers within and outside Zimbabwe.
In the last year some 340 sales accounted for 1700 items to a value of Z$55000.

3. Approaching 2000 superior individual trees have been identified, and some 4000 progeny have been established in 80 Clonal Orchards.

4. About 60 Breeding Seedling Orchards have been planted, together with more than 260 experiments in the Breeding Program, totalling in all about 9000 Stocks.

5. There are at least another 5600 Introduction Plots and trial plantings.

How was a Solution to this Database Problem approached?.

1. On-line access to a Main-frame Computer became available in 1983. The Biometrics Unit programmed a standardised system of Experiment Data management.

2. The Database Management System available on the Computer was not considered suitable for the wider needs of the Research Division. It was only in 1986, with the acquisition of IBM-PC-XT equipment, that progress could be planned.

3. A major virtue of the micro-computer is the great variety of software available at affordable prices, most of it reasonably easy to use. Moreover, looking ahead:
Micros permit decentralisation and portability.

4. It was agreed that the first priority should be a Management System for those Seed Stocks, available for Sale.

The STOCK NUMBER is the Primary KEY to IDENTIFY the Seed-lot.
What other information is necessary &/or desirable?.
^^

* Name (Acronym e.g. PPAT)
* Date received
Mass received

ORIGIN
^^^^^^

Supplier (incl.reference)
Country of collection
* Collection Area (Provenance)
Detail of Collection Area
Date collected

Other Detail of Location

* Detail of Parentage
Stand Type
Population (B.S.O)
O.P or Cross (with Parentage specified)

* File Reference
* Other Comment

QUALITY
^^^^^^^

* Seed Type (ORD, SEL, SOR)
* Viable Seed Count /unit mass
* Effective Germination Factor (E.G.F)

RECOMMENDED for:
^^^^^^^^^^^^^^^^

* Altitude Range
* Resistance to Pests/Diseases

* Available for Sale
* Present in Trials

* Mass currently in Store

OUTLINE of the SYSTEM of FILES proposed for the DATABASE.

Detail of LOCATION Latitude Longitude Map Grid Ref Altitude Rainfall, etc.	Dictionary of ACRONYMS	EXPERIMENT Description and Content
QUALITY: Seeds/unit mass Germination % Purity %	**SEED STOCK REGISTER**	PLUS-TREE Register
SALES and SUMMARIES	STANDARDS and PRICES	CLONAL & BREEDING SEEDLING ORCHARDS

Present Developement and the Future.

1. Although the Seed Sale modules of the System have been used very successfully for some months, the developement of the System, as a whole, is proceeding satisfactorily, but slowly. Capture of a massive quantity of Data, with the necessary checking, is no small undertaking.

2. Such progress, which has been made, has demonstrated the need to maintain a FLEXIBLE approach in, what is a DYNAMIC situation.

3. To be really valuable, the System should endeavour to provide as much of the information, as possible, to assist DECISION MAKING in the widest range of problems.

4. The major deficiency, at present, in the System, as described, is absence of Production Data, derived from the various Experiments and Trial Plantings. The developement of a Standardised procedure for this purpose is a primary objective.

MOBILIZATION OF FARMERS AND SCHOOL CHILDREN FOR TREE SEED COLLECTION

A Strategy Towards Tree Seed Sufficiency

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* The Kenya Woodfuel Development Programme is implemented by the Beijer Institute in cooperation with ETC Foundation, under the auspices of the Kenya Ministry of Energy and Regional Development and with financial assistance from the Government of the Netherlands and the Swedish International Development Authority.

ABSTRACT

Seed supply is a constraint for tree planting programmes, and traditional methods of collection and distribution do not seem to respond adequately to the demand recently created by tree planting awareness.

The Kenya Woodfuel Development Programme (KWDP) has developed a strategy for seed sufficiency by working closely with farmers to solve their problems. Farmers need to raise cash for food, shelter, clothing and school fees, and if tree seed was given a value, farmers should collect and sell it. KWDP has tested this hypothesis and the results have been startling.

Primary schools also constitute another source of seed supply. Head teachers and agriculture masters are receptive to new ideas and activities especially if they are relevant to the curriculum. Tree planting, nursery establishment and seed collection are seen to contribute directly to raising of educational standards and for environmental conservation.

1 INTRODUCTION

Insufficient quantities of seed of required species has always been a serious bottleneck in tree planting programmes, whether governmental, non-governmental (NGO) or even individual's. One apparent reason is the few seed suppliers compared to users. African governments have recently placed emphasis on environmental conservation and fuelwood production. Tree planting is one of the means to meet these challenges, especially for soil erosion control, sand dune fixation, wind breaks, soil fertility restoration by nitrogen-fixing species and provision of wood for fuel. Governments have also encouraged NGOs and individual citizens to plant trees for these and other reasons.

As a result of the enormous response to this tree planting call, the gap between seed demand and seed supply has widened even further. However, if one observes what is happening in the rural areas in the way of tree planting, there are two interesting things to note. Farmers have planted many trees on their farms using different species from what one finds in central government nurseries. Farmers have traditional ways of regenerating trees which may be through wildlings, cuttings or direct sowing. Secondly, all these trees growing on the farm, and along roads produce seed every year but the majority of that seed is never collected. The seed is unused while programmes are paralyzed due to seed shortages. What could be the missing link?

The Kenya Woodfuel Development Programme (KWDP) believes it is necessary to work closely with farmers. KWDP is also convinced that farmers understand the need to plant trees for various uses but there are other more pressing problems which give this particular activity a low priority. Cash for food, clothing for the family and school fees is needed. If seed could provide some of this cash, farmers will be willing to collect it for sale.

2 KENYA'S SEED DEMAND AND SUPPLY PROBLEMS

2.1 Kenya's Seed Demand

There are three Ministries involved in tree planting and which, therefore, require a lot of seed. The Ministry of Environment and Natural Resources' Forest Department has the normal plantation programmes and a Rural Afforestation and Extension Scheme (RAES). The Ministry of Energy and Regional Development (MOERD) coordinates all agroforestry activities in the country and has six regional centers. The Ministry of Agriculture's Soil Conservation Division establishes fruit and tree nurseries to supply seedlings in all areas of operation. Besides these three Ministries, there are over 75 tree planting organizations in Kenya (Kaudia, 1986) and millions of individual farmers using tree seed.

The quantity of seed required is difficult to determine. However, the Kenya Forestry Research Institute's (KEFRI) Seed Center estimated in 1982 that for the Government's 200 million annual seedling production, some 17,835 Kg. of seed of 30 odd species would be required each year.

2.2 Kenya's Seed Supply

There are two main suppliers: KEFRI handles all Forest Department requirements while Kenya Renewable Energy Development Programme (KREDP) supplies the Ministry of Energy. In 1986, KEFRI received 3,945 Kg. of seed of over 100 species. Some 25% of this seed was for two species, Cupressus lusitanica and Pinus patula (Jestaedt, 1986). KREDP collected 5,513 Kg., also of over 100 different species. Data for the Ministry of Agriculture is not available. NGOs usually receive seed from Kenya Energy Non-governmental Organization (KENGO), although some collect limited quantities for internal use.

2.3 Seed Supply and Demand Gap

As some species (e.g., Pinus spp.) are solely planted by the Forest Department, balances of such species are likely at the end of each year. However, the actual deficit of seed of other species is in the region of 8-10,000 Kg. per year. In 1986, only 86 million out of the 200 million targeted were produced; the major bottleneck being availability of seed.

2.4 Tree Seed Supply Problems

Kenya's tree seed problems are universal to other countries (Carlowitz 1986).

i) There are too few suppliers compared to users.

ii) Seed is not readily available to the rural projects and individuals that need it.

iii) The available species are generally few and often inappropriate for local needs.

iv) The quality of seed affects field programmes.

v) Collectors overlook important practices such as selection of proper mother trees, documentation of seed and inclusion of information on handling and pre-treatment of various seed types.

vi There is lack of information on species for agroforestry.

3 KWDP'S INITIAL SEED SOURCES AND SUPPLY PROBLEMS

3.1 The Programme

KWDP was initiated in 1983 to encourage farmers in four specific high agricultural potential and high-population density districts to plant trees on their farms for self-sufficiency in woodfuel. KWDP's aims include the development of technical agroforestry packages and extension methodologies that can be replicated in other districts outside the Programme area.

When KWDP started work in the pilot district of Kakamega in 1984, three baseline surveys were carried out. A district resource analysis analyzed all physical and human resources in the district; an agroforestry survey studied tree-planting activities on farms; while a cultural survey investigated social cultural issues that influence farmers in making decisions on tree planting.

The results indicate that planted woody biomass covers 20-28% of the land in some parts of the district; that indigenous farmer knowledge and experience is considerable (79% plant trees and 40% establish farm nurseries every year); and that women continue to experience firewood shortages in spite of all these planted trees. Women have no access to tree resources. Men control tree planting and harvesting, and sell the products for cash. The firewood problem is, therefore, not a technical but a cultural problem and a purely technical solution is not sufficient.

Sesbania sesban grows in some parts of the district and is being managed by women. It is planted together with food crops solely for firewood and soil fertilization, being a nitrogen-fixing species. KWDP decided to introduce Sesbania-like shrubs which women could establish and manage for fuelwood. Four species were chosen for first tests; Calliandra calothyrsus, Leucaena leucocephala, Mimosa scabrella and Gliricidia sepium.

In order to capitalize on the farmer's knowledge in tree plan ing and farm nursery management, KWDP gave farmers both seedlings and seed. This continued for two years and the problems experienced through the Programme's central nursery seedling production and distribution were considerable. On the other hand, the farm nursery system was simple, cheap and flexible. Farmers raised the number of seedlings they could manage and outplanted when it suited them (KWDP working papers 1984-87).

As the farm nursery system caught on, so did the demand for seed increase.

3.2 Importation of Seed

Apart from Sesbania sesban, seed for the other four species was not available in the Programme area and had to be brought from outside. Leucaena leucocephala was brought from the Coastal areas of Kenya; Calliandra calothyrsus, Mimosa scabrella and Gliricidia sepium seed was imported from Europe.

Problems of Importing Seed

i) Imported seed is expensive and requires foreign exchange;

ii) Delays affect Programme activities;

iii) Viability is not always adequate;

iv) Customs clearance is sometimes difficult.

3.3 Local Seed Sources

After the first two years of seed distribution for the original five shrubs, KWDP added a few more species primarily because of farmers' requests for larger slow-maturing trees that could give split fuelwood and construction poles. Among these were Croton macrostachys, Markhaemia platycalyx and Grevillea robusta. It became apparent that continuous seed importation was too expensive and that KWDP would have to look within Kenya for seed source.

i) **Seed Production Units (SPUs)**

An SPU in KWDP is a square block measuring 10m x 10m or 18m x 18m planted with 196 trees of four species in four small plots. The trees are spaced at 0.5m x 0.5m or 1.0m x 1.0m, respectively. SPUs were established on school compounds, state land or individual farmers' land with the aim to produce seed which schools and communities could collect and use for tree regeneration. SPUs brought seed to the farmers' door steps.

Problems of SPUs

While the Programme expected the community to maintain the SPUs, the opposite happened. SPUs were seen as KWDP's property and maintenance remained poor. Due to close spacing, the amount of seed produced was minimal. Farmers did not seem interested to collect the seed.

ii) **Seed Orchards**

Seed orchards were established on state land in Kakamega to serve two purposes; first as a trial for appropriate spacing for maximum seed production, and secondly, to produce seed for the Programme. Two years after establishing the seed orchards, seed production was poor, again because the spacing (1.0 x 1.0m, 1.5 x 15m and 2.0 x 2.0m) was too close.

iii) **Trees on Farms**

The first species established by farmers in 1984 were producing seed in 1986 and KWDP used field staff to collect it. Training for the seed collectors was done but again results were poor as the exercise was laborious for staff members who were also involved in other extension work.

4 A STRATEGY TOWARDS TREE SEED SUFFICIENCY

4.1 Motivating Farmers to Collect Seed

Trees growing on farmers' land, whether planted or naturally standing, produce seed regularly. Tree seed collecting programmes sent their collectors with introductory letters to farmers for permission to remove the seed for free. However, the total expense incurred in transport and subsistence allowances results in costly seed.

KWDP is testing a strategy that focuses on the farmer as the collector of his own seed. As the farmer needs cash to solve his family problems, like buying of food and clothing and paying school fees, any amount of money received from the sale of seed would be useful. KWDP believes that the farmer would become positive, not only in seed collection, but also in tree planting because he sees one more direct benefit of trees. His seed, which probably might rot on the tree if no cash incentive was offered for collection, would be used by others within Kenya and outside. The country would also save and eventually earn foreign exchange by seed import substitution and exportation, respectively.

Experience from First Tests

KWDP tested seed buying from farmers in Kakamega, Kisii and Murang'a in early 1987. A price tag was attached to each tree species, basing it on current Forest Department price guidelines. Farmers were informed through staff and seed was brought to the offices or to collection centers.

Table 1 shows how much seed was bought within two months.

Table 1. Seed bought by KWDP from farmers, 1987. *

Species	Quantity bought in Kg.			
	Kisii	Kakamega	Murang'a	Total
Sesbania sesban	503	227	-	730
Acacia mearnsii **	648	-	-	648
Leucaena leucocephala	-	219	357	576
Markhaemia platycalyx	240	-	-	240
Caesalpinia decapetala ***	179	-	-	170
Grevillea robusta	-	-	52	52
Shinus molle	27	-	-	27
Harungana madagascarensis	5	-	-	5
	1,602	446	409	2,458

* Source (Mung'ala, 1987).

** The only species with a local market for seed at KShs. 20/Kg.

*** A specific request from the Ministry of Energy and Regional Development.

Problems of Buying Seed from Farmers

i) Seed source is uncertain in terms of mother tree quality.

ii) Farmers may collect poor and immature seed.

iii) Due to lack of technical training, farmers may collect, handle and store seed inadequately and this is likely to affect viability.

iv) Quality control is difficult.

v) If farmers feel that they are not well compensated for their efforts in collecting certain species, there could be a risk of excess seed of a particular (easy to collect) species.

vi) If farmers see seed production as a lucrative business, they may decide to keep trees permanently for that purpose and not cut them down for fuelwood and other uses on the farm.

Possible Ways to Solve the Problem

i) Form an inspection team that would survey seed collection areas to identify mother trees.

ii) Provide standards and ensure that they are followed.

iii) Provide technical information and training on each species.

iv) Work out fair pricing so that farmers are motivated to collect seed.

4.2 Mobilizing School Children

The recently-introduced educational system in Kenya (8-4-4) has made agriculture for primary schools a compulsory subject. Tree planting activities have been popularized because schools have been sensitized to environmental degradation and are raising seedlings for planting within their compounds. Through the schools, KWDP hopes to reach parents with whom tree planting ideas can be tried and from whom tree seed can be obtained.

Schools will be rewarded for seed collection in the form of books, tools and equipment, the quantity of which will be equivalent to the money that would have been earned.

Together with other tree-planting activities in the schools, the seed collection project will discuss with the District Education Officer the possibility of starting a competition on zonal, divisional and district basis where KWDP can contribute shields, trophies, books and any other agreed prizes in order to motivate and mobilize students and staff. This should have three advantages. It will have an immediate benefit to the schools in terms of nursery establishment and tree planting on the compounds. Through seed collection, the schools will benefit directly in the way of books, tools and equipment while KWDP also gets seed as a product of the pupil's efforts. The long-term and indirect benefits will include the inevitable raising of awareness and standards in tree-planting activities in schools. Last but not least, these activities will hopefully instill a respect for tree planting in the youth who are tomorrow's farmers.

A preliminary test of this approach in Murang'a resulted in 12 kg. of Grevillea robusta seed from one school in one week.

Problems of Seed Collection Through Schools

i) Seed quality: there is a possibility that pupils could bring in dirty, immature, rotten or damaged seed, especially if the communication by their teacher is inadequate.

ii) Problems could be experienced where technical information and tools are lacking on how to collect, handle and store seed.

iii) The mother trees may be unsuitable.

iv) Quantities could remain low if teachers are unhappy with prices of seed or methods of compensation.

Possible Solutions

i) Stringent quality standards will be applied.

ii) Technical information will be communicated through teachers to pupils in the form of simple pamphlets.

iii) Prices and the reward system will be discussed with the DEO, head teachers and agricultural masters.

iv) Inspection/survey of seed sources will be done in advance of collection to ascertain quality of mother trees.

5 HANDLING, STORAGE AND DISTRIBUTION OF SEED

Once the seed is received from farmers and schools at the collection centers, it will be packed in plastic containers and transported to KWDP's District Offices for drying, cleaning, fumigation, packing, testing, storage, and distribution.

In order to make sure that seed does not deteriorate during storage, it will be thoroughly dried in the sun under polythene sheets to the required moisture content. Chaff, rotten, broken and undersized seed will be removed either manually or by mechanized vibrators before fumigation.

Fumigation will be necessary to avoid contamination and damage of seed by insects and fungi during storage and in transit. Recommended chemicals will be applied in required dosages.

Immediately on receiving seed from farmers and schools, at various intervals during storage and just before distribution, various seed lots will be tested for viability as a normal procedure.

The seed will be packed in air and moisture tight bags at various quantities depending on targeted users. Small quantities (5-25 gm) will be packed for small-scale farmers while bigger ones (1-20 kg) will be made available to institutions, organizations and large-scale farmers. Glossy paper bags with photos of various trees will be used. Minimum information on seed treatment and use will be inscribed on the bags.

Once packed, the seed will be stored either in cool, dry room conditions or in cold rooms depending on species and duration of storage. Organizations and institutions are expected to pick seed from KWDP's office stores. Plans are also underway to use non-tree commercial seed distribution channels with a view to reaching more seed consumers within the country.

KWDP will seek assistance through collaboration with the Kenya Forestry Seed Center and others on such areas as seed research and information exchange.

6 CONCLUSIONS

Conventional seed production and collection systems are not meeting the ever-rising demand for tree seed. One possible solution to the identified seed shortage is to motivate farmers and mobilize school children to collect seed from those trees growing on the farms, road-sides and riverbanks. If a value is attached to tree seed and a collection, handling, storage and distribution system worked out, a lot of tree seed could become available.

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A PRELIMINARY SESBANIA SEED STUDY IN UGANDA

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ABSTRACT

The preliminary study of one wild stand of Sesbania species in Ankole Region revealed it to be S.sesban and an outcrossing species which is easily suppressed by inbreeding depression. The study called for more elaborate research encompassing all available species and inclusion of tree characteristics besides seed characteristics.

INTRODUCTION

Uganda is a land locked country with an area of 241,000Km^2 at an altitude of 1,000-1,600 m.a.s.l., and between 1°S and 4°N of the Equator. The mean minimum temperature is 17°C while the mean meximum is 32°C. There are two rainy season namely, March to May and August to October, giving a range of 500-2160mm of rain a year. On the whole soils are generally considered fertile.

The population is 14 million, increasing at the rate of 3% annually, giving, rise to a density of 64 persons per Km^2. Uganda is mainly an agricultural country and 90% of the population are small land holders.

Considering the population density and the poor agricultural methods, farmers no longer have enough land to follow to restore soil fertility. Instead land productive capacity has gone down, less food is produced, both animals and man are malnurished and poverty is rampant. In a search for solutions to remedy the situation, the Research Division of the Forest Department has identified a number of multi-purpose tree species, one of which is Sesbania for inter-cropping with food crops and as sources of other wood products.

Sesbania uses

A wide range of qualities render Sesbania a possible remedy. Sesbania species grow very fast, have short rotations, and flower profusely facilitating establishment. Eggling (1952) and Cross (1986) personal communication, have records of 6m and 7m of annual height growth of S.sesban respectively. Mbonye (1986) states that in Western Kenya S.sesban is harvested annually for fuelwood.

Sesbania species are used in Hawaii and India to conserve and improve soil through preventation of erosion and use as fertilizer and green manure (Evan and Rotar 1986). The deep tap root deposits mineral salts from lower soil layers into top soil layers through forage decomposition. In addition, as legumes, Sesbania species fix atmospheric nitrogen rendering their use a valuable assest to a peasant farmer who cannot afford expensive artificial fertilizers.

Young leaves and branches provide high quality fodder for reminant animals and is especially recommended for lactating animals (Mbonye 1986). Leaves have a high protein content of 34% (Mbonye 1986). In some cases, especially during famine seeds, flowers and young leaves are eaten by human beings.

Sesbania species provide good source of fuelwood. Although the wood is light and soft, it burns well (Mbonye 1986). For a long time in Western Uganda, Toro district S.sesban has been grown special for fuelwood production.

D i s t r i b u t i o n

In Uganda the genus Sesbania is represented by five different species, S.dummeri, S.pubescens, S.sesban, S.bispinosa and S.macrantha (Eggling 1952). Distribution within the country is shown in Table I below

Region	S.bispinosa	S.dummeri	S.marantha	S.pubscens	S.sesban
Mengo	X	X	X		X
Masaka	X				
Mubende					X
Ankole			X		
Kigezi					X
Toro				X	X
Bunyoro				X	
Mbale					X
Busoga	X			X	X
Teso	X				
Karamoja					X
Lango	X			X	
Acholi					X
Ssesse Is.					X

At the moment little is known about the genetic value of Sesbania species in Uganda simply because no work has been carried out to evaluate them.

METHODOLOGY

Having realised the importance of Sebania and the fact that hardly any information is available, a wild stand from Ankole Region was randomly picked on for a preliminary study. According to Eggling (1961), in Ankole, there is only S.macrantha and it was therefore known that the study was dealing with S.macrantha. However, it was to be further identified after raising seedlings.

The seed was tested for viability, weight and colour. Seedlings were raised issued to the public while some was planted within individual gardens on Nakawa compus.

Over a year, pods were collected from trees grown on Nakawa Campus, and measured for pod length and width, number of seeds/pod, and number of viable and dead seed. Viable and dead seed were determined according to the naked eye. Among the viable seed, there were two distinct colours, green and brown, whose numbers were also determined. In addition, seed weight and germination were determined for the whole seed lot as well as for the two different colour seed lots. A total of 368 pods were measured.

A second generation of trees was raised to replace the dead, dying and lost ones of the first generation. They were also planted at Nakawa.

RESULTS AND DISCUSSION

On identification, S.macrantha proved to be S.sesban which means that since Eggling published his book in 1952, more species have been introduced in different areas or could be some were left out accindentally.

The original seed from Ankole was dark green and mottled in black, full and turgid with a germination of 100%. The seed weight was 79,100 seeds per kilogram. The resulting seedlings were full of vigour and within 6 weeks in the nursery, they had over grown pot of 16.5 x 12cm, size. Those planted at Nakawa were healthy with abundant foliage and started fruiting at 7 months. They flowered, fruited and seeded profusely for most of the year.

The seed that was collected from these seedlings was not full and turgid, instead it was more slender, and the dark colour had segregated into green and brown. Results of the various measurements and determinations are summarised in Table II.

Table II Summary of the Various Measurements and Determination of Sesbania Sesban Seed

Trait	Numbers Recorded			Seed Lot	
	Minimum	Average	Maximum	Total	Viable
Pod length/cm	4.0	18.6	32.0	-	-
Pod width/cm	0.2	0.3	0.4	-	-
Total No.seed	0 (5)	36	53	-	-
No. Viable Seed	0 (65)	20	47	-	-
No. Dead Seed	0 (3)	18	46	-	-
No. Green Seed	0 (66)	19	49	-	-
No. Brown Seed	0 (281)	6	37	-	-
% Viable Seed	-	-	-	56	-
% Dead Seed	-	-	-	44	-
% Green Seed	-	-	-	53	95
% Brown Seed	-	-	-	17	5

Key

( ) - No. of pod contributing to the zeros recorded.

The seed viability went down from 100% of the original Ankole seed to 38% before sorting the colours. On sorting the colours, green seed had a viability of 48% while brown seed had 22%. Seed quality declined indicating a recombination of more deleterious genes especially in the brown seed lot. According to the literature, Sesbania sesban establishment is easy and so is germination. Without any treatment, the peak germination was obtained between the 3rd and 12th day from commencement.

The seed weight increased from 79,100 seeds per kilogram of the original lot to 115,000 of the unsorted, 120,000 of green and 110,000 of the brown seed lots again showing the same decline in seed quality.

It was noted that any seed left to dry on the tree was easily attacked by fungi and black ants whereas that collected soon after pod withering remained desease and insect free.

Seedlings of the second generation are not as healthy as those of the first generation in that they are smaller in diameter, shorter in height, carry much less foliage, have smaller seed pods and a good portion of the seed is vestigial. Similar seed measurements and determination have not been done on the second generation.

CONCLUSION

Based on the foregoing results, there is evidence that Sesbania sesban is an outcrossing species. The decline in seed quality and tree vigour of the second generation is an indication of the inbreeding depression. Therefore, there is need to take adequate representative samples of a population so as to avoid inbreeding. Again, there is need to extend the same study to all other Sesbania species for more meaningful results. Besides seed characteristics, tree characteristics and effects on soil should also be investigated. Consequently, species distribution and genetic values will be highlighted facilitating ranking of species for various use.

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Effect of seed pretreatment on the germination of some hardwood species for dry zone afforestation in Malawi

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ABSTRACT

The effect of seed pretreatment on the nursery germination of 10 indigenous and 11 exotic hardwoods were investigated. The results have shown scarification as the most effective pre-treatment method for rapid and high germination success in the nursery for both indigenous and exotic hardwoods used in the study. Sulphuric acid, hot water and hoiling water gave variable results.

More pretreatment studies for other promising species for dry zone afforestation in Malawi are being developed.

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INTRODUCTION

Rapid and uniform germination of seed in forest nurseries is required in order to achieve uniform good quality planting stock in a minimum of time. Achieving this requires a prior knowledge of proper nursery techniques for raising each species.

Seeds of some hardwoods germinate readily (most eucalyptus for example) when subjected to favourable conditions of moisture and temperature. However, germination of other species, especially most legumes, is difficult as the seed coat is in many cases impervious to water. Since germination requires both water absorption and an exchange of gases, it can only occur once the coat is made permeable. In nature, the seed coat may be worn away in many ways: attacked by micro-organisms or corroded by stomach acids as the seed passes through the digestive tract of birds or animals for example. These natural procecces need to be simulated artificially thereby shortening the germination period in the nursery.

Several pretreatments, including mechanical, water, acid and heat have been used to render many leguminous seeds permeable. All these, however, require careful quantification for different species. This paper presents germination results of pretreated seed of some promising species for dry zone social forestry and agroforestry programmes in Malawi.

MATERIALS AND METHODS

Two seperate experiments were conducted at the Forestry Research Institute's (FRIM) nursery in Zomba. The first experiment investigated the effect of seed pretreatment on the germination of seed of 10 indigenous hardwood species and the second studied the effect of seed pretreatment on the germination of 11 exotic dry zone hardwood species from Central America. Seed for the indigenous species was locally collected, and seed for the exotic hardwoods was offered by the Oxford Forestry Institute (OFI) for trials in Malawi.

Seed Pretreatment of Indigenous Hardwoods

Four pretreatments, including a control, were applied to 10 indigenous species, each treatment consisting of 25 seeds. The treatments were as follows:-

- control: seed sown straight without any treatment;
- mechanical hand scarification: each seed was scratched individually using medium grade sand paper and sown straight;
- cold water: seed being soaked overnight in cold water
- hot water poured on seeds in a container and then being left overnight as it cooled.

The seeds were sown into soil in black polythene tubes in the nursery; treatments were arranged randomly in a non-replicated design. The pots were watered twice a day (morning and evening) and germination counts made daily during the 60-day experimental period.

Seed Pretreatment of Exotic Hardwoods

Six pretreatments, including a control, were applied on 11 Central American dry zone hardwood species, each treatment consisting of 30 seeds. The treatments were as follows:-

- control: as above;
- mechanical hand scarification: as above;
- moderate acid immersion: seeds immersed in sulphuric acid, 98% assay, for 10 minutes;
- extended acid immersion: as for moderate acid, but for 20 minutes;
- hot water: as above;
- boiling water: seed added to boiling water (removed from heat source) for 30 seconds, thereafter the water is poured off and replaced by tap water; the seed is then left to soak overnight.

The seeds were sown into soil in black polythene tubes in the nursery, the pots being watered twice a day: morning and evening for 21 days during which germination counts were made daily.

RESULTS AND DISCUSSION

Seed Pretreatment of Indigenous Hardwoods

Total germination for the 60-day experimental period in the nursery for each species and pretreatment are summarised in Table 1.

The results in Table 1 show that scarification treatment was effective with all the species, achieving a higher germination in a shorter period than the other treatments except in *Sterculia africana* where hot water and control achieved 80% germination compared to 64% for scarification. With scarification treatment care should be taken not to scarify too deeply and expose the cotyledons to damage. It is more than likely that the low germination success with this method in *Sterculia africana* is due to the cotyledons being damaged during scarification. Hot water and cold water treatments were successiful with *Adansonia digitata* (96% and 92% germination respectively) although the germination period was rather lengthy. The same applies for *Afzelia quanzensis* where high germination percentages were also achieved with hot water, cold water and control. It should be noted, however, that the effectiveness of hot water treatment also depends on the seed to water volume ratio and the ambient temperature as these influence the total amount of heat the seeds are exposed to over the soaking period. The inferiority of this treatment in this study for most species is most probably due to seed having been "cooked" by the excessive heat from the water.

Table 1: Germination response (% and duration) of indigenous hardwoods seed following pretreatment.

Species	Control	Scarification	Hot water	Cold water
Acacia albida	40 (10-56)*	68 (7-14)	64 (7-56)	36 (9-42)
A.compylacantha	35 (9-35)	90 (6-16)	70 (8-30)	40 (11-40)
A. karoo	12 (12-40)	80 (6-15)	50 (11-40)	10 (11-35)
A. nilotica	8 (37-40)	70 (7-20)	16 (7-60)	8 (41-49)
Adansonia digitata	72 (11-42)	80 (6-21)	96 (7-35)	92 (10-42)
Afzelia quanzensis	100 (11-35)	100 (6-21)	96 (10-35)	100 (10-28)
Albizia lebbek	60 (6-56)	80 (6-14)	56 (6-28)	60 (6-56)
Burkea africana	64 (10-21)	44 (11-56)	44 (11-56)	32 (11-60)
Sterculia africana	80 (8-21)	64 (6-21)	52 (10-21)	80 (6-21)
Tamarindus indica	92 (12-35)	100 (8-21)	92 (10-28)	100 (10-28)

*Figures in brackets indicate the germination periods, ie; number of days from sowing.

Seed Pretreatment of Exotic Hardwoods

Germination percentages for each species and pretreatment for the 21-day experimental period are presented in Table 2. The results indicate that scarification treatment is effective for all the species except *Simarouba glauca* which did not germinate at all in any of the treatments.

Simarouba glauca seed is reported to have a short viability period (Abastida, 1986; pers. comm.), and as the seed was stored for about a year before the present tests, it is likely that the germination failure of the species is due to loss of viability rather than the treatments applied.

Boiling water treatment achieved more than 70% germination throughout, but for sulphuric acid (both 10 and 20-minute treatments) and hot water treatments, the results vary greatly with species. The failure of the hot water treatment in most species here is undoubtedly due to the seed to water volume ratio problem as described earlier. The depressed germination percentages associated with sulphuric acid treatments, however, is possibly due that the period the seeds were left to soak in the acid was either too short (10 minutes treatment) for effective corrosion of the seed coats or so long(20 minutes treatment) that it damaged the tissues within the coat.

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Table 2. Germination response (% and duration) of exotic Central American hardwoods seed following pretreatment.

Species	Control	Acid (10 Min)	Acid (20 Min)	Hot water	Boiling water	Scarification
Acacia pennatula	10 (6-21)*	30 (3-14)	80 (2-9)	70 (3-14)	80 (2-14)	100 (4-6)
Caesalpinia eriostachys	100 (5-11)	100 (3- 7)	100 (3-6)	20 (2-16)	90 (5-16)	100 (3-7)
C. velutina	40 (3-17)	100 (2- 5)	100 (2-5)	50 (4-14)	100 (2- 6)	100 (2-3)
Crescentia alata	90 (6-14)	0 (21)	0 (21)	30 (5-21)	100 (3- 7)	100 (2-5)
Enterolobium cyclocarpum	0 (21)	40 (3-21)	100 (3-8)	30 (2-14)	90 (2-14)	100 (4-7)
Gliricidia sepium	60 (5-14)	80 (2-10)	30 (10-21)	0 (21)	80 (6-18)	100 (2-5)
Guazuma ulmifolia	0 0(21)	40 (3-14)	27 (6 -14)	0 (21)	74 (3-14)	67 (4-14)
Parkinsonia aculeata	50 (3-21)	80 (3-10)	100 (2 - 3)	30 (5-12)	72 (2-12)	100 (2- 7)
Pithecellobium dulce	60(10-21)	60 (4-18)	100 (3 -14)	80 (5-12)	100 (3- 8)	100 (2- 6)
Senna atomaria	0 (21)	100 (4-10)	100 (4 -11)	50 (4-10)	100 (3-14)	100 (2- 3)
Simarouba glauca	0 (21)	0 0(21)	0 (21)	0 (21)	0 (21)	0 (21)

* Figures in brackets indicate the germination period, ie; number of days from sowing.

RECOMMENDATIONS

Scarification is the best treatment for achieving high germination success in a short period in the nursery for both indigenous and exotic hardwood species in this study. Sulphuric acid and boiling water were also successful with most of the species (exotic hardwoods only). However, mechanical hand scarification is only practical with small samples and sulphuric acid has risky features of injury to both operator and seed and may require foreign exchange to secure it. Therefore, if small numbers of indigenous or exotic hardwood tree species are to be raised, the seed should be hand scarifier. If large numbers of seeds are to be sown, or a suitable scarified is not available, then seed of exotic hardwood species should be pre-treated with boiling water; of the indigenous hardwoods, Acacia albida, A.compylacantha, Albizia lebbek Burkea africana and Adansonia digitata should be treated with hot water, Afzelia quanzensis and Tamarindus indica treated with cold water, Sterculia africana be treated with cold water or not at all, and Caesalpinia eriostachys seed needs no pre-treatment.

CURRENT RESEARCH

There is now a renewed interest in indigenous tree species for use in small-holder woodlots, and for agroforestry programmes. There are also plans to use indigenous tree seedlings raised in forest nurseries to enrich degraded natural woodlands. Seed and nursery techniques for securing good quality planting stock for these species are therefore being developed by FRIM.

Exotic hardwood timber species are also being considered at FRIM. For example, a preliminary study on germination of pretreated seed of teak (Tectona grandis) under nursery conditions in Zomba, has already been done.

F O R E S T   S E E D   P R O B L E M S   O F   N I G E R I A

by

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SUMMARY

This paper describes the problems of forest tree seeds in Nigeria under four heads: production and collection; processing; germination and storage. Production problems include alternate years of light and heavy fruiting superimposed with overall scanty production by certain species and different times of seed ripening between the north and south. The absence of designated areas for seed collection and insufficient information on fruiting, makes collection excercise unduely expensive. Lack of mechanical mean of getting into the crown makes collection harzadous and incomplete. Seed extraction is still manual and laborious often leading to production of poor quality seeds. The germination and storage requirements of seeds of the various species have not been sufficiently studied.

Key words: Forest, trees, seeds, problem, Nigeria.

INTRODUCTION

Forest tree species in Nigeria number about 900 and are distributed amongst 78 families (Keay, Onochie and Stanfield, 1964). They are all angiosperms and include introduced species such as Gmelina arborea and Tectona grandis. Tropical pines have since been introduced and Pinus caribaea and Pinus oocarpa have been shown to be the most versatile in the Nigerian environment (Iyamabo, Jackson and Ojo, 1972). Of all these species put together, the wood of only about 72 species are currently being utilized (Bamgbala 1981) and research is focused on still a fewer number of species.

Regeneration of the forest was initially by natural regeneration but emphasis shifted to artificial regeneration in the fifties (Olatoye 1968) when the importance of seeds in forestry practice assumed a new diamension. Seed now had to be collected, processed and stored for use at a future date when they had to be artificially germinated. Each of these stages poses its own attendant problems. The updated research effort on tree seeds in Nigeria was summarised by Aina and Okoro (1986).

PROBLEMS

The seed problems will be discussed under specific headings viz production and collection: processing; germination and storage.

Production and collection

Most of the forest trees generally fruit very well but there are references in the literature to mast years (Jones, 1974 and Okoro, 1978) suggestive of periodicity in quantities of seeds produced from year to year as generally reported for tree species including tropical tree species (Longman and Jenik, 1974). However superimposed on this normal periodicity are species which are sometimes called "shy" seeders and these include an indegenous angiosperm Triplochiton scleroxylon (Jones, 1975) and the tropical pines (Okoro and Okali, 1987). These two species do not produce adequate quantities of seeds and so alternative means of producing planting stock has been sought in mass cloning of available seeds. Microprepagation and microcuttings will come in very handy for these species. The time of seed collection varies greatly between the north and the south for some species. Examples are Gmelina arborea (Okoro, 1976) and Azadirachta indica.

Seed collection has been entirely from non designated areas such as natural forest and plantations with a few collections for few species made from seed stands or orchards. This leads to extensive travelling during seed collection which makes seed collection very expensive especially at this time of economic crunch. Seed collection activities have therefore been reduced. Seeds/fruits are sometimes allowed to drop off the tree to the ground from where they are picked. Such seeds are often blown away by wind as in the case of Bombax buenopozense, trampled upon as for Nauclea diderrichi, attacked by termites or animals (Chlorophora excelsa) or larvae (Guarea spp), rot (G. arborea) or collectors sink due to marshy ground condition as in Rhizophora racemosa. Ground collection is often resorted to when tree trunks are too large or tall to be climbed as in the case of B. bunopozense or branches are tightly packed in whorls making climbing difficult (N. diderrichii). Clubs are sometimes thrown at fruits in the crown of B. buonopozense while wire mesh trays are spread on the ground under the N. diderrichii mother tree. Throwing clubs could be dangerous. To ensure collection of good quality seeds, tree climbers climb into the crown of trees by means of simple and relatively cheap climbing ropes designed on the principle of the tree bicycle. They cut off the stalks of the fruits by means of parrot head. Sometimes the Denish ladder is used and in one location ladder is mounted on land rover. Branches fruiting heavily are sometimes cut down as in Terminalia ivorensis onto canvass spread under the tree. The trunks of these trees are often infested by biting ants and have to be sprayed with insecticide. With the curtailment of importation these have become scarce commodity. Labour have become too aware now and rate this operation as high risk and humiliating. They consequently are reluctant to undertake it.

There is need to revise our seed collection procedures. First of all, effort should be geared towards identifying seed production areas and selection of seed stands in the case of indegenous species. For both exotics and indegenous species, functional seed orchards should be established. In this way seed collection would be limited to specific areas and travelling costs drastically reduced. Improved seeds will also be obtained in these areas. Mechanical means of harvesting the fruits such as tree shaker or hydraulic lift (also useful in controlled pollination) need to be provided to make work less harzadous and ensure maximum fruit collection. Although Somade, Dada, Soladoye, Olagunju and Ugbechie (1987) published an article on phenology, the information is imcomplete. The phenology of the tree species should be so well known that the time of seed collection could be predicted with some precision from year to year no matter the weather condition.

Processing

Seed handling procedures adopted depend largely on the type of fruits produced by the species. Okoro and Dada (1971) categorised the types of fruits produced by the trees grown in Nigeria. Many of the species, including Afzelia africana and B. buonopozense, produce pods or capsules which either split on the trees, releasing their seeds or are harvested green and dried after which the pericarp splits releasing the seeds. Over drying is sometimes injurious to seed. Therefore seeds need be collected as soon as pods split and then gradually dried. However there are cases where seeds are not released after drying and the pods have to be split using knife as in *Afrormosia elata*. This is laborious, dangerous and time consuming. The second category consists of dry one-seeded fruits such as *Terminalia spp* and *T. scleroxylon*. These are often winged and require dewinging which is usually carried out manually either by rubbing inbetween the palms or thrashing in netlon/jute bags and the chaff blown off. In the case of bristly fruits (*Pterocarpus osum*) using the former method hurts. The third category consists of berries and drupes with fleshy pericarp which is removed by fermentation in heaps (*G. arborea*), in pits (*Canarium schweinfurthii*) and soaking overnight in water (*C. excelsa*) or depulping in fresh water (*N. diderrichii*) or manual removal by abraission with sand (*A. indica*). When fermentation is used, pulp is removed at the end of the fermentation period by crushing the fruits under the feet on concrete slab, followed by water wash. Usually fermentation lasts over a long period of time, up to two weeks, leading to reduced germination attributable to heat generated during fermentation or inhibitors leached into the seeds from fermented pulp as in the case of *G. arborea* (okoro, 1984). Manually depulping fresh fruits of *G. arborea* has been shown to give good results but is laborious.

A simple device for dewinging the various types of winged seeds and fruits is required. Also a versatile depulping machine is needed to handle all types of fleshy fruits to facilitate fresh extraction which will yield good quality seeds.

Germination

Seeds of some species such as A. elata and A. indica germinate very easily. However at temperatures below or above 27°C, A. indica germinates poorly (Ezuma, 1984). Some species (G. arborea) may germinate well if extracted fresh but not uniformly (Okoro, 1979). Yet, there are some which germinate poorly and slowly as in the case of T. ivorensis (Okoro, 1976) while others require specific pretreatment to germinate. The last group includes the leguminous species which are characterised by impermeable leathery testa that has to be chipped or abraissed in some way and soaked in water before sowing (Dada, 1968; Adeola and Dada 1983). Pretreatments used for other species include gibberrelic acid for C. excelsa (Olatoye, 1965), leaching of Tectona grandis (Ibrahim, 1979), alternate soaking and drying of Canarium schewinfurthii and mere soaking in water of Desberdesia glaucescens. Grading fruit stones of G. arborea produces uniform germination (Woessner, 1979; Okoro, 1979 and 1984) and larger fruit stones germinate faster (Ogbe, 1960; Okoro, 1979). However, grading of fruitstone is not done routinely. Other seeds require special germination conditions such as alternating temperature for T. ivorensis (Okoro, 1976), light for C. regia (Olatoye, 1965).

There is need to investigate and document the germination requirement of every species. A mechanical grader is required for grading G. arborea and other species which may require it to encourage uniform germination and facilitate the use of mechanical planter in future. Depulping method for fleshy fruits that will prevent interference of inhibitors in the pulp with seeds should be developed and the nature and mode of action of the inhibitors on germination studied.

Storage

Once cold storage facility was installed in Forestry Research Institute of Nigeria in 1959 and was found to prolong the longevity of otherwise short-lived seeds such as Entandrophragma angolense, T. scleroxylon, Khaya spp. and Mitragyna ciliata (Olatoye, 1968), seeds were now routinely stored at + 5°C in this store. Occassional breakdown of standby generators is detrimental. However it became clear that certain species such as A. indica do not store well under this condition. Part of the problem could be attributed to moisture content of seed at the time of storage which is not usually given much attention. By drying T. scleroxylon to 8 - 10% moisture content, it can now be stored at ambient for 9 months in sealed containers containing silica - gel and at - 18°C for 18 months and longer (Howland and Bowen, 1977). For short-term storage *A. indica* could be stored in air-tight containers at room temperature for two to three weeks. The high moisture or oily seeds such as the meliaceous species do not store well in the cold.

There is need for intensive research into storage requirement of every species, paying particular attention to the moisture content before storage and the packing material during storage.

CONCLUSION

Future investigation will concentrate on creation of seed production areas, seed stands and orchards where phenology of flowering and fruiting will be thoroughly studied for each species of interest. Assistance will be required in the supply of simple equipment and materials required for grafting, pollen handling and artificial pollination; mechanization of fruit harvesting and processing; and germination and storage. Also assistance in giving short specific training to professional and technical staff in this field will be most welcome. Thought should be given to providing facilities for micropropagation and microcuttings as means of providing alternative planting stock to seedlings for species that have seed production problem.

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FOREST TREE SEED PROBLEMS IN BURKINA FASO (SAHELIAN AND SOUDANIAN REGIONS)

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SUMMARY

Reforestation activities in the Sahelian and Soudanian Regions demand seeds of a good genetic and physiological quality. The National Forest Tree Seed Centre (CNSF) of Burkina Faso is one of the main West African Institute involved in supplying these seeds.

Since its establishment in 1983, considerable progress has been made. The problems that were and had to be faced in Burkina as well in the whole region are summarised in this article. The CILSS [1] member countries have asked the CNSF to play a pioneering role in the Region.

To confirm the Regional tasks to be carried out, a Seminar has been planned for the beginning of 1988.

INTRODUCTION

The questions we would like to discuss in this article are related to

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(1) CILSS : Comité Inter Etat de Lutte contre la Secheresse dans le Sahel/Inter State Comity for Drought Control.

forest tree seed problems in the Sahelian and Soudanian region where Burkina Faso is located. The forest tree seeds situation is almost the same for the different West African countries of this region. Activities in this field started several years ago as National Programmes to deal with desertification problems. One of the most important activities to be undertaken is reforestation. In order to garantee an optimal success for these activities, it is very important -among other things- to supply seeds and plants of good genetic and physiological quality.

Unfortunately, only a few countries are able to do this. Moreover, no development and research structure exists in most of the region's countries. Thus, most of the countries are just starting the activities to be undertaken. Nevertheless, all the reforestation activities that were carried out in the region do have an impact on the improvement of the quality of the plants material to be used (BELLEFONTAINE,1985).

In this article emphasis is put on the experience obtained at the CNSF in Burkina Faso, since it is one of the West African Centres specialised in supplying improved forest seeds for research as well for development purposes (OUEDRAOGO et al, 1985).
Discussed here are problems related to structural, organisational, technical, human, material, and financial aspects of the Centre.
For each of the aspects, recommandations or solutions are proposed to improve the quality of forest tree seeds (OUEDRAOGO, 1987).

I. STRUCTURAL AND ORGANISATIONAL PROBLEMS

Two sentences summarize the situation here :

- In most of the countries concerned no Seed Centre exists.
- Cooperation between the existing Centres is minimal.

Recommandations and solutions :

- The recent reforestation activities in the Sahel demand a reinforcement of existing Centres and the establishment of Seed Centres in countries where none exists yet.

A Regional Centre can play an initiating role in this (COMIDES, 1985 ; IDRC,1985

- For the Sahelian countries it will be of a great interest to organise and develop regional cooperaton on seeds, improvement of plant material exchange of information, and training. For this reason the CILSS member countries have asked the CNSF to act as a Regional Centre for West Africa (CILSS 1987). Not only is a cooperation within the Region important but an optimal coordination between Regional Centres should also be considere Thus, the use of scientific and technological information can be optimilised, which is important to Sahelian forestry.

II. TECHNICAL PROBLEMS

1. Poor Circulation of Technical and Scientific Information

- Most of the countries -among them Burkina Faso- cannot make a proper use of the technical and scientific information available since no well equiped and specialised libraries exists. Also, much of the research work done has not always been published, which makes this work useless to other countries or institutions.

2. Collection and supply of Seeds.

- The genetic quality of the seeds collected is very often doubtful. (see II.4, "Constraints for Genetic Improvement of Plant Material").
- A lack of knowledge of the phenology of species does mean that it is not always possible to have an optimal planning for seed colletion.
- For most of the countries in the region, it is a serious problem to obtain enough seeds at the right time for the reforestation operations these countries plan.
- The absence of a legislation in most of the countries restricts the exchange of material.

3. Physiological Quality, Technology, and Seeds Conservation Problems

- Not controlling the techniques and equipment for extraction, cleaning and preparation of seeds means great losses of seeds quantities.
- If the techniques for seed pretreatment are not known, a low germination rate will very often occur at the nursery. The nurseryman should also be informed of the pretreatments to be applied before sowing on the nursery, since it is not always possible to sow immediately after laboratory pretreatment of the seeds.

- Storage facilities and longevity of seeds can be very much improved by defining and setting criteria for seed moisture content of optimal temperatures, and relative humidity in the cool room.

- Special attention should be paid to a group of recalcitrant seeds for which the germination rate strongly decreases after about one month. In most cases, this concerns microbiotic seeds like those of *Azadirachta indica*, *Lannea microcarpa*, *Sclerocarya birrea*, *Butyrospermum paradoxum spp. parkii*, etc.

4. Constraints for Genetic Improvment of the Plant Material.

- Very few activities have been carried out to explore the natural range of different (local) species.

- Most of the time seeds are collected by the nurseryman and no selection criteria are applied. As a consequence, the genetic base is often very narrow and the quality of the plants produced doubtful.

- Programmes to improve the genetic quality of forest trees are not applied at a large scale.

- Except for the exotic species such as Eucalyptus, no seed orchards exists presently. Up to now, seeds are collected from (selected) natural seed stands.

- Most exotic species have been introduced without testing. So we do not know what provenances are well adapted to local conditions.

- Vegetative propagation techniques are not always very well known.
- Species hybridisation and varieties have to be studied.

5. Nursery Problems

To have available plants of a good genetic quality comes first, but the conditions under which they are grown in the nursery are also very important.

- Very often, the very knowledge of the techniques (composting using containers, sowing techniques, etc) to be applied is missing. Nursery activities are not always well organized and planned.

RECOMMANDATIONS AND SOLUTIONS

ad .1. Circulation of Technical and Scientific Information.

To improve the circulation of technical and scientific information, the CNSF publishes a bulletin every semester "Semences - Forêt et Développement". This bulletin deals with information on forest tree seeds, scientific articles, and functions as a link between research and developpement programmes.

Also, the CNSF publishes each year a catalogue which contains information on the seeds available per species and per seed source as well an advice on how to handle them.

Technical notes on forest seed problems and nursery techniques are published from time to time as practical guides.

The CNSF's idea is that all and any information provided should not be restricted to Burkina Faso only, but be used by at least other West African countries.

For an optimal communication, meetings are to be prepared with participants from the different countries, to evaluate the progress achieved in the region and to agree upon the different tasks to be carried out in the participating countries.

Courses, seminars and symposia should be initiated.

In order to process the relevant literature available, a central library should be established. Initiatives have already been taken by the CNSF to achieve this.

In close cooperation with the other Regional Centres, a summary of recent articles should be published regulary.

The Regional Centres should also take care of films and documentaries on foresty projects used to make the general public aware of foresty problems.

ad. 2. Collection and Supply of Seeds.

- To fullfill the demand for seeds, more National Centres are urgently needed. A Regional Centre could inform the concerned contries of this need or even initiate such centres.

- To facilitate the exchange of material, a legislation should be formulated for the countries concerned.

- Thus, the CNSF has sent over a 5,000 kg of seeds to 25 countries in Africa, Europe, America and Asia between 1984 and 1986.

ad. 3. Physiological Quality, Technology and Conservation of Seeds.

- To allow a better control of the techniques for extracting and cleaning seeds, the CNSF has published a paper on the subject (SOME, 1987). This paper deals with a range of techniques to be applied for several Sahelian and Soudanian tree species.

- Dormancy problems of 45 species have been studied since 1984 at the CNSF (SOME, 1987).

- Phenological studies have been carried out for Anogeissus Leiocarpus (GAMEME, 1987). Studies on other tree species are planned for 1988.

- The CNSF succeeded in finding improved conservation techniques for several so called recalcitrant species as well as for orthodox ones.

- Attention has so far been payed at the CNSF to phytosanitary problems, and an even more intensive programme is foreseen in the near future.

- Detailed studies carried out in the Laboratory for some important species permitted to determine optimal germination conditions with respect to light and temperature conditions.

- Studies concerning the optimal moisture content have been carried out for several species. The results have been applied to the storage facilities available at the CNSF.

- The post maturation phenomena of Acacia albida and Parkia biglobossa are studied.

- To determine the genetic variability according to origin from different ecological zones, tests are carried out for Acacia albida and Parkia biglobossa.

ad. 4. Genetic Improvememt of Plant Material

- The first step in a forest tree improvement programme is to select the best phenotypic stands. In Burkina Faso this has already been done for Acacia albida and Parkia biglobossa, Acacia Senegal, Acacia nilotica var. adansonii and Acacia nilotica var. tomentosa. For the last three species, whose existence is threatened, an ex situ conservation of stands has been realized.

- In Burkina Faso, over 500 stands have been selected in the different ecological zones.

- At the CNSF five year projects are formulated for the most important tree species.

- For exotic species, provenance trials will be laid out.

- It is hoped that exchange of material will soon be possible not only in the interest of Burkina Faso but also of the neighbouring countries. During the Regional Seminar to be organized at the CNSF at the beginning of next year, it migth be possible to agree upon such a programme.

ad. 5. Nursery

- Nurserymen should be better trained through courses, seminars and follow up activities in the nursery. For this reason the CNSF has already organized seminars.

- To make an inventory of the problems on nurseries, the CNSF has developed a check-list and applied it to a great number of nurseries.

- Some technical notes have already been prepared.

III. HUMAN PROBLEMS

- The staff is very often lacking in scientific and managememt knowledge. Universities in West Africa do not offer the possibility to specialise in Genetic Tree Improvement and Seed Technology. At Foresty Schools these aspects are not dealt with.

Recommandations and Solutions

- There does exist a cooperation in the technical domain between the CNSF and "The Foresty Research Institute Dorschkamp Wageningen in the Netherlands." Also the IDRC (International Development Research Centre) that has often provided the opportunity to follow relevant courses. However, a more coherent policy is very much needed in order to offer specialisation possibilities at a West African university.

- Aspects of Genetic and Seed Technology should also be included at all levels of Foresty Education.

- Managenent aspects are often neglected, yet are very important for the prop functionning of an institute. Courses should be provided in the matter.

IV. MATERIALS

- For Seed Technology, a number of apparatus is needed to carry out a proper work.

- The use of advanced materials requires certain technical skills for its maintenance, but skilled technicians are not always available.

- Special attention should be payed to automatisation, for project administration as well as for statistical analysis of experiments.

Recommandations and Solutions.

- Despite the existence of a rather good information on the materials to be used (IUFRO, ISTA), this information is not always known. A Regional Centre, familiar with the developpements in the region, could play an intermediary role.

  At the CNSF,the laboratory is rather well equiped and a further extension is foreseen.

  For most of the West African countries storage facilities are the minimum requirement.

- Training the personnel to maintain the equipement should be done when more advanced equipement is introduced.

- More important Seed Centres should possess a computer. A workshop should soon be organized to evaluate the possibilities to come to a uniform computer programme in order to facilitate the exchange of data.

V/ FINANCIAL PROBLEMS

- Financial means are very often unavailable to create a seed centre, not only for buildings and equipement, but also for financial support needed to operate such institutes.

  One should always aim at financial independance, e.g. through the sale of seeds.

Recommandations and Solutions

- At the moment the CNSF is funded by The Netherlands ("Dorschkamp") and Canada (IDRC), which made it possible to develop an operational Seed Centre.

- However it is more problematic for many countries to get the most basic equipememt because of a lack of financial means.

C O N C L U S I O N S

The activities outlined above show the necessary steps considered and followed in setting up a comprehensive seed programme as well as the priorities and constraints encountered (FAO, 1985).
At present the CNSF is operational even if more remains to be done.
The main task for the future is to gradually improve the work programme at other seed centres when they do not exist. The CNSF might play a coordinating role in this by functioning as a Regional Seed Centre.

The availability of sufficient amounts of high quality seeds of a large range of species encourages more ambitions forestry programmes. Consequently, the survival as well as the growth of the plantations improve, which leads to better successes in forestry operations in the Sahel.

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IMPROVING SEED SUPPLIES IN NEPAL
- A PROGRESS REPORT -

by

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INTRODUCTION

A background to seed supply problems in Nepal was presented at the last IUFRO symposium held in Bangkok (1). This paper gives details of some aspects of progress made to date.

Until the beginning of 1987, forest seed supply activities were the responsibility of the Community Forestry and Afforestation Division of the Department of Forests. Now these activities are covered by a 'National Tree Seed Project (NTSP)', which His Majesty's Government of Nepal (HMGN), with assistance of the European Economic Community and the UK Overseas Development Administration officially initiated in February 1987.

The main objective of the NTSP is to ensure adequate seed supplies for all afforestation projects within Nepal, which now number over 20, covering almost all of the 75 forest districts, and totalling over 18,000 ha of plantation per year. The strategy of the project, in line with HMGN's policy of decentralisation and dictated by the mountainous and inaccessible geography of Nepal, is to provide support to the 75 forest districts in achieving self sufficiency in seed supplies, and to take responsibility for those aspects of seed supply which the districts cannot handle.

This support is being provided at three levels. Centrally, in Kathmandu, the project has its headquarters at the Tree Seed Building which comprises offices, longterm cold store, laboratory and processing facilities. The staff there are, or will be, concerned with the following support activities:

- Documentation of seed requirements of all projects and districts.
- Survey and registration of existing seed sources, with assistance from the districts.
- Improvement of existing seed sources, in cooperation with HMGN's Research Office.
- Establishment of new improved sources, with assistance from the districts.
- Collection of seed from species that will benefit from a centralised operation.

- Long term storage of seed, either collected by the centre or supplied from the districts.
- Processing and treatment of seed collected by the NTSP or the districts.
- Testing of seed lots held by the NTSP or of samples submitted by projects or districts.
- Import of seed of species or provenances that are not available in Nepal.
- Distribution of seed to projects and districts that have been unable to collect locally.
- Training of personnel at all levels and in all aspects of seed procurement
- Provision to the districts of equipment and materials required for local seed collection.
- Publication of a series of manuals and technical notes on all aspects of seed handling
- Research into problems of seed improvement and handling.
- Export of seed for research and commercial requirements.
- Certification of seed quality to international standards of exported seeds.
- Contact and cooperation with other seed organisations within and outside of Nepal.
- Advice and technical assistance in planning and budgeting at district level.

At regional level, 3 field stations will be established to carry out those activities that are best undertaken regionally such as medium term storage of seed, seed source selection and establishment, and seed collection.

At district level, the responsibility for the majority of seed collection and handling will lie with the district forest office, or project within which the district is included, with the NTSP providing support as already indicated.

SOME ADVANCES

During the past three years, prior to the project's official initiation, steps have been taken to advance as many of its objectives as possible. Some of the more important aspects of progress that may be of interest to the symposium participants are as follows:

C o l l e c t i o n

Three training courses in tree climbing for seed collection have been organised over the past three years in collaboration with the DANIDA Forest Seed Centre. These courses have given emphasis to teaching techniques of climbing using spurs and safety belt with saddle, with a view to improving the rate of seed collection, decreasing damage to trees, and ensuring the maximum safety to the climber.

The strategy of the courses has been to train forestry staff from the various districts/projects who, besides doing actual collections, can themselves act as trainers within their respective areas, and thus diseminate the techniques as quickly as possible.

Based on the experience of these courses, a series of documents has been produced to enable further courses to be carried out by national staff. These could be of interest to other countries wishing to introduce similar techniques:

-Organiser's guide to running the course.
-Tree climbing with spurs. An illustrated manual for seed collectors (2) (copies available for inspection at symposium).
-Training supervisors notes.
-Equipment notes.

District seed handling

As mentioned previously, the strategy of the project is to support the forest districts in becoming as self sufficient as possible in seed supplies. Many of the species planted within each district occur there naturally, and so it is most appropriate if the seed is collected and used locally.

This is at present done by many districts, but the activities need to be strengthened and improved, and as a first step in promoting this, the NTSP has produced a Manual on Tree Seed Handling for field staff (3), covering collection, processing, storage and testing. It is not possible yet to say how effective the manual will be until proper evaluation has been carried out. Copies of the manual are available for inspection during the symposium.

In addition to the manual, equipment is being supplied to the districts, in particular to improve drying and storage of seed and minimising post-harvest losses. Prefabricated wire mesh drying trays, and galvanised iron tins with thick polythene bag liners are the main items being issued.

Testing and storage

The central seed testing laboratory is now fully equipped and organised, although not yet adequately staffed. Germination tests are carried out in plastic boxes with sand substrate, placed in incubators. Various studies have been carried out on the storability under different regimes of several species (in particular Alnus, Prunus, Pinus (4) and Dalbergia), which have produced useful guidelines for field storage. A simple hotwire seed scarifer was developed, which is the subject of a DANIDA DFSC technical note (5). Unfortunately, technical problems with the seed store have frequently produced a fluctuating temperature. How damaging this has been to the seed is not known, as studies do not appear in the literature. This might be a useful topic of further research for the IUFRO project group.

Improvement of seed sources

A paper is being produced on this subject, in cooperation with the DANIDA Forest Seed Centre, to provide a background on which to base future work of the NTSP and other projects, both national and regional. Since species, end use and sites are so varied within Nepal, it is important to establish priorities as to the type of improvement required, and on which species it should be carried out.

Readers requiring further information about the project are requested to write or visit the following address:

The Project Manager.
National Tree Seed Project (HMGN/EEC/ODA)
c/o The British Embassy, P.O.Box 106.
Tree Seed Building, Hattisar, Naxal,
Kathmandu, Nepal. Tel. 412004.

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STRATEGIES FOR THE IMPROVEMENT OF TREE SEED SUPPLY IN KENYA

Gert Rode

Kenya Forestry Seed Centre Muguga

INTRODUCTION

Simultaneously with the foundation of the Forest Department in Kenya in 1902 the import of seed of exotic tree species commenced. Species to replace the clear-felled indigenous forests usually were Eucalyptus and Acacia, later on reafforestation activities were dominated by Cupressus lusitanica and Pinus patula. By 1925 the central seed store and sales office was handling over 600 kg of seed of exotic species annually (ODERA, 1984) and about 5,500 kg of various indigenous species (GARDENER, 1926). Until 1982 the industrial plantation programme comprised about 160,000 ha with more than 90% of Cupressus lusitanica, Pinus patula and Eucalyptus spp. with a respective increase of the seed demand for these species. Planting of indigenous species was limited to a few local cases. During the period 1983-1988 it is intended to establish a total of 190,000 ha mainly with the above mentioned plantation species.

The enormous increase of the population in Kenya (4% per annum) committs to an urgent extension of the agricultural production. The establishment of new plantations will therefore be concentrated on the large unplanted areas within the gazetted forests and on planting activities outside the forest, like single trees, tree groups, living fences, etc. (JESTAEDT, 1986). In particular the latter field received strong support from the Kenyan Government. In order to reach the new target of an increased seedling production (from 38 millions up to 200 millions annually) seed supply was so far a major bottleneck. The recent turn towards an intensification of planting indigenous tree species as new guiding principle in forestry politics moreover sets foot on an area, which has not been considered in regard of seed supply so far. Within the framework of the project "Kenya Forestry Seed Centre" it shall be tried to take immediate measures to improve the continuous seed supply.

ORGANIZATION STRUCTURE OF FOREST SEED HANDLING

In particular due to the insufficient equipment, the small, so far centralised operating tree seed unit in Muguga as part of the Kenya Forestry Research Institute (KEFRI) was not able to fulfill the requirements for a tree seed centre satisfactorily. According to DORAN (1984) the main functions of a tree seed centre are procurement and supply of high quality seed, research and extension and training. By the end of 1986 a new Seed Centre has been set up and provides all necessary spatial and technical requirements (offices, laboratories, spacious cold rooms) for appropriate seed testing and storage. The staff is familiar with the supplied equipment and has been trained in the most important techniques of seed handling. In seed testing the aim to be reached within a reasonable time is the achievement of standards in accordance with the ISTA-rules.

The essential task of the Seed Centre is the control of seed quality. The importance of genetic constitution and germination performance has to be emphasized clearly. The Seed Centre centrally arranges for selection of the suited seed sources (seed stands, individual trees) and conducts seed testing as a permanent task. To follow the provenance of the collected seeds, collection data reports have been introduced which contain information about the location, climatical and site data, number and quality of parent trees, etc. To ensure a co-ordinated acquisition of tree seed, all new germplasm will be introduced through the Seed Centre (ODERA, 1984).

On the field of seed collection and processing the tasks of the Seed Centre were decentralized to five sub-centres (a sixth is planned) which are spread over the whole country. The sub-centres shall also increase local capacities in seed collection. They cover all ecological zones with their respective sphere of responsibility. Every sub-centre is headed by a forester and has 4-6 trained harvest climbers. Seed collection and precleaning is carried out by these institutions under supervision of the Seed Centre. The sub-centres are or will be provided with all necessary equipment for harvesting, climbing, seed processing and transport. Seeds collected in the sub-centres are forwarded to the Seed Centre for further processing (final cleaning, testing, storage, distribution).

Basically the seed stored at the Seed Centre can be obtained by everybody. The current distribution system to the forest stations is in an urgent need of improvement because the procedure via the Forest Department proved to be time-consuming and caused high viability losses. Most probably the consignees will be delivered direct due to frequent transport problems on their side.

EXTENSION OF SEED SOURCES

At present seeds in Kenya are collected from the following sources:

- seed orchards (selected plus-trees without checking of heritability so far)
- seeds stands
- individual trees
- general collection (non-selected stands or single trees)

Although the establishment of indigenous species shall be promoted considerably it seems to be obvious that the exotics Cupressus lusitanica and Pinus patula will remain to be the most important plantation species in Kenya for the foreseeable future. For both species seed can be obtained from seed orchards and selected seed stands. The general collection is applicable for most of the indigenous and agroforestry species. In future seed of indigenous species will be collected increasingly from individual trees while seed for agroforestry purposes to a large extend will originate from specially established seed stands.

Seed orchards

For the two plantation species Cupressus lusitanica and Pinus patula seed can be procured without restrictions from four clonal seed orchards in each case. The collected quantities especially of Pinus patula remained on quite a low level upto 1984 which can be related to a too close spacing in the orchards. Not until after necessary thinning in 1986 more abundant flowering and cone production can be expected due to an improved crown development and a higher light incidence.

There is a need to increase the seed harvesting in the seed orchards because of a too narrow a genetic base of both species in Kenya. Until 1985 about 75% of the seed quantities of Cupressus lusitanica originated from only two seed stands which most probably are offsprings of only 12 parent trees of a research plot (DYSON, 1986). There is evidence that seed of Cupressus lusitanica from seed orchards have a better genetic variation since plus-trees selection was conducted in a number of stands of presumable different origins in Kenya, Tanzania and Uganda (JESTAEDT and RODE, 1986b). The problem is similar with Pinus patula because the African plantations originated from about 15 kg of seed introduced from Mexico (JESTAEDT, 1986). The established seed orchards of Pinus radiata contain either too little a number of clones after heavy losses caused by Dothistroma pini or were established for resistance breeding purposes without conducting progeny tests. Furthermore the disease resulted in an abondonment of the plantation programme of P. radiata.

Seed stands

Although the demarcation and establishment of seed stands should be an interim measure in forest tree breeding programmes (KEIDING, 1975), the high demand for seed of different species necessitates the selection and protection of seed stands for future collection in Kenya. For the plantation species - exotic and indigenous - seed stands are considered to be the only measure for continuation or initiating a tree improvement programme. Seed stands in Kenya are subject to thinning and other treatments to improve the genetic quality.

The selection criteria for seed stands are:

- superior volume production
- uniformity
- form and growth habit
- fine branches
- minimum area of 5 ha, exception for seed stands of rare indigenous species 1 ha
- adequate age for long term seed production
- accessibility.

The selection occurs in plantations only as (1) frequently the size of the remaining natural forest area is too small, (2) the natural forest is not accessable, (3) species to be selected are mixed and scattered over a large area in a number of different forest types and (4) there is no possibility of demarcating the collection units.

An inventory of the earlier (before 1985) selected seed stands revealed that from 73 stands only 25 could be used for further seed collection. While 24 of them comprised exotic species (*Araucaria angustifolia*, *A. cunninghamii*, *Cupressus lusitanica*, *Eucalyptus regnans*, *Pinus patula*, *P. pinaster*, *P. radiata*) the only seed stand of an indigenous species was one of *Brachylaena hutchinsii*. A seed stand selection programme was launched in 1985 which still continues. Until 1987 42 new seed stands were selected with a total of 456.3 ha comprising 5 species exotic to Kenya (*Eucalyptus saligna*, *Gmelina arborea*, *Grevillea robusta*, *Pinus caribaea*, *P. patula*) and 7 indigenous species (*Brachylaena hutchinsii*, *Juniperus procera*, *Maesopsis eminii*, *Polyscias kikuyuensis*, *Prunus africanum*, *Ocotea usambarensis*, *Vitex keniensis*). All selected stands were recommended for long term protection to the Forest Department (JESTAEDT and RODE, 1986a). Thus including more stands to be selected an essential step towards a continuous seed supply was done provided the seed stands are protected from early clear-felling.

Selection of individual trees

Within the natural forest and in the semi-arid and arid land the important indigenous species can only be found scattered over a large area. Selection and protection of identifiable units as seed stands is thus not possible. The phenotypical selection of individual trees within a defined area of homogenous climatical and if possible soil conditions was considered to be the alternative. It proved to be good to restrain the area to the vicinity of a forest station, as only their protection and actual collection from the selected and marked trees are ensured. Within the defined area 20-50 individual trees per species are selected with a minimum distance of 50 m apart. In this connection criteria are taken into account, which distinguish the selected tree from the other trees of the same species on the same site. The selected trees are thus phenotypical better than the population mean. The selection standards depend absolutely on the purpose the respective species is used for. Heavy branching and a large crown are desired for firewood-, fodder- or charcoal- species. On the other hand, species providing quality timber are selected with emphasis on straightness of stem and vigour. The selected trees must have fully developed their characteristics.

In case the natural distribution of the species allows to do so, individual trees of the same species shall be selected in different forest regions of the country to obtain seeds from various provenances.

Recording of all individual trees on detailed maps is necessary containing all informations about geographic location, ecological and phenotypical data. It is intended to register about 50 species as a first phase. Similar to the selection of dry zone species in Central America (HUGHES, 1984) are collectable populations frequently difficult to locate and the number of desired parent trees cannot always be reached due to rarity in the respective area. The genetic gain might be low since the selection criteria can show little heritability but it will extend the little knowledge we have about these species so far.

Establishment of seed stands

The demand for seed of the agroforestry species spectrum has increased considerably in the last years in Kenya. Seed of e.g., Calliandra calothyrsus, Gliricidia sepium, Grevillea robusta, Leucaena leucocephala, Parkinsonia aculeata, Prosopis chilensis, Sesbania sesban, etc. can only be obtained in small quantities from seed stands (Grevillea robusta) or scattered single trees (Parkinsonia aculeata, Sesbania sesban). For this reason a programme was set up which aims at the establishment of seed stands of seed production areas as immediate source of seed of suitable origin. In 1986 one stand of Prosopis chilensis was planted, others will follow including species like Calliandra calothyrsus, Dalbergia melanoxylon, Gliricidia sepium and Parkinsonia aculeata. The size of the stand is usually 2 ha, but depends on the respective possibilities in the area. Seeds of species in high demand which cannot be obtained locally, are imported in small quantities and subsequently used as a seed source for the establishment of a seed stand.

RESEARCH AND INFORMATION SPREADING

For most of the indigenous and some of the exotic species in Kenya information about necessity and methods of seed treatment is still lacking or not available. Henceforth research work contributes to minimize the costs for seed collection and handling, to reduce the seed consumption and to shorten the nursery period (RODE, 1986).

One of the essential objectives of the Seed Centre is the development of seed collection-, storage-, processing- and germination techniques , especially for indigenous species. It is also applicable for practical sowing-methods in the nursery and for flowering and fruiting phenology which differs widely according to the various climatical and site conditions within the same species. Frequently knowledge is existing in some places but it is not available for central authorities. This knowledge has to be accumulated and evaluated and eventually to be transferred to practical forestry.

It has to be ensured that seed which is procured at high costs, will be used effectively. Therefore the consignees receive with the seed the necessary information about pretreatment and sowing methods. Not in all cases, however, this information is readily available due to lack of results or experience with a certain species. At irregular intervals the Seed Centre publishes reports about achieved results in seed testing or makes use of the possibility to spread some information to a larger number of interested people by means of a newsletter.

SUMMARY

The demand for forest seed in Kenya will increase considerably in the next years due to a high population growth rate, the promotion of planting indigenous tree species as new guiding principle in forestry politics and the support for agroforestry activities. This resulted in some measures taken by the Kenya Forestry Seed Centre. After a change of the organization structure essential functions could be decentralized. The seed collection

sources were extended by a comprehensive seed stand selection programme, the selection of individual trees and the establishment of seed production areas. The selection criteria and methods for the programme are described. Furthermore the need for research and transfer of information in seed handling especially for indigenous species is pointed out.

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SEED PROBLEMS IN ZAMBIA

By

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ABSTRACT

Seed research problems including shortage of funds facilities and staff are mentioned. Some problems with clonal seed orchards and indigenous species seed are given, and possible solutions regarding seed orchards are indicated.

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1.0 Introduction

Forest tree seeds in Zambia are handled by staff of the Tree Improvement Research at Kitwe. The section of the Division of Forest Research has operated since 1965 when the first seed orchards were established in the country. In addition to seed production, processing, testing and storage, the section is responsible for research into provenance and progeny trials, plus tree selection and gene conservation. All afforestation programmes in this country depend on seed which has been collected or imported, stored and tested by the section.

The section is headed by a professional Forester who is being assisted by four technical staff and 10 general workers. There is co-ordination in some work between the section and Tree Improvement Research Unit (indigenous species) of the National Council for Scientific Research of Zambia. The total area of seed orchards in Zambia is 175 hectares. Most of these orchards are exotic, but the area of indigenous species is likely to increase. Many of these orchards are at a stage of maturity where decreased quantities of seed are being harvested, so that the problems relating to seed become especially important.

The main indigenous timber species are _Pterocarpus angolensis_, _Baikiaea plurijuga_, _Khaya nyasica_ and _Brachystegia_ species. Exotic timber species include _Pinus oocarpa_, _Pinus kesiya_, _E. grandis_, _E. cloeziana_, _E. tereticornis_ and _E. camaldulensis_.

The main problems are lack of trained staff on seed maters, shortage of facilities and equipment, and lack of funds, low production in some clonal seed orchards, difficulties in seed collection, poor isolation and elephant damage.

2.0. Problems in Seed Orchards

2.1. Difficulties in Seed collection

Eucalyptus grandis seed orchards at Chati are so tall (35-40m) that traditional tree climbing cannot be used for seed harvesting. This problem is most serious with _Eucalyptus_ species and the bulk of the flower and fruit is not readily accessible, either for application of treatments or for fruit collection.

The small amounts of seed obtained form *Pinus kesiya* orchards at Chati are not only due to poor flowering but also is attributed to difficulties in cone collection. The lower branches are so thick that climbers cannot pull them close enough to pick cones.

The problems with eucalypts can be solved by treating trees so that they will develop a short, wide and bushy habit. The trees can be shaped by topping them and bending branches by tying or weighting. A small trial was established at Chati in *Eucalytpus grandis* clonal orchard and in a *Eucalyptus maculata* seed stand. There were twenty trees cut before the rainy season in both stands. All the cut grafts in *Eucalytpus grandis* orchard formed epicormic shoots but only a few *Eucalyptus maculata* trees did so.

In pine orchards shaping of trees has not given good results (Barnes and Mullin, 1974). The cone crop may decrease remarkably and more selfing than normal is likely to occur. However, the only method to remove difficulties in seed collection in pine orchards might be to develop mechanical aids. In future a tractor with hydraulic lift may solve the collection problems, but the close spacing of the Chati seed orchard (2.74 x 2.74 in some cases) might create another problem to the hydraulic lift. This might call for heavy thinning of the clonal seed orchards.

2.2. Low productivity of some clonal pine orchards

The seed crops collected from *Pinus kesiya* clonal orchards have been low (0.5-11.4kg/ha/yr) although most of the seed orchard stands have reached maturity. Seed crop data from *Pinus kesiya* orchards else-where are not available. However, in comparison with Austrarian *Pinus radiata* D. Don orchards, there exists a considerable difference. According to Brown and Pederick (1976) seed production in *Pinus radiata* clonal orchards starts at the age of about 5 years and tends to increase every year thereafter reaching 20-25 kg/ha at age 12 years. In some years it is reported that heavy crops may reach 40kg/ha. There are also some other pine species in Australia which produce more seed than *Pinus* radiata, for example *Pinus elliottii* may yield up to 170 kg/ha.

Amongst the different kinds of flower-promoting treatments applied to seed orchards, selection of site, fertilizer application,root, stem and crown treatments and application of plant growth substances, a fertilizer application was tried in 1979 in a Pinus kesiya clonal orchard at Chati. There were four experimental treatments used (NPK 5kg/gr), (NPK 2.5kg/gr), (NPK 5 kg + 20g borate/gr), NPK 2.5kg + 20g borate/gr) and control. The difference between treatments were not statistically significant. However, it is concluded that NPK has a slight stimulating effect, but borate fertilizing on the contrary seemed completely without any effect. It is possible that treatment could have had most effect on flowering in 1979 and corresponding on cone crop in 1981, but that crop was not studied, so that the influence had been only slight on the next cone crop. In view of the comparatively large amounts of fertilizer used, NPK fertilizing can be regarded as an uneconomical means of stimulating cone production in a 7-year-old Pinus kesiya clonal orchard at Chati (Mikkola and Mubita, 1982). However, it has become apparent that cone crop is remarkably increasing as the orchards are ageing. Also fertilizing might be effective at older age.

The results of first fertilizer application trials in tropical pine orchards have varied from depression of flowering through no response, to considerable gains. The attempt by Shelbourne (1963) to stimulate flowering in Pinus kesiya in Zambia by fertilizer treatments, girdling and root pruning showed negative results, and it was concluded that male and female flowering of young <u>Pinus kesiya</u> is not stimulated by any of the three treatments. The trees were 3-5 years old and the amount of fertilizer used were small, 442-885g NPK/tree. Comparatively large amounts of fertilizer have been applied in successful trials else-where. In a trial in Zimbabwe, Barnes and Mullin, (1974) applied 2550g and 5100g NPK/graft in <u>Pinus elliotii</u> and <u>Pinus taeda</u> L. seed orchards. There was no doubt that treatments improved the productivity of male and female strobili.

2.3. Possible solutions to problems of seed orchards

A plan to renew seed orchards with the assistance of FINNIDA/ Finnish International Development Agency) is being executed as a solution to seed orchard problem. The earlier tasks of the Division of Forest Research were connected to meet the needs of Industrial plantations.

However, the importance of forestry in other parts of the country outside the Copperbelt province is increasing, so that community forestry, production of fuelwood, poles, sawn timber by villagers, commercial farmers and businessmen will receive special attention in future.

The order of relative importance of the species from the Government point of view is: *Pinus oocarpa*, *Pinus kesiya*, *Eucalyptus*, *grandis*, and *Eucalyptus cloeziana*. The proportion in area of pines to eucalypts has been about 3:1. The silvicultural practice for eucalypts to have at least two coppice crops after the first clear-felling diminishes the need for eucalypt seed. Other species, *Pinus merkusii*, *Pinus patula*, *Pinus caribaea*, *Pinus michoacana* and *Gmelina arborea* have only secondary importance, but will be included in the plantation programme.

Eucalyptus tereticornis and *Eucalyptus camaldulensis* have special importance in community forestry in many parts of the country as drought resistant species. The main task is establishing a *Pinus oocarpa* seed orchard and interspecific crossing trial, *Eucalyptus tereticornis* X *Eucalyptus camaldulensis*.

2.4 Poor Isolation in the Chati Seed orchard area.

Isolation of the Chati seed orchards was probably not considered at establishment. Presently, the area is sufficiently isolated from other plantations, but isolation within the area is poor. The species which may cross have been planted close to each other, and at times side by side. This means there are orchards of the same species but different provenances which will exchange pollen.

The planting of different species of pine orchards on the same site might not be advisable. The problem of isolation in the Chati seed orchard can possibly be improved by clearfelling some useless seed stands and some orchards where seed is not collected. It is also not certain whether *Eucalyptus*-fence plantations around the pine orchards have any value for isolation. However, no hybrids or serious inbreeding so far has been reported from our seed users.

2.5 Root stock - scion incompatibility

Graft incompatibility is a serious problem in *Eucalyptus cloeziana* seed orchards, and partly in field-grafted *Pinus kesiya* seed orchards. The species exhibit early stock-scion incompatibility symptoms. Late age graft incompatibility has been found in 17 years old *Pinus merkusii* grafts in the Dola Hill orchard. However, this has not yet created any serious problems since only about 5% of the grafts are affected.

2.6 Damage by elephants at Chati seed orchard

Elephant damage in *Pinus kesiya* orchards is an increasing problem and no satisfactory solution has been found. Damage occur mostly during the rainy season when the phloem comes off easily. Elephants strip off the bark of stems from the base up to breast height or more.

Some of the stems lose all their bark and phloem at this level and die.

The clonal seed orchards are affected more seriously than other commercial plantations, where often edge trees are in danger.

The wider espacement in clonal stands seem to attract elephants and very many trees are usually destroyed. Every year 30-100 trees are debarked and the worst year was 1978 when more than 150 stems were damaged which had by then just started seed production. By now most of these trees have died.

In 1979 creosote treatment of stems was tried and the results were negative. The fence plantations and electrical fences can be proposed, but these may have their own disadvantages.

Shooting of elephants was tried in 1980 when two elephants were killed within the seed orchard area, but elephant shooting is no longer encouraged by the Government.

2.7 Fire damage

Fire damage to pine and eucalypt seed orchards has also contributed to low seed productivity. In 1979 about 50 hectares of the total seed orchard area were destroyed by fire. Fire protection measures were not implemented as expected due to lack of facilities and funds.

3.0 Seed collection and processing

Seed collection is organized by the Tree Improvement section staff, forest officers, provincial and district officers based on the guidelines prepared by the Forest Geneticist. The seed is sent to the seed section at the Riverside Forest Research station for extraction, testing and storage. The exchange of seed between the forestry sectors is allowed but reports on seed sources, quantities and date of collection are sent to the Forest Geneticist for registration and control.

The fruit and seed of some indigenous species are collected from the ground after shedding, for example Afzelia quanzensis and Baikiaea plurijuga etc. The collection operations are usually carried out as soon as the seeds or fruit fall to avoid loss of viability and damage by fungi. However, largest quantities of seed are collected from standing trees in seed orchards and indigenous forests. The trees are climbed manually and the fruit/cones picked by hand or knocked off with hooks and poles.

Seed processing includes extracting seeds from cones or fruit, cleaning and drying the seed before storage. The cones of pines, capsules of eucalypts and most Acacia pods are dried in the sun on concrete floors, shallow wire mesh trays or on canvas and shaking. However, with some species, fruit/cones/capsules are dried in an oven at appropriate temperatures and after drying are opened by hand or flailed to release the seeds.

Pulpy fruits of Gmelina aborea, Maesopsis eminii are macerated and the seeds are separated from the pulp by washing in water and drying. The lack of equipment has made it impossilbe to obtain sufficient supplies of forest seed from the local seed orchards, particularly from indigenous stands. There is a need to provide transport during seed collection periods.

4.0. Problems with Insects

4.1. Exotic plantations

Information on the cone and seed insects of pines in Zambia and other neighbouring countries is scarce. This is largely due to the fact that seed collection in the field is found free from insect attack and/or, the importance of any seed destroying insects is believed to be negligible. However, cones and seed must be thoroughly inspected during the field and during storage . Apart from seed ripening in the field, seed in storage can be infested by many species of insects. In general these insects are commonly polyphagous on any seed material and not confined to any species. They are often beetles and include several members of such families as Cucujidae, Anobidae, Tenebrionidae or Bruchidae. The stored seed can also be attacked by Pyralid moths (eg Plodia-interpunctella).

There are no records available about insects destroying eucalypt seed in the field. As to stored seed, the above applies to eucalypts as well.

4.2 Indigenous species

The seed or any fruiting structure of indigenous trees are often attacked by various insects. Unfortunately there is no particular study or survey carried out on this subject in Zambia, all information in based on general observations and insect collections. In this context, the beetle family Bruchidae and particularly the genus Bruchidus is well represented on leguminous tree species.

5.0 Conditioning of Forest seed

The pathology laboratory conducts seed testing to determine the health status of both indigenous and exotic seeds. This gives information that can be used to compare the value of different seedlots. Health testing of seed is carried out also on import and export seed. A survey of forest diseases, disorders and seed-borne fungi is currently being conducted in major forest plantations and is to cover the whole country.

Seed tests are carried out on viability, germination and number of seeds per kilogramme. There are two types of germination tests carried out. Experimental tests are done for species which give poor or slow germination in order to determine the presowing treatment or germination media which produces the best results. The quality of seed entering storage is maintained by Control of the storage environmental factors, relative humidity and temperature.

The tree improvement laboraotry conducts medium scale testing of seed, and a coldroom is available which can store up to 15 tonnes of seed. This can be expanded so as to accomodate additional cooling equipment to facilitate bulk storage.

The major problems in seed processing and testing include lack of specialists, facilities and funds. Presently, there is a shortage of qualified technicians in seed technology. There is a need for staff training in seed technology and this could be organized by international organizations. It is also hoped that developed countries can help train people enganged and interested in tree seeds from Zambia and other developing countries.

More research has been done on exotic softwoods in Zambia and less attention has been paid to indigenous hardwoods. In future, there is need for expansion to include research on indigenous hardwoods.

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FOREST TREE SEED SUPPLY IN TANZANIA PROBLEMS AND PROSPECTS

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Summary

Recently there has been a tremendous increase in seed requirements for afforestation in Tanzania as a result of increase in awareness among the people on the need to plant trees to meet their wood requirements. The paper emphasizes the need of finding ways and means to meet seed requirements. The paper has reviewed what has been done and what reamins to be done to meet the increase in demand for seeds in the country. It has indicated the need for intensifying research on seeds of indigenous tree species, a field which has been overlooked in the past.

INTRODUCTION

Afforestation in Tanzania for industrial purposes started in the early 1950's in a number of places, by introducing fast growing exotic timber species to augment the generally slow growing indigenous trees (Borota J. & Proctor J., 1967).

Recently there has been an increase in planting targets to meet a variety of objectives including provision of fuelwood, building poles and raw materials for woodbased industries. The most extensively planted species include; Pinus patula, P. caribaea, P. elliottii, Cupressus lusitanica and Tectona grandis. Other species planted on a small scale include Pinus kesiya, P. oocarpa and P. taeda, Acacia mearnsii, Grevillea robusta, Chlorophora excelsa, Pterocarpus angolensis, Maesopsis eminii, Terminalia ivorensis, Olea welwitschii and Eucalyptus species.

Several multipurpose trees are also planted in various parts of the country (Forest Division, 1984).

The increase in planting for various purposes has resulted in a significant increase in seed requirements within the last ten years. The Silvicultural Research Centre which was established in 1952, had a section on seeds which was created to procure and handle seeds for establishment of industrial plantations has now to include the new behaviours, with their new seed problematics. It is expected to take into account the increase in demand for afforestation. In order to achieve this there is a need for conducting research on flowering, seed maturation, collection and processing, storage, germination studies and nursery techniques for the various indigenous tree and shrub species, some of which appear to have specific requirements.

Such research programmes will certainly need personnel, equipment and funds, in order to operate smoothly and come out with acceptable results. The central seed store of the country at Lushoto which is supposed to meet the internal demand has often failed to meet the quantity and kinds required more particularly for indigenous tree species. Even advice on when and how to collect, handle and germinate the indigenous agroforestry species is incomplete because of lack of experience.

This paper analyses the seed situation in Tanzania by showing what has been done, the problems encountered and the future expectations, in order to meet the growing demand of tree seeds in the country.

THE SUPPLY SITUATION

In the past the national afforestation programmes concentrated on fast growing exotics to augment the timber supply from natural forests, while most indigenous tree species were left to undergo natural regeneration on their own. This meant that it was not necessary to undertake seed collection for the indigenous species.

An average of 500 kg of four major softwood exotics i.e. Cupressus lusitanica, Pinus caribaea, Pinus elliottii and Pinus patula was supplied annually to the afforestation programmes. In addition 500 kg of Tectona grandis seed was collected for the hardwood projects.

The seed supply and demand were in equilibrium in the sense that all seed required could be easily handled by the seed centre either by local collections or through imports.

Today there is a big gap between the amount of seed required and that which can be supplied. In addition the species diversity required for the varied ecological zones and end use of the trees has increased the problem of meeting the demand. The increase in population and the general awareness of the people on the value of trees for fuel, building and fodder etc, has triggered the seed requirements of the country. Many requests are turned down because the seed centre cannot handle the requirements. Village forestry and individual programme planners have been advised to collect seeds at their local places or elsewhere for their own use and send in their surplus for storage and exchange.

On an average the centre now distributes about 1500 kg of seeds per year for commercial and research purposes within the country and outside. These include 200 different trees and shrubs of indigenous and exotic species (Msanga H.P. & Shehaghilo I.M., 1984). All seed supply for industrial plantations is collected from seed orchards and seed stands (Table 1).

Seed supply for non-industrial planting is collected from wherever seed trees are seen e.g. woodlots, homesteads, avenues, windbreaks etc. without much consideration of genetic quality. Very little of the non industrial seed species have been supplied by the seed centre at Lushoto, therefore overall figures on supply and demand for the whole country for both industrial and non industrial plantations are not available, but it is understood that the total collections are generally lower than the overall requirements.

Table 1. Seed orchards and seed stands in Tanzania.

Species	No. of seed orchards	Area (ha)	No. of seed stands	Area (ha)
Pinus patula	6	12.0	5	15.0
Cupressus lusitanica	5	6.0	5	3.2
P. radiata	4	8.0	0	0
P. caribaea	1	20.0	3	62.0
Juniperus procera	0	0	1	0.7
Cephalosphaera usambarensis	0	0	1	0.08
Olea welwitschii	0	0	1	0.08
Maesopsis eminii	0	0	1	0.24
Eucalyptus grandis	0	0	1	0.04
Tectona grandis	0	0	2	27.27

Problems of seed supply

Apart from collections from seed orchards and seed stands which are insufficient, the rest of the collections cannot be ascertained as to their quality and continuous availability. There have been some cases where best collection areas were no longer available for seed collections because the owners have felled the trees for their own use. Many indigenous species which have shown some promise for planting in village forestry because of their multipurpose uses, are new to the seed collectors. Their seed problematics from flowering, maturity, dispersal, collection and processing, storage and germination are not fully known. Any phase out of these if improperly handled will hinder the end supply of viable seeds, thus crippling the intended afforestation activities.

Collection costs are frequently high for some species particularly if the best sources are scattered in isolated places. This tends to influence the village foresters who have insufficient appreciation of the value of using an optimum seed source to collect from as near as possible and in the cheapest way without considering the genetic quality. Such exercises sometimes end up with getting insufficient seed and of low quality. Given the manpower constraints and inadequate training, collection equipment and facilities, and inadequate funding, the seed centre in its present set up, cannot catch up with the present seed demand of the country.

Prospects for future supplies

To meet the ever increasing demand of tree seeds, and to ensure their continuous supply, it has been decided to establish more seed stands not only for the traditional timber species, but also for the much demanded eucalypts for firewood and building poles. With DANIDA's support, the recently established gene conservation stands as shown in Table 2, will greatly increase the supply of seed both in quality and quantity.

Table 2. Gene conservation stands in Tanzania

Species	No. of stands	Area (ha)	Remarks
Pinus caribaea	4	62.0	
Pinus oocarpa	1	14.4	
Eucalyptus camaldulensis	2	16.0	
Eucalyptus tereticornis	1	8.0	

These are still in experimental stages, but because they are planted and managed with the aim of producing maximum amount of seed of known quality and origin, and continuous supply is guaranteed, it is hoped that they will greatly alleviate the shortage of seed of these species in the near future.

Research needs

The indigenous tree species in Tanzania which were once in abundance, have now been over-exploited. All logging operations were selective - aiming at taking the best trees and often immature leaving defective ones which are unmerchantable. There was no consideration of leaving some best trees for seeds or as mother trees. The defective trees therefore appear to have taken the motherhood position, bearing seeds for future generations. This practice if unchecked will slowly turn the valuable indigenous forests to undergo genetic degeneration. To ensure future crops of the best phenotypes, it is imperative that seeds to be used should come from best mother trees. Therefore there is a need for demarcating gene conservation stands, which should be conserved and managed for seed production purposes. Conservation efforts have been initiated for a few species e.g. Juniperus procera at Lushoto (O. 7ha), Cephalosphaera usambarensis at Amani (0.09ha), Olea welwitschii at Ngurdoto (0.9ha) and Maesopsis eminii at Amani (0.24ha). More work is needed to increase the area for the existing stands. It is also necessary to demarcate other areas for other important indigenous tree species.

In addition to the longterm studies, shortterm research on indigenous tree seeds should be undertaken. A list of species which should be given high priority and their study areas is shown in Table 3.

Table 3. List of trees seeds needing reserach and their study areas.

Species	Study area
Acacia albida	Phenology in different localities and peak seeding time
Allanblackia stuhlmanii	Dormancy, storage and germination
Beilschmedia kweo	Storage
Brachylaena hutchinsii	Phenology and germination
Cephalosphaera usambarensis	Storage
Chlorophora excelsa	Storage
Cordia abyssinica	Phenology in different localities and storage conditions
Entandrophragma excelsum	Storage
Hagenia abyssinica	Phenology and storage
Khaya nyasica	Storage
Juniperus procera	Phenology and storage
Maesopsis eminii	Storage and germination
Markhamia platycalyx	Storage
Ocotea usambarensis	Phenology and storage
Olea welwitschii	Treatment and storage of seed
Rauvolfia caffra	Phenology, storage and germination
Trema guinensis	Phenology and germination
Trichilia roka	Storage

Many of the above listed species are little known as indicated in their study areas and some appear to be specific in storage conditions and germination requirements. Once the requirement of each is known, it will be easy to deal with each accordingly and thus increase its afforestation potential.

CONCLUDING REMARKS

In Tanzania today there is a growing support by the government on the idea of planting trees and managing forests not just for industrial purposes but also for the production of fuelwood, poles, improvement of soil fertility etc. The general acceptance by the villagers of the integration of trees into agricultural systems in order to get sustained productivity of food, fuel and fodder has very much aroused the need to plant more trees than hitherto. In order to satisfy this demand, there is a need for devising strategies for procuring and handling adequate quantities of seed, otherwise the planned afforestation activities may be hampered. The biblical truth that "what so ever a man sows that shall he also reap" should apply also to the provision of high quality seeds for afforestation programmes, thus seed orchards and seed stands establishments and management have their place in forestry.

It is necessary to intensify research on indigenous tree seeds which appear to have been overlooked by science from flowering, seeding, processing, storage and germination. Any unbroken bottleneck in these stages may impair the afforestation needs of the country. Exchange of research information with countries which have similar trees and similar problems should be encouraged.

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SOME STUDIES ON THE COLLECTION AND EXTRACTION OF **cupressus lusitanica** SEED AT LUSHOTO, TANZANIA

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ABSTRACT

This paper discusses the best time to collect Cupressus lusitanica seed at Lushoto bearing in mind the availability of cones, economy, weather and working conditions without impairing the seed quality. The weather parameters taken into account are rainfall and temperature which mainly govern collection days and extraction periods. October to March is seen as the best period.

INTRODUCTION

One of the fast growing exotic timber tree species grown in the highlands of Tanzania is Cupressus lusitanica Mill, its growth is only exceeded by Pinus spp. (Borota and Precter, 1967; and Shehaghilo, 1973). The seeds used in 1950s were imported mainly from Central and South Africa. Towards the end of the 1960s, it was possible to meet local demand of this seed from selected small stands in different localities of the country. Seeds were collected by local foresters in these areas and brought to the central seed store at Lushoto for storage, testing, verification and later distributed to the places they were required.

As the collection times, methods, storage conditions at the local station and despatch means to Lushoto varied, the quality of seed correspondingly varied. During the mid 1970s seed collection from seed orchards established in the Lushoto area (4°45'S, 38°15'E, altitude 1450 m.a.s.l., mean annual rainfall 1070 mm) began. The quantities produced meet the present demand for the afforestation programmes in Tanzania.

It appears that C. lusitanica seed can be collected throughout the year at Lushoto in varying quantities. The availability of mature cones throughout the year has been confirmed by phenological observations carried out in the seed orchards located in Lushoto arboretum in 1974-1977 (Ruffo and Mtui in prep.). However, quality and quantity as well as economy are important considerations in deciding the time of collection. The aim of this paper therefore is to give some light in programming the collection and extraction of C. lusitanica seed at Lushoto, without impairing its quality.

METHODS

Climatic conditions

Collection of seed was divided into four quarters of the year for the purpose of observation. This kind of arrangement is more convenient and has been used in the past (Shehaghilo, 1977) because there are distinct differences in climate (Table 1).

First quarter, January-March: This period is characterised by hot dry and sunny period except towards the end of March when long rains normally start. During this period the mean air temperature for the quarter is 27°C, and mean annual rainfall is 58 mm.

Second quarter, April-June: This period is characterised by rainy periods most of the time with some sunny days. During this period the average max. temperature is 21°C, and average rainfall is 126 mm.

Third quarter, July-September: During this period it is mostly cloudy and cold with some showers. This being also one of the coldest periods where the temperature drops to 7°C on some days of July and rises slowly to about 20° towards the end of September. The mean rainfall for this quarter is 20 mm.

Fourth quarter, October-December: Temperature and sunshine are nearly the same as in the first quarter above, but the period is more moist rather than dry. The short-rain period comes and ends in this time. It is important to note, however, that the temperature sometimes drops to 3°C on certain nights in the June to August period (Anon, 1982). On some occassions in November to March, the temperature can raise to 40°C at midday on sunny days (Shehaghilo, 1973). Table 1 gives an overview of monthly temperature and rainfall pattern at Lushoto Silviculture Research Station which is the nearest meteorological station to the seed orchard sites. Lat. 4° 47'S Long. 38° 17'E elevation 1400 m.

TABLE 1. Mean temperature and rainfall at Silviculture Research Station Lushoto.

Quarter		Temperature(Co) Max.	Min.	Mean (quarter) Max.	Min.	Rain-fall (mm)	Mean	No of rainy days	Mean (quarter)
	Jan	26	11			59		9	
1st	Febr	28	12	27	11	25	58	7	9
	March	26	11			85		12	
	Apr	24	12			173		21	
2nd	May	21	12	21	11	151	126	22	18
	June	17	9			56		12	
	July	17	8			33		10	
3rd	Aug	18	7	18	8	8	20	6	8
	Sept	20	8			20		10	
	Oct	23	8			20		6	
4th	Nov	22	9	23	9	100	73	13	10
	Dec	23	10			101		12	

Data source: Meteorological file readings for the year 1972-1976.

Collection and extraction practices

The normal practice is to collect cones by picking them from the branchlets or clusters using secateurs and then weighing each day's collection before drying.

Extraction is done by spreading the cones on screens of timber frames each with a wiremesh beneath. The screens are kept in opensided shed except for hot, sunny not rainy periods when the screens with the cones are put under direct sun to accelerate the release of seed.

After extraction, the extracted seeds are weighed and sampled for germination tests just before storage.

Germination tests using Copengagen (Jacobsen) tanks (ISTA 1966) were conducted.

To simplify observations, amount of seed obtained on average of each 10 kg. lots of cones was compared for each quarter collection.

The quarter giving the lowest quantity of cones per kilogramme of extracted seed, shortest extraction period, and high germination capacity for the extracted seeds, was designated as the most suitable period for seed collection (Table 2).

Table 2 shows amount of seed produced for each 10 kg of cones, time taken to extract and germination figures of each collection season.

RESULTS

The results of observations arrived at in Table 2 indicate that first and fourth quarter produce high amount of seed for a given amount of cones and extraction period very much shortened as compared to other periods. The germination capacity hinges to high level also.

Table 2. Average germination capacity, extraction period and quantities of cones needed to produce a kilogramme of C. lusitanica seed at Lushoto, Tanzania.

	Kg. of cones needed to produce kg. of extracted seed	Extraction period (weeks)	No of deter-minations	Average germination (percent)	No of tests
1st quarter	6-7 (6.5)*	1	4	33	3
2nd "	10-12 (11.0)	3-4	5	31	3
3rd "	10-12 (11.0)	4-6	5	29	3
4th "	7-8 (7.5)	1-2	5	32	3

* Average

DISCUSSION

It has been pointed out in some literature including U.S.D.A. (1974) that success in harvesting requires an understanding of seed ripening, dispersal characteristic and knowledge of seasonal weather trends affecting timing of collection.

Since the actual collection is not done on rainy days, the cones picked on sunny days, characteristic of the first and fourth quarters, are dry enough and lighter. Dry cones open and can have seeds extracted more quickly than wet ones.

When it is rainy or cold, working conditions become unfavourable and contribute to total output, as has also been pointed out by Keiding, (1976) that, seed collection should aim at getting the largest possible quantity of seed in the best conditions. This keeps the costs to the minimum.

The second and third quarters of the year can be used for collection of other seeds which cannot be collected in other periods.

The initial quality of the seeds as seen in the germination tests (Table 2) seems to be less affected by the time of collection. There are, however, conspicuous differences in the periods needed for extractions as well as in the quantities of cones needed to produce a kilogramme of fresh seed.

The extraction space and number of screens are limited, so shortening the extraction period, gives room for more seeds to be extracted in the same length of time. Therefore considering economy and climatic conditions, the best time to collect Cupressus lusitanica seed at Lushoto in Tanzania is from the month of October to March.

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TESTING OF MECHANICALLY DAMAGED SEEDS BY VAPOROUS CONTRAST X-RADIOGRAPHY

BY

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ABSTRACT

Mechanical damage to the seeds of Pinus silvestris during processing leads to high economic costs in plant production and poor plant quality. In practice an adequate test is needed for determination of this damage in order to be able to take the necessary measures for improvement of the seed processing. At present, there are few test methods available satisfying this demand.

A radiographic method using chloroform vapours as contrast agent ($CHCl_3$) for determination of different types of damage is presented in this paper. The seeds are treated for 4 hours in $CHCl_3$ vapours and then radiographed. The damaged seeds become impregnated completely or partially by the $CHCl_3$. The impregnation appears with high contrast on the radiograph. This method has the advantage that it indicates not only the visible damage but also the invisible one. The latter damage is difficult to identify with other methods. Even in a standard germination test it remains hidden. The invisible damage can lead to serious consequences. For seeds with such damage exposed to stress, e.g. storage, germination under supoptimal conditions, etc., the effect can be disastrous. Standardization of the $CHCl_3$ test is discussed.

For en easier interpretation of the $CHCl_3$ test it is recommended to subject the seed sample to vacuum in a water container (PREVAC method) whereby the visibly damaged seeds sink to the bottom and the undamaged and the invisibly damaged ones remain floating on the surface of water. Both fractions should then be $CHCl_3$ tested as described above.

INTRODUCTION

Great efforts are made to guarantee a good supply of forest tree plants for reforestation program. Plant production does not depend only on the quantity but also on the quality of seeds. One of the most serious factors changing the technical seed quality for the worse is the mechanical damage caused by man during cone and seed processing, i.e. extraction, de-winging, cleaning and other mechanical procedures. Huss (1950) found that in the middle of this century there were several de-wingers in use in Sweden that were practically deadly weapons to the seeds. According to his investigations, 10-20 % of the annual harvest in Sweden was damaged during de-winging. Although most of the de-wingers used in Sweden today are not destructive to the seeds we have to pay attention to the new machines and equipments that are continuously introduced in seed processing. These machines from a technical point of view usually well constructed are often less than careful with the seeds passing them during processing. Moreover, the processing of seeds in many countries is still performed rather roughly. Thus de-winging of coniferous seeds by putting them in bags and beating them by sticks can still occur. Damage caused by processing can be of different kinds and degrees; from the finest invisible to the most drastical ruptures occurring clearly in the seeds.

An account of the damage to seeds caused by mechanical processing is rarely given in the certificate of seed analysis. This is of course a serious negligence since without information about the extent of damage neither the seed producer nor the user can supervise the mistakes made during seed processing and take the necessary measures. The main reason is that a universally recognized test method is still lacking for identification of the damage. None of the known methods can give satisfactory information about the frequency of different types of damage in a sample as will be discussed later. In this paper special attention is paid to the recently developed method called PREVAC for removal of mechanically damaged seeds from a lot (Bergsten & Wiklund, 1987), which seems to be useful also as a test method. The principle is that the damaged seeds emerged in container with water sink to the bottom, after evacuation of air from the container, whereas undamaged seeds remain floating on the surface.

In Sweden mechanical damage to forest tree seeds is often determined using a test that is less known among seed analysts. The principle for this test method is that seeds are kept for some hours in chloroform vapours and then radiographed. Damaged seeds become impregnated by the vaporous agent and appear contrastfully in comparison with the undamaged ones on the radiograph. These contrast radiographic tests are in the text further called $CHCl_3$ tests. The method applied for the first time to aged and damaged seeds of Pinus silvestris and Picea abies was presented as a pilot study (Simak, 1974a) in which the reactions of the seeds to different treatments with iodine, chloroform and other alkanes vapours were described. In another paper (Simak, 1974b) it was shown, among others, that Scots pine seeds de-winged with three different methods, i.e. by water moistening, by rubbing in hands and by conventional burst de-wingers*, showed different degrees of impregnation after $CHCl_3$ test. The burst de-winged seeds were more impregnated than those de-winged by water and by hand, respectively (cf. Fig. 4 by Simak, 1974b). Despite these differences in impregnation pattern, the seeds in all three de-winging series germinated equally when tested under standard conditions following the de-winging (cf. Fig. 3 by Simak 1974b). However, when Lestander & Mähler (1984) tested the same seed material after 10 years of conventional storage they found that the germination rate of the burst de-winged seeds dropped significantly in comparison with the other two series. This shows that the $CHCl_3$ test is not only a good method for testing the efficiency of different processors for de-winging but may also predict whether a particular seed lot is suitable for long-term storage or not. A demonstration of the fact that the $CHCl_3$ test can reveal a certain weakening of the vigour of seeds was given by Bergsten (1980a). He shook Scots pine seeds for 5 and 12 hours in an apparatus. The subsequent $CHCl_3$ test resulted in higher impregnation frequency the longer the shaking lasted. Although the conventional germination test in laboratory did not indicate any differences in the germination capacity between shaken and control seeds, the shaken seeds germinated significantly slower and lower than control when the germination test was conducted under stressful conditions. Bergsten (1980b) also found using $CHCl_3$ test that seeds sown by a certain type of sowing machine could be damaged by

* Note. The de-winging experiment itself was performed by the personnel at the Institute for Forest Improvement, Sävar, Sweden.

impact occurring during the sowing process.

$CHCl_3$ test was successfully applied to seeds of various species, i.e. *Pinus caribaea* and *Pinus oocarpa* (Simak, 1980), *Abies amabilis*, *Picea glauca*, *Pinus contorta*, *Pseudotsuga menziesii* (Leadem, 1981), *Pinus kesya* (Simak, 1986) and also to different agricultural species (Ostromecki 1984). A common characteristic in all these cases was that the plant species tested possess a naturally high content of fats in the seeds.

Despite the promising results obtained so far, the $CHCl_3$ test is still not standardized but is used as such for want of anything better. Our laboratory has now started a project to standardize this method. This first paper of the project is aimed at answering the questions: How do different types of damaged seeds react to $CHCl_3$ test and how do they germinate? Moreover, the most actual problems within this project are presented under Discussion.

MATERIAL AND METHODS

Seeds of Scots pine (*Pinus silvestris* L.) of a provenance from northern Sweden were used.

Lycksele: Latitude: $64^{o}45'$N, altitude: 300 m, Collection year: 1980,
Germination capacity: 96 %, Germination on day 7: 92 %.

Even in the most carefully processed seeds slight, invisible damage can occur. Therefore the seeds for the experiment were first exposed to $CHCl_3$ vapours for 4 hours, as described below, then radiographed under individual control and finally all seeds with any impregnation were removed from the material. Thus only unimpregnated, presumably undamaged seeds were used. This procedure may have had a slightly positive effect on the germination of the selected seeds (cf. control in Table 1 and the data above).

The selected seeds were then artificially damaged in 9 different treatments (b-j). From each treatment 50 seeds were used for $CHCl_3$ test. The following types of damage were studied.

a) Control: Undamaged seeds (seeds without impregnation or visible damage).

Visible damage: Seeds showing visible cracks, deformation or other types of mechanical damage to the seed coat and possibly to the gametophyte and the embryo.

b) Pinching: The coat of each seed was pressed with a metallic piece on the flat side without cracking the seed coat. By this pressing a visible dent in the coat but no cracks occurred (each seed was tested under stereomicroscope).

c) Incision: Each seed was longitudinally cut on the flat side using a scalpel. The cut passed through the seed coat into the gametophyte but was not allowed to reach the embryo.

d) Pricking: Each seed was pricked on the flat side by a thin needle. The needle protruded partly the gametophyte but not the embryo.

e) Piercing: Each seed was pierced on the flat side using a thin needle passing through the whole seed, i.e. through the gametophyte and embryo.

f) Cutting: Part of the coat and the gametophyte was removed from each seed by a scalpel without damaging the embryo.

g) Rubbing: The seeds were placed in a cloth bag and were rubbed between palms in the same way as by de-winging of small samples. However, the rubbing was more rough than when conventional dewinging was used so as to produce a high number of differently damaged seeds.

Invisible damage: Seeds showing no visible cracks, deformation or other types of mechanical damage to the testa.

h) Impact: Each seed was individually dropped 25 times from a height of 1.5 metres on to a glass plate.

i) Shaking: The seeds were placed in a glass bottle and shaken in hand by 5 shocks.

j) Centrifuge: The seeds were centrifuged for 30 minutes at 5 700 r.p.m.

The differently treated seeds were tested as follows.

$CHCl_3$ test. Seeds were spread out on the bottom of a bottle. A piece of cotton drawn in chloroform was placed in the hollow of the glass stopper with which the bottle was tightly closed during treatment for 4 hours at 20°C (Simak, 1980). In order to study the tolerance of damaged and undamaged seeds to $CHCl_3$ treatment, an amount of the respective seeds was exposed to $CHCl_3$ vapours for different times, up to 9 days.

In an attempt to simplify the interpretation of the impregnation pattern, the $CHCl_3$ test was combined with the PREVAC method. Seeds of a sample were artificially crushed in order to get a sufficient number of damaged seeds for the experiment. The mixture of damaged and undamaged seeds was then separated by the PREVAC method in bottom and surface fractions. Both fractions were dried and subjected to $CHCl_3$ test separately.

Radiography test. Seeds were radiographed under individual control in frames with indentations in order to be able to study the damage on particular seeds under stereomicroscope and compare them with the corresponding radiograph. Radiographs were made in Faxitron apparatus at 15 kV, 3 mA, 25 sec, focus 45 cm. X-film Agfa-Gevaert, D7, was used.

Germination test. From each of the 9 treatments 4x25 seeds were put for germination test in Jacobsen apparatus. These damaged seeds were not treated in $CHCl_3$. The light during germination test was constant $20 \mu E \cdot m^{-2} \cdot s^{-1}$ (Thorn T 40 W/33 cool light), temperature was 20°C constant and test period 21 days. Seed developing normal root, the length of which was at least the same as the length of the seed itself was considered as germinated. Germination was controlled daily and germinated seeds were removed.

RESULT

The 9 treatments described above have resulted in different visible and invisible damage showing specific impregnation patterns for chloroform (Table 1).

Table 1.

Treatment	Impregnation pattern on the radiograph $CHCl_3$ - 4 hours	Germination % days 5	7	21	Not germ. seeds % F	D	Ab
a) Control	No impregnation	70	97	99	1	-	-
Visible damage							
b) Pinching	The whole pinched area impregnated	1	3	10	86	2	2
c) Incision	Impregnation strong around the damage, goes deep into the gametophyte	52	75	84	4	2	10
d) Pricking	Ditto c)	31	87	95	4	-	1
e) Piercing	Ditto c) even embryo impregnated	0	1	11	-	10	79
f) Cutting	Ditto c) sometimes even embryo impregnated	50	74	90	3	6	1
g) Rubbing	Impregnation depending on kind of damage	34	52	70	23	1	6
Invisible damage							
h) Impact	Small dots, sometimes coalesced	11	90	97	3	-	-
i) Shaking	Ditto h) but not so frequent	22	97	98	2	-	-
j) Centrifug	No impregnation	46	97	98	-	1	1

Not germinated seeds were analysed by cutting test at the end of germination test. F = fresh seeds, D = dead seeds, Ab = abnormal germinants. The terms visible and invisible damage are relative since the visibility is determined by the enlarging ability of the stereomicroscope used for observation; in the actual case 32x.

Fissures, cracks and other types of damage to seed coat were never impregnated by $CHCl_3$ vapours. Still, this type of unimpregnated damage except for delicate fissures could be detected on the radiograph (Figure 4). Moreover, this damage was indirectly revealed by the impregnation of the adjacent gametophyte tissues that were usually damaged, too. The vapours always penetrated the seed coat, irrespective of whether the testa and tegument were visibly damaged or not. This was assumed by the fact that the residual tissues of the nucellus not only in damaged but also in control seeds were almost always impregnated by $CHCl_3$ after 1-3 hours treatment (cf. Figures 1a and 2). By prolonged treatment the impregnation of nucellus disappeared. Coming inside the seeds, the chloroform vapours got into touch with the gametophyte. If the gametophyte was not damaged, it remained unimpregnated (Figures 1a and 4) if damaged visibly or by impact (cf. invisible damage), it became impregnated partially or totally (Figures 1 b-i and 5).

The visible damage to the gametophyte, caused by rubbing, incision, pricking, cutting or pinching, became impregnated close to the point where testa and tegument were broken or deformed. The impregnation appeared already after a few minutes of treatment. The impregnation area was sharply marked after about 4 hours in chloroform vapours and was larger than the damaged part of the tissue itself. In pierced seeds also the embryo was impregnated (Table 1 and Figures 1 b-g and 2).

The invisible damage to the gametophyte caused by impact and shaking began to be impregnated after about 1 hour of treatment. The impregnation pattern had a characteristic radiographic image like small round dots that coalesced into larger patches depending on the seriousness of the damage and the time of treatment in vapours (Table 1 and Figures 1 h,i and 2). Centrifugated seeds showed no reaction by $CHCl_3$ treatment.

Concerning the changes of the impregnation pattern related to the time of treatment in $CHCl_3$ vapours, it was found that the seeds with visible damage in the gametophyte and embryo became impregnated faster than those with invisible damage. Both the visible and the invisible damage appeared contrastfully on the radiograph after about 4 hours treatment. By extending the time of impregnation over 4 hours the per cent of impregnated seeds as well as the size of the impregnation pattern within a seed increased (cf. Fig. 2). Also the control seeds became impregnated after prolonged treatment. However, some control seeds resisted impregnation even after 9 days treatment. The most weakened seeds endured the stress in $CHCl_3$ vapour least. First appeared small dots that became larger as the treatment continued and at culmination the whole seed could be impregnated. At further impregnation for several days, the intensity of the impregnation pattern decreased and finally faded out completely. The gametophyte of such seeds showed an emaciated radiographic image. This process of impregnation proceeded at varying speeds depending on the type of damage.

The combined PREVAC-$CHCl_3$ test showed not only the efficiency of the PREVAC method to remove the heavily damaged seeds from a lot but also the capacity of $CHCl_3$ to distinguish the different types of damaged seeds within a fraction (Figure 3).

Damage hurting the embryo itself, i.e. caused by pinching and piercing, is practically deadly. Pricking, cutting, impact and shaking did not influence the germination capacity considerably. Only the vigour was lowered (cf. germination percentage after 5 and 7 days in Table 1). The treatment in centrifuge did not affect the germination of the seeds, with the exception of slightly declined germination after 5 days. Incision and particularly piercing increased the percentage of abnormal seedlings (Table 1). The figures for germination percentages in Table 1 must be considered with some reservation, since the extent of damage to the seeds varies even within the same treatment. Moreover, the presented germination values show clearly that damaged seeds do not necessarily be dead.

DISCUSSION

From a practical point of view, three types of mechanical damage to seeds can be distinguished. 1) visible damage occurring in the seed coat (testa, tegument) only, 2) visible damage to the seed coat, gametophyte and embryo, and 3) non-visible damage to gametophyte and embryo.

The damage to seed coat only is usually less harmful and immediately after the injury influences the vigour of the seeds not at all or quite slightly. Of course, even the slightest damage to seed coat appearing as fissures, cracks, etc., paves the way for infections and thus easily causes the seeds to be deteriorated later, e.g. in long-term storage.

The second type of damage affects visibly all parts of the seeds. Damage to the embryo caused by piercing practically always resulted in the death of the seeds. Even damage caused by pinching is deadly, probably due to indentations of the gametophyte into the embryo. Visible injuries to the gametophyte, i.e. pricking, incision, cutting, did not necessarily kill the seeds immediately, as the result of the germination test under optimal conditions shows (Table 1). However, these injuries will become disasterous under stress conditions, i.e. by germination in nursery or field (Huss, 1956). The increased number of damaged seeds caused by incision and piercing occurs frequently among injured seeds, cf. Huss (1950), Nilsson (1963) and Kamra (1978).

The third type of damage can hurt all parts of the seeds but is not even visible in microscopical analyses (Huss, 1950). This damage caused by impact can affect the germination of the seeds differently; if slight it does not influence the seed germination under optimal conditions, if heavy it kills the seeds. Impact and shaking did not affect the germination percentages after 7 and 21 days. Only the germination start was slightly delayed in comparison with control (Table 1). However, under suboptimal conditions during germination the damage caused by impact can lead to serious consequences (cf. Bergsten, 1980a). Huss (1950, 1956) found that a decrease in laboratory germination capacity of only a few per cent can lead to a drop in plant percentage of 20-40 % in the field and also result in considerably deteriorated plant quality (Nilsson, 1961). The strength of the impact in the present experiment was certainly lower than when using mechanical de-winging machines or other mechanical processors. Huss (1950) for instance, showed that seeds were killed in certain de-winging machines, mostly by impact (blow damage) without showing any damage in the seed coat. The impact damage may be one of the main reasons for the present inexplicable changes of seed vigour.

None of the existing tests alone can reveal all three types of damage. Thus, the ocular analysis of seeds, which is very tedious, and the quick PREVAC-method can disclose only the first two types of damage. With the introduction of aqueous contrast agents for testing the seed quality by radiography it was found that visibly damaged seeds are readily impregnated by these contrasts (Simak, 1957 using $BaCl_2$; Kamra 1965, 1967 using umbradil and urografin, two contrast agents used in human radiography and Vozzo, 1979 using various organic compounds). Most of these agents only reveal the visible damage to gametophyte and embryo. $BaCl_2$ test produces the same impregnation patterns for mechanically damaged as for physiologically dead seeds and thus, in many cases, exact information about the occurrence of only mechanical damage in a sample cannot be obtained by this test. Umbradil and urografin indeed indicate exclusively the visible mechanical damage in gametophyte, but the method is not developed so far for practical use. None of the above methods reveals the invisible damage to the seeds. The only approach to studying this type of damage was made by Huss (1950) who used TZ test. He found that embryos of seeds injured by impact did not show the colour reaction typical of viable seeds. Besides, the analyses reported by Huss are very restricted, the method is tedious and in the test results the mechanically invisibly and physiologically damaged seeds cannot be distinguished from each other. Mainly, it is postulated that the mechanical damage to the seeds manifests itself in the result of a conventional germination test, i.e. in a lowered germination capacity and rate. However, as has been shown in Table 1 and also confirmed by other investigators, the mechanical damage does not necessarily affect the germination. Consequently, it would be meaningless to seek a correlation between impregnation pattern and germination percentage carried out under conventional test conditions. The conventional germination test is not suitable for determination of mechanically damaged seeds in a sample.

In this paper it has been shown that the different types of damage to seeds can be distinguished by using radiographic test with $CHCl_3$ vapours as contrast agent ($CHCl_3$ test). Each type of damage has a characteristic impregnation pattern (cf. Table 1 and Figure 1). Since the time of treatment in $CHCl_3$ is important for the impregnation pattern (Figure 2), the 4 hours treatment was chosen preliminarily as standard. This time has been approved as the most convenient even in all the earlier cited investigations on $CHCl_3$ test.

The determination of ruptures occurring in seed coat only is limited to observations made on the radiograph. The ruptures often appear clearly though not impregnated by $CHCl_3$. In addition, there seems to be the possibility of using other contrast agents specifically disclosing the damage in seed coat (cf. Vozzo, 1979). In any case, seeds with this type of damage can be determined in a sample using the PREVAC-method prior to performing the $CHCl_3$ test itself (cf. Figure 3).

According to the criteria used at our laboratory, seeds showing a connected impregnated area >50 % of their radiographic image, or a smaller area but with visible cracks in testa and gametophyte, are classified as visibly damaged seeds.

The invisible damage caused by impact appears after $CHCl_3$ treatment as small impregnated dots on the radiographic image of the gametophyte. There is of course a variation in the impregnation pattern, e.g. number and size of the dots depend on the strength of the impact (cf. Simak, 1974; Bergsten, 1980a; Lestander & Mähler, 1984; Pehap in prep.).

However, it must be emphasized that the above presented criteria for distinction of different types of damage by $CHCl_3$ test are based mainly on experience, and experimental standardization of the test is therefore necessary. The main goal of the standardization of the $CHCl_3$ test must be, firstly, to work out a standard procedure for the $CHCl_3$ treatment itself, secondly, to establish a clear definition of the characteristic impregnation patterns for different types of damage, and, finally, to clarify the reaction of physiologically dead seeds to $CHCl_3$ treatment. Some pilot studies for this purpose have been made earlier, e.g. concerning $CHCl_3$ impregnation pattern, time of treatment, stability of the impregnation, germination of the treated seeds, impregnation of mechanically damaged seeds and relation between impregnation pattern and germination of the seeds (Simak, 1974a). There is still some uncertainty concerning the impregnation ability of physiologically dead seeds, e.g. seeds that died during storage. Though we have clear evidence that physiologically dead seeds do not necessarily become impregnated in $CHCl_3$ vapours, we still do not know whether "dot"-impregnation in the dead seeds indicates impact occurred before storage or physiological death occurring during storage. On the other hand, we found in very rare cases single seeds stored for many years that were visibly damaged deep into the gametophyte but did not become impregnated when treated in $CHCl_3$ vapours. It is apparent that the reactions of aged seeds have to be extensively studied.

Although carried out on limited seed material so far, the studies on $CHCl_3$ test indicate well the direction in which the further research should be conducted. For instance, for identification of heavily damaged seeds only, as those with ruptures in coat and gametophyte, a shorter time of $CHCl_3$ treatment (between 15 and 60 minutes) may be sufficient, since according to the results in this paper, heavily damaged seeds become impregnated faster than impact damaged seeds (cf. Figure 2). A four hours impregnation has the disadvantage that the visible and invisible damage occurs in the same seed simultaneously, which sometimes makes a correct determination of the injuries difficult. This disadvantage can be partly eliminated by combining the $CHCl_3$ test with the PREVAC method (Figure 3). Through the PREVAC method the undamaged seeds, the seeds with invisible damage (floating fraction) and those with the different types of visible damage (bottom fraction) can be separated from each other and then tested more in detail by $CHCl_3$ test within each fraction. The identification of invisible damage among the seeds in the floating fraction can be of particular value for determination of seed quality. Since the number of seeds tested in a sample is relatively small, the PREVAC device may probably be replaced by simpler water vacuum pumps used in microscopy for fixation of research material.

Of particular interest for the practice would be to use $CHCl_3$ test for testing damage occurring during a certain step of cone and seed processing, e.g. during de-winging. In such case it is necessary to consider the damage that may occur in the seeds before de-winging ("background damage"). For instance, in Figure 2 the control seeds treated for 4 hours in $CHCl_3$ showed about 15 % damage that after subsequent shaking increased to 33 %. Consequently, after substraction of the "background impregnation" (15 %) the shaking alone was responsible for 18 % of the damage. The damage indicated by background impregnation in this case could have arisen during cone extraction, seed cleaning, etc. Actually, we have evidence that impregnation dots can also occur in seeds from cones that have been subjected to rough treatment, as can happen by cone processing in drum extractor. Moreover, slight damage was occasionally found in seeds extracted very carefully from freshly collected cones. This would indicate that damage of unknown origin can arise in the seeds before cone collection (frost damage during seed maturation)? These observations show that there are many aspects to be considered when standardizing the $CHCl_3$ test.

The chemical processes proceeding in seeds and plants during chloroform treatment have been very little studied. We found some evidence that the impregnation of seeds is due to the affinity between chloroform and fats in the seeds which may limit the use of this test only for species with fatter seeds, e.g. Conifers. These biochemical processes are intensively studied at our laboratory (Pehap in prep.).

At the present stage, the mechanical damage to seeds could be determined by taking the following steps:

1) Using the PREVAC principle the visibly mechanically damaged seeds can be separated from a sample. After impregnation in $CHCl_3$, the seeds with injuries in coat only can be distinguished from other heavily damaged seeds on the radiograph.

2) The rest of the seeds, separated as undamaged, should be subjected to $CHCl_3$ test. From the frequency and quality of the impregnation dots the invisible damage can be estimated (standardization necessary).

The above described performance is illustrated in Figure 3.

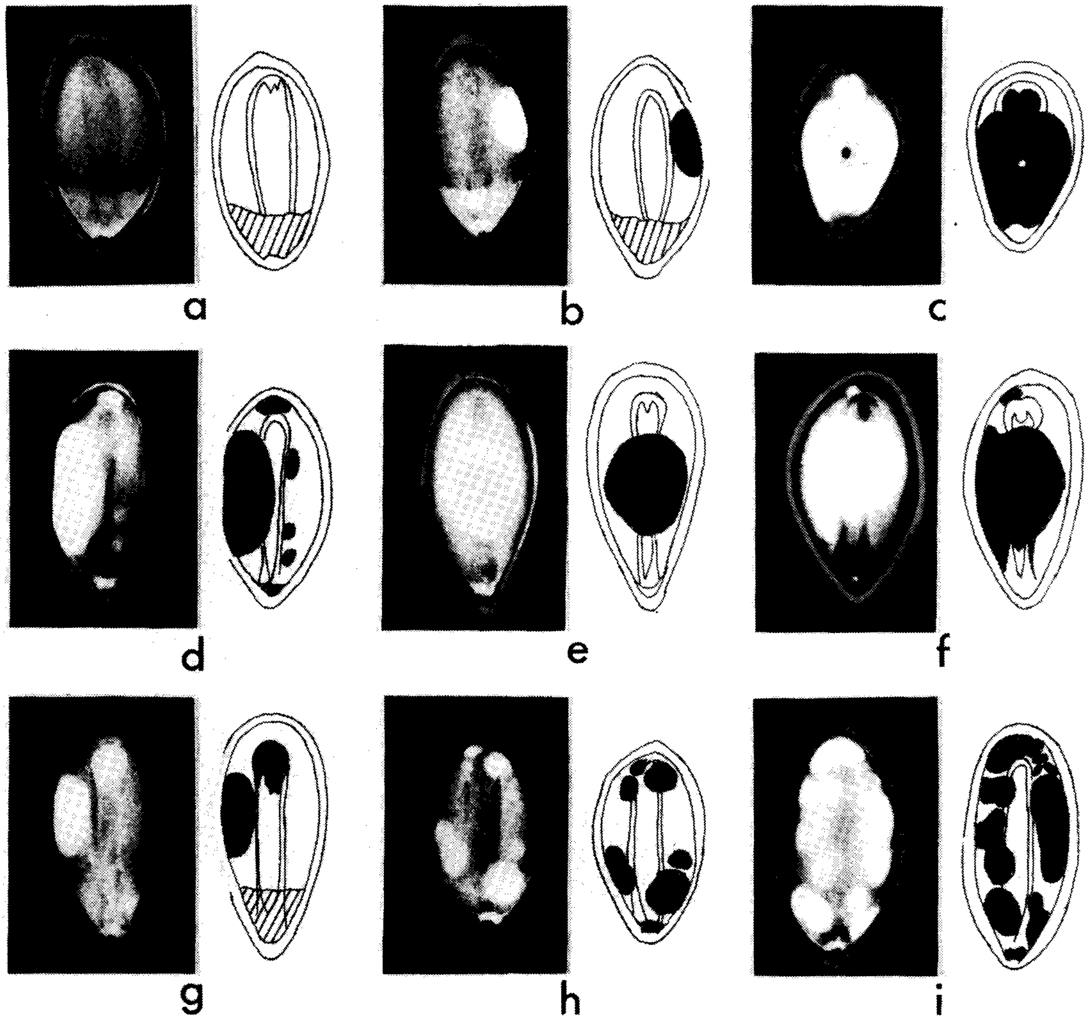

Figure 1. Radiographs of different types of damaged seeds treated in $CHCl_3$ vapours for 4 hours. The impregnated gametophyte/embryo is indicated black on the sketch to the corresponding radiograph. The impregnated nucellus in a), b), g) figures dashed. a) Not damaged seed with impregnated nucellus, b) by rubbing damaged seed coat and gametophyte, c) by piercing damaged seed, both in gametophyte and embryo, d) cutting damage, e) pricking, f) pinching, g) damaged testa, gametophyte and embryo, h) dot-impregnation caused by impact, i) heavy impact damage. The radiographs in these figures were first reverted two times and then printed. Many details well visible on the radiographs have thereby disappeared. For this reason, the seed coats in Figures a-d and f-i were retouched.

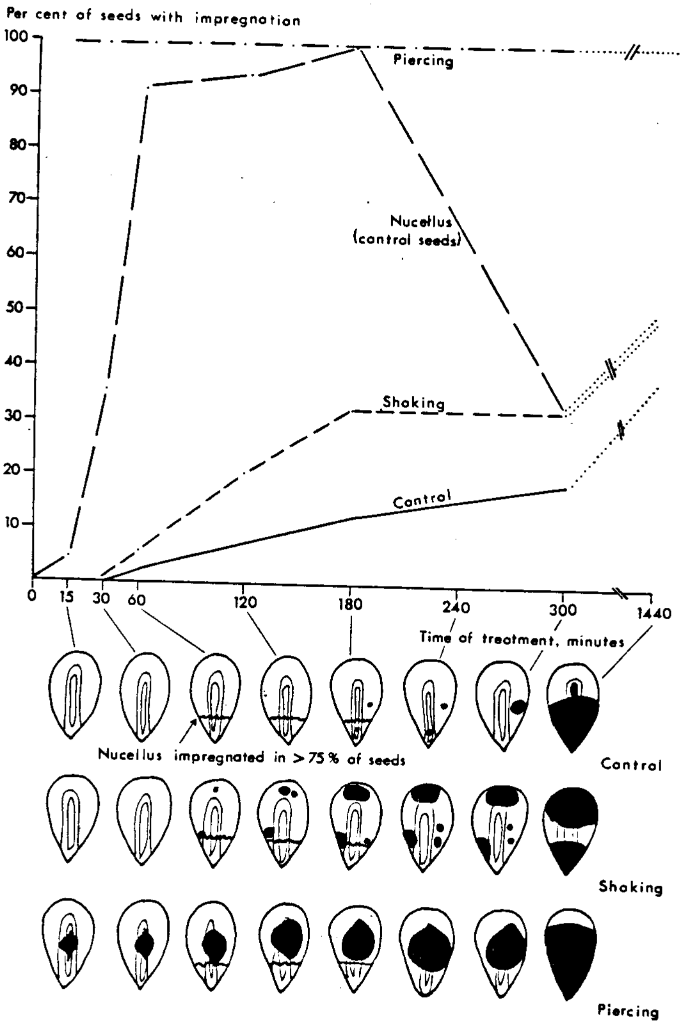

Figure 2. Changes in the number of impregnated seeds and in the impregnation pattern at increasing time of treatment in $CHCl_3$ vapours (50 seeds). One typical seed from each of the three treatments control, piercing and shaking, was selected to illustrate the impregnation changes in nucellus, gametophyte and embryo as appearing on the radiograph.

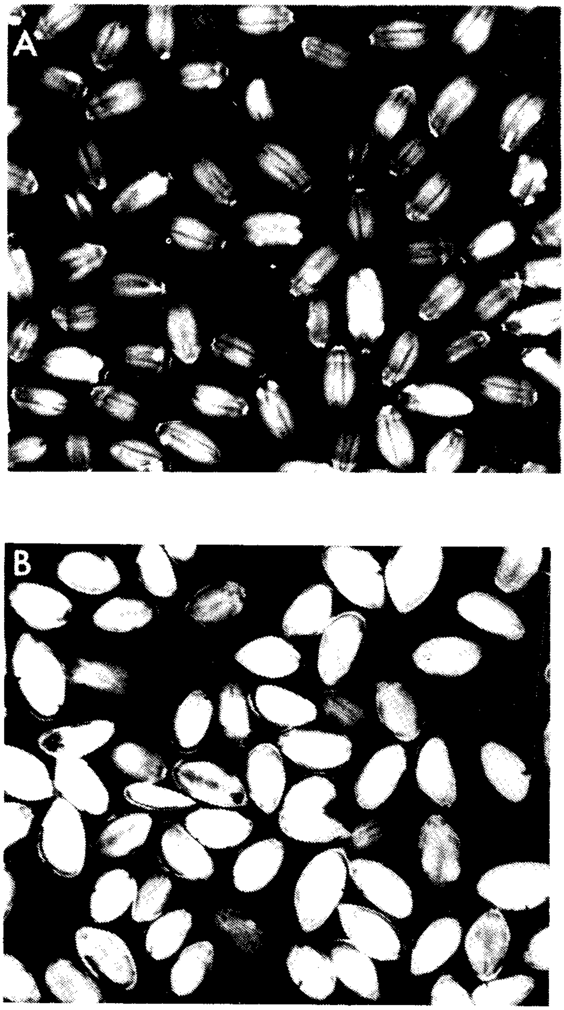

Figure 3. The combined PREVAC-$CHCl_3$ test for determination of different types of mechanical damage to seeds in a sample. The mixture of damaged and undamaged seeds was separated by PREVAC method into two fractions. Each fraction was subjected to $CHCl_3$ test. Seeds with visible damage in the fraction below (B) are heavily impregnated, with the exception of seeds with damage in the coat only that cannot be identified by $CHCl_3$. In the above fraction (A) the chloroform test indicates the invisible damage in the seeds as small dots. This type of damage cannot be separated by PREVAC.

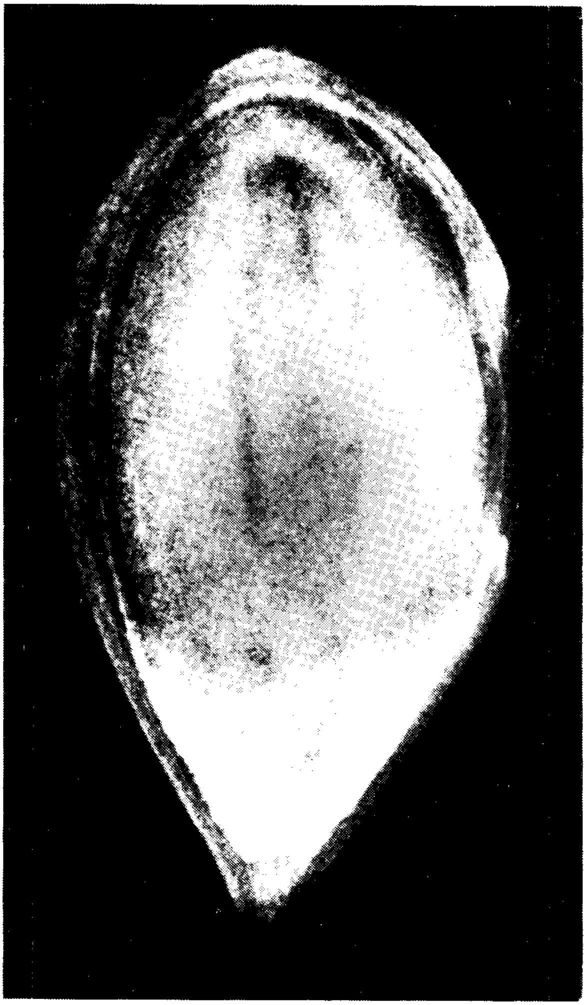

Figure 4. Radiograph of a seed with damaged testa but not tegument, gametophyte not impregnated though the seed was treated with $CHCl_3$ vapours for 4 hours. Nucellus impregnated.

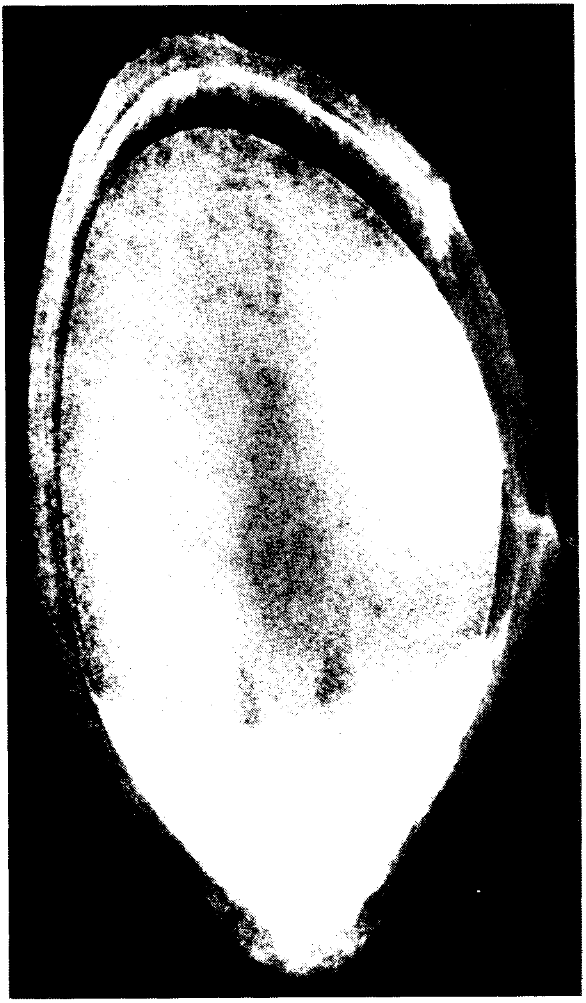

Figure 5. Enlarged radiograph of seed b) in Figure 1. Testa is damaged, gametophyte impregnated, probably due to damage by impact. Nucellus impregnated.

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THE EFFECT OF CONE IMPACT DAMAGE ON SCOTS PINE SEEDS

by

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ABSTRACT

Closed cones of Scots pine (Pinus sylvestris L.) were subjected to impact for 0, 5, 30 and 60 minutes and then extracted at room and kiln temperature (about 20°C and 49°C, respectively). Seeds were germinated on Jacobsen apparatus. The germination percentage after 7 days test decreased with increasing impact treatment. Within the impact range used, no changes in germination capacity were observed. The impact damage to the seeds could also be identified by XC-$CHCl_3$-test. Vaporous $CHCl_3$ impregnated the impact area that appeared on the radiograph since the chloroform served as contrast agent. The stronger the impact, the larger the impregnation area. A slight impregnation was also observed in seeds from cones that were not subjected to impact. It is suggested that these seeds were damaged by early frost during maturation on the trees. Temperature effects of the extraction were evident from the germination rate but could not be identified by XC-$CHCl_3$-test.

XC-$CHCl_3$-test seems to be a good method for revealing impact damage to seeds caused by careless cone processing.

INTRODUCTION

The modern methods for commercial raising of forest plants, especially of conifers, aim at producing vigorous seedlings from each sown seed (e.g. containerized plants). The primary prerequisite for fulfilling such a goal is to use seeds of the highest technical quality. Therefore, the seed researchers make every possible effort to identify and eliminate all factors lowering viability and vigour of the seeds in a lot. These deteriorating factors are in operation already during seed maturation (frost, short growing season, insects, etc.) and not least in the course of cone collection and processing.

The damage to coniferous seeds during processing was extensively studied at our laboratory by Huss (1950). He showed, among others, that seeds of Scots pine (Pinus sylvestris L.) could be damaged inside the cones that had been subjected to strong blows before the extraction was performed. It is remarkable that this type of damage to seeds has not yet been seriously considered in practice, in spite of the fact that the cones pass through several procedures such as collection, transport, cleaning, during which they may be exposed to impact. Especially in the course of extraction in drums, the cones are often tumbled for several hours before they release the seeds. Certainly, voices have been raised in warnings against the danger of damaging seeds by tumbling. However, these warnings were made with reference to the high temperature prevailing in the kiln or to the mechanical damage caused by the friction between cones and released seeds in the drum. To avoid such damage, the seeds are taken out of the drum as soon as they have left the cones (Morandini 1961).

One reason why damage to the seeds caused by impact to the cones has not been sufficiently considered so far may be the difficulty to identify it. Firstly, the effects of it are often hidden when the seeds are tested under optimal germination conditions in a laboratory. Secondly, in case a decrease in seed viability and vigour is noticeable in a germination test, it is ascribed to something quite different, or maybe to "unknown" factors since the impact damage itself is not visible ocularly.

Simak (1974), Bergsten (1980 a,b) and Simak & Pehap (1987) showed that the x-radiographic method in combination with chloroform vapours as contrast agent (further called XC-$CHCl_3$-method or -test) is a sensitive test to reveal damage to Scots pine seeds being subjected to different kinds of direct impact, i.e. shaking, cast, friction, etc. The main object of the present study is to find whether the XC-$CHCl_3$-test would be suitable for testing the indirect impact damage to Scots pine seeds, i.e. to seeds from cones that have been subjected to impact.

This pilot study is part of the project "Conditioning of Norrland seeds of different maturity" financed by "Skogsbrukets plant-projekt".

MATERIAL AND METHODS

The cones were collected on December 16, 1986, on many clear-felled trees at Norum (63°55'N, 20°45'E, alt. 30 m). They were stored at 5°C until April 9, 1987, when they were used for the experiment.

Seed quality

The anatomical development of the seeds was determined by x-radiography. The embryo spectrum was as follows:

Embryo class	I	II	III	IV p	IV d
Per cent	2	8	9	32	49

The higher the embryo class, the better the anatomical development of the seeds and the better the seed viability and vigour (cf. Simak 1980).

In this investigation Embryo class IV is divided into two subclasses; the poorer one (IV p) in which the embryo length is just above the upper limit for class III (75 %), and the well developed subclass (IV d) the embryo of which fully occupies the embryo cavity (the upper limit for Embryo class IV, about 100 %). This subdivision was made in order to present the anatomical characteristics of the experimental material more specifically than the practical classification of embryo length allows. The empty seeds occurring in the material were excluded from all calculations.

Treatment of cones

All the cones were closed at the time when the following 9 treatments were performed.

1 Cones were spread out on a table in laboratory where they were extracted at room temperature (about 20°C). This is the control treatment. A complete release of seeds was achieved after about one week.

2 The cones were extracted for 16 hours at 49°C in the extractor used at our laboratory.

3 The same treatment as in 2 but after extraction the cones were shaken for 5 minutes in an apparatus used to remove the seeds that had got jammed between cone scales.

4 Before being extracted, cones were shaken for 5 minutes in the same apparatus as in 3 and then extracted as in 2.

5 Cones were shaken for 5 minutes as in 4 and then extracted in laboratory as in 1.

6 Cones were shaken for 30 minutes and then extracted according to 2.

7 Cones were shaken for 30 minutes and then extracted according to 1.

8 Cones were shaken for 60 minutes and then extracted according to 2.

9 Cones were shaken for 60 minutes and then extracted according to 1.

The shaking was effected using compressed air causing short impacts to a metallic bottom of net on which the cones were spread out (amplitude 4 cm, approximately 2.5 impacts/sec.). All cones were closed during this treatment with the exception of the extracted cones of treatment 3. In this case the seeds fell through the bottom when being shaken out of the open cones. In all the other treatments the seeds were removed from the extracted cones with the greatest care and then dewinged one by one to avoid damage to the seeds. 60 cones were used for each treatment.

Germination test

3x100 seeds per treatment were laid out for germination test on Jacobsen apparatus for 21 days at 20^{o}C constant and constant light, 20 $\mu E \cdot m^{-2} \cdot s^{-1}$ (Thorn T 40 W/33 cool light). Germinated seeds were counted and removed from germinator every day. Germinant with the root length equal or longer than the length of the seed itself was recorded as germinated seed. The germination results after 7 and 21 days are based on filled seeds only. The 7 days test is assumed to be a good indicator of changes in the seed vigour caused by improper extraction (Rohmeder 1962, 1972). The number of filled seeds in each 100 seed set was determined by x-radiography test.

XC-$CHCl_3$-test

200 seeds of each treatment were exposed to chloroform vapours for 4 hours and then radiographed (cf. Simak 1980). The chloroform vapours react with the impact damage in the seeds and make it visible on the radiographic image owing to the high absorption of x-rays by the contrast agent.

Depending on size of the impregnated area appearing on the radiographic image of the seeds, the following impregnation classes were distinguished:

Class 0 No impregnation (except for the nucellus) visible
1 Up to 25 % of the seed area impregnated
2 Between 25 and 50 % of the seed area impregnated
3 Between 50 and 75 % of the seed area impregnated
4 More than 75 % of the seed area impregnated

The pattern of the impregnated area occurred connected or as small dots.

More about the XC-$CHCl_3$-test is to be found in Simak & Pehap (1987) and in the references cited there.

Statistics

Tukey's test for multiple pairwise comparisons was used for statistical analyses (Scheffé 1959).

RESULT

The seed maturity of the investigated material is not accomplished which is common for northern seed sources of Scots pine. Well matured cones of southern provenances would usually contain seeds of Embryo class IV d only, i.e. fully developed seeds.

The result is given in Figure 1 A-C. The seeds in treatment 1 (control) showed the highest germination percentage after 7 days test, 67 %, i.e. the highest vigour. For comparison, well matured Scots pine seeds of southern provenances would germinate to more than 90 % after 7 days test.

Firstly, it is evident that seeds exposed to 49^{o}C during 16 hours extraction, treatments 2, 4, 6 and 8, have lower vigour than seeds in the corresponding treatments 1, 5, 7 and 9 at room temperature (Fig. 1 A).

Secondly, the impact to the closed cones before extraction has a lowering effect on seed vigour (Fig. 1 A). The stronger (longer) the impact the more delayed the germination (cf. treatments 5, 7, 9 versus 1 and 4,6,8 versus 2). The germination capacity of the seeds after 21 days test is rather high for a northern seed source. There is no significant difference in germination capacity among the treatments (Fig. 1 B).

Thirdly, the XC-$CHCl_3$-test presented in Fig. 1 C shows clearly that the impregnation area of the seed treated with chloroform vapours increases with increasing impact to the cones.

DISCUSSION

Kiln temperature and impact to the cones lowered the percentage of germinated seeds during the first 7 days of the germination test.

The reason for performing the impact treatments at two temperature levels was to keep the effect of the conventional kiln temperature and that of impacts under separate control. A comparison of the same impact treatment at two different temperature levels shows that the germination percentage within the first 7 days was in all cases higher by extraction at room temperature than by extraction at 49^{o}C in kiln (cf. treatments 1 and 2, 5 and 4, 7 and 6, 9 and 8 in Fig. 1). This difference may seem peculiar since the extraction temperature used in the experiment lay below the critical limit, 50-55^{o}C, which is commonly accepted in practice for extraction of Scots pine cones and considered safe to the seeds. However, it should be remembered that this temperature limit was once determined on well matured cones from Central Europe or Central Sweden (Haack 1905, Romell 1925, Messer 1949, etc.) and then applied without restrictions even for extraction of the often immature cones from circumpolar regions. Seeds used in this experiment were not mature, as the embryo class analysis showed. According to

Hermelin (1958), seeds of low embryo classes are more susceptible to high temperatures than mature seeds, particularly if the temperature interacts with high air humidity, as can be the case during cone extraction. Also Stefansson (1953) pointed to the fact that seeds from northern Sweden with poorly developed embryo are sensitive to drying at kiln extraction. Pehap (1986) showed that the activity of enzymes acid phosphatase, alkaline phosphatase, esterase and peroxidase decreased in the seeds after extraction at 45^{0}C during 13 hours in comparison with seeds extracted at 20^{0}C. In general, a drastic drying of immature seeds may lead to irreparable physiological damage (cf. Perl 1987) that must be avoided especially when processing immature cones from circumpolar regions. Thus, there seem to exist plausible explanations why the kiln extraction in the experiment had a lowering effect on seed germination. However, the investigated material is too limited to draw any definitive conclusions. It is quite clear that the biological role of the temperature used by extraction of immature cones must be conclusively investigated and on the basis of such result a proper extraction procedure be worked out for practice.

In earlier papers (Huss 1950, Simak 1974, Bergsten 1980, Simak & Pehap 1987) the effects on seed germination of different types of direct impact to the seeds, e.g. blow, friction, shaking, were studied. The present experiment concerns the effects of indirect impact, i.e. the impact directed to the cones and through them on to the seeds within the cones. The indirect impact simulates the conditions prevailing in the course of cone processing, particularly during extraction in drum kiln. There is no earlier information available about the effects of indirect impact on seed germination with the exception of the observations made by Huss (1950). He cast cones of Scots pine 15 times on to the floor whereby the germination capacity of the seeds was lowered from 98 % to 85 % and the length of the first-year seedlings was reduced from 4.2 cm to 3.7 cm. For a laboratory test performed under optimal conditions, this is a considerable decline in seed quality influencing not only the germination capacity but also the seedling quality.

In the present experiment the germination rate declined only slightly after the impact and the germination capacity was not affected at all. The comparison of the treatments 2 and 3 is worth attention. It shows that 5 minutes cone shaking after extraction reduces the germination per cent after 7 days test by 11 %, though the difference is not significant. However, in practice the shaking of extracted cones in order to release the seeds is usually more intensive than in treatment 3, and thus the loss of vigour would in reality be greater and even significant. The effects of direct and indirect impact are often small in a laboratory test but can be disasterous under stress conditions as, for instance, during long-term storage and germination in field. Thus, according to Huss (1950) a decrease in germination capacity of 5 units in a laboratory test can mean a drop in plant per cent of 20-40 units in field. Consequently, the losses in plant production can be serious if the damage to seeds caused by improper cone processing is neglected.

When using the germination rate to detect damage to the seeds the test must be made under strictly constant conditions, which is not always an easy task. Moreover, the test takes time - at least 7 days - which may be a disadvantage when the damage has to be continuously checked during different processing steps. It is therefore desirable to try to find other test methods less depending on the environmental conditions and quicker than the germination rate determination. Such an alternative is the XC-$CHCl_3$-test, described elsewhere.

It may seem peculiar that the control seeds (treatment 1 in Fig. 1 C) became impregnated by $CHCl_3$ despite that all precautionary measures were taken to keep the seeds safe from any impact. The explanation is that the impregnated control seeds are those damaged by early frost during maturation on the trees. A support of this statement are the recently obtained results (unpublished) of some comparable analyses made on seeds originating from different parts of Sweden. $CHCl_3$- impregnation occurred rarely in fresh collected seeds from southern parts of the country but frequently in immature seeds from the north. To a large extent, the poor maturity itself is the result of early frost damage to seeds, as shown by Simak (1972). If the impregnation of frost damaged seeds can be proved to be conclusive, then the XC-$CHCl_3$-method could be used also for testing of frost damage to seeds.

Accordingly, the impregnation of the control seeds in this experiment should be considered as a background impregnation (cf. Simak & Pehap 1987), i.e. as a base value for all comparisons with other treatments. Thus Figure 1 shows that the average impregnation area has increased in the seeds by approximately 30 %, 100 % and 200 % after 5, 30 and 60 minutes of shaking the cones, respectively, in comparison with the impregnation area of the control seeds. It is to be noted that the 30 % increase of the impregnation area was so pronounced that it could be distinguished directly by ocular viewing of the x-ray film, i.e. without performing the classification of the individual seeds. An increase of the impregnation area in seeds from cones exposed to impact was also confirmed on several other samples. However, for practical use the correlation between impact intensity, size of impregnation area and germinability of the seeds remains to be tested on more extensive material.

Seeds extracted at room and kiln temperature, respectively, show no clear difference in the size of the impregnated area (Fig. 1 C) though there exists a significant lowering of seed vigour at kiln temperature (Fig. 1 A). XC-$CHCl_3$-test does not indicate changes in the seeds caused by temperature, at least not under the conditions used in this experiment. A useful method for discovering such changes seems to be the TZ-test which can reveal damage both in gametophyte and embryo (Bartels 1958). Since the TZ-test can even indicate impact damage to seeds, as Huss (1950) showed, this test can be a useful comparison test by standardization of XC-$CHCl_3$-test.

The tasks to be considered in further developing XC-$CHCl_3$-test are as follows.

Firstly, to clarify the biochemical and physiological processes in impact damaged seeds. A report dealing with the amino acids situation in damaged seeds was published by Pehap (1986).

Secondly, to translate the impregnation result into practical terms describing field emergence of the seeds. This is a rather tricky problem, because the germinability varies under different environmental conditions.

Thirdly, to work out a statistically acceptable procedure for XC-$CHCl_3$-test, especially concerning the classification itself; size of the sample to be tested, replicated classification of the same sample, etc.

Finally, it should be examined whether other criteria than the applied can be used for classification. For instance, one could consider the impregnation of different parts of the seeds (embryo, gametophyte) or the specific patterns of the impregnation area (dots, great patches, etc.).

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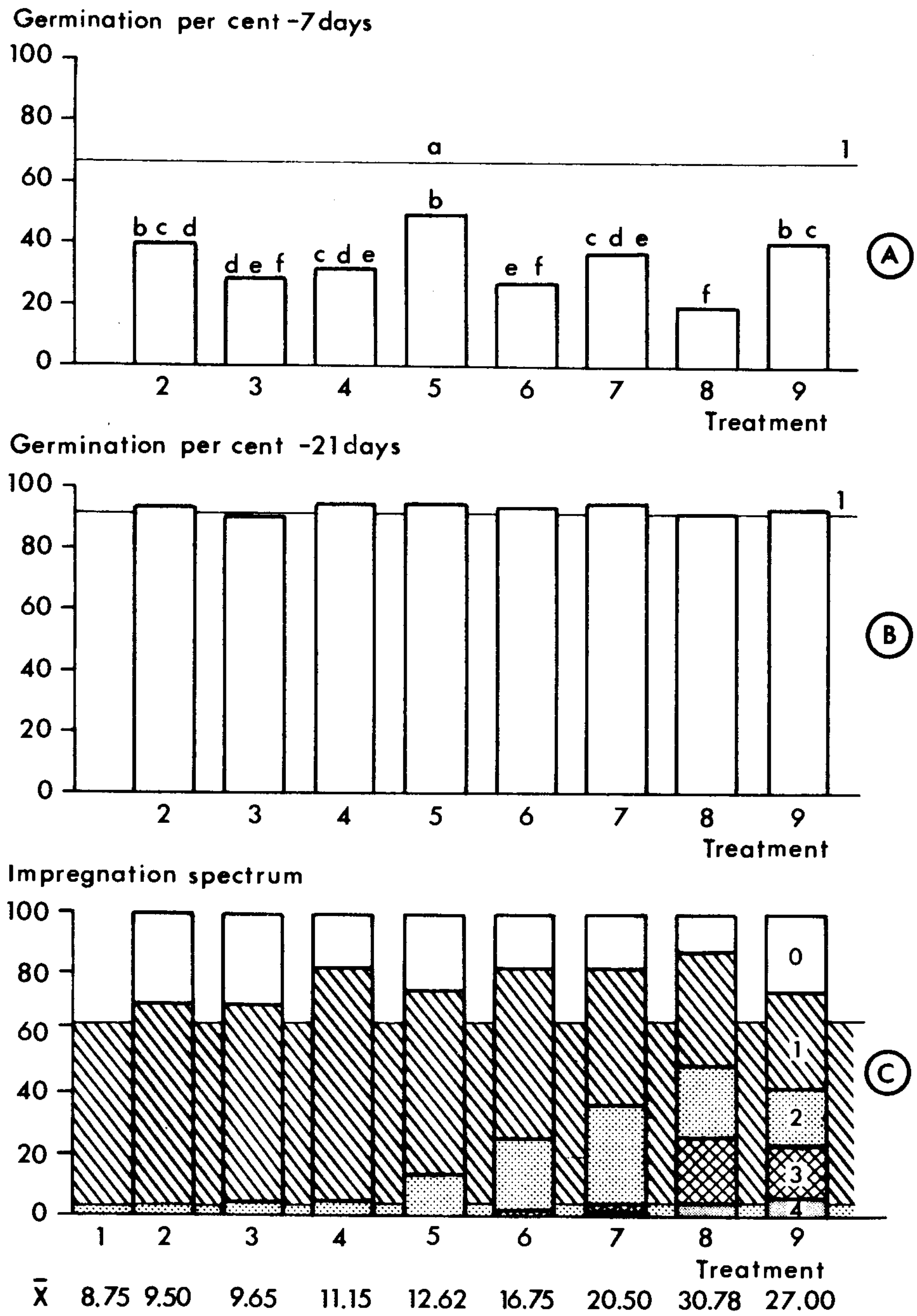

Figure 1. A: Germination percentage on the 7th day of the test. Treatments with the same letter-index are not significantly different (p = 0.05). B: Germination capacities of the treatments are not significantly different. C: Impregnation spectrum for each treatment according to classes 0-4 as described in MATERIAL AND METHODS. $\bar{x}$ = average impregnated area per treatment.

EFFECT OF HOT WATER AND ACID TREATMENT ON GERMINATION OF Cassia fistula L. SEEDS

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SUMMARY

Effect of hot water and sulphuric acid pretreatment to improve seed germination of Cassia fistula L. was studied. Distilled water soaking did not improve seed germination significantly over control. The 85°C water soak treatment for one minute significantly increased the seed germination. This treatment for 3 minutes however resulted in decreased germination. The hot water soak of 95°C for 1 minute resulted in 70 % germination. The best result was obtained in acid treatment for 20 minutes.

Key words: Hot water, acid pretreatment, germination, Cassia fistula seeds.

INTRODUCTION

Cassia fistula L. (Indian laburnum; Amaltas) is a cultivated tree of family Leguminosae. It grows in south east Asia and may be found in a variety of habitats from humid to arid tropical regions. Recently, it has been included in the list of plants to be grown in social forestry programme in India. Besides, its wood, pulp of pods and leaves are medicinally important. Some of the Egyptian Papryi, written as early as 1600 B.C., record the name of Cassia as medicinal plant (Hill, 1952). The tree is grown along roadsides, open lands and is also planted as shelter belt tree.

The trees bear flowers, unripe pods and fully mature pods during the period of February, March and April. The seeds of Cassia fistula germinate poorly without pretreatment and routine boiling before testing or use may be required as in

Acacias (Larsen, 1964). Therefore, it was thought desirable to study the correct pretreatment for seeds to ensure high percentage germination.

MATERIALS AND METHODS

Bulk seed sample collected in March 1985 was obtained from Govt. nursery of forest department, involved in raising seedlings of Cassia fistula for social forestry programme. The seeds were pretreated as follows -

1. Distilled water soaking at ambient temperature
   (a) Seeds soaked for 12, 24 and 36 hours
2. Hot distilled water
   (b) 95°C water, seeds soaked for 1, 2 and 3 minutes
   (c) 85°C water, seeds soaked for 1, 2, 3 minutes. In both (b) and (c) the seeds were removed from the heat after treatment and cooled before being allowed to germinate.
3. Acid treatment
   (d) Seeds were soaked in sulphuric acid (Sp.gr.1.84) for 1, 5, 10, 20, 30, 40, 50 and 60 minutes and then washed for 5 minutes in tap water to remove all acid. Untreated seeds served as control. Germination tests were conducted with 4 replicates of 100 seeds in each case. The treated seeds were set to germinate in sterilized moist sand in plastic germination boxes. The ambiant temperature fluctuated between 24 + 1°C to 30 ± 1°C. Seeds were counted as germinated when the radicle was about twice as long as the seeds. The results so obtained are presented in Table 1.

RESULTS AND DISCUSSION

It is evident from Table 1 that the effect of various pretreatments on seed germination is variable. Without pretreatment only 15.50 % germination was observed, thereby indicating that pretreatment is essential for the seeds of Cassia fistula. Pretreatment with distilled water did not improve the germination significantly over control. Hot water treatment and acid treatment variously affected the germination of seeds.

The hot water soak of 95°C for one minute resulted in 70 % germination, however with increase in soaking time, the germination reduced to 42 %. This indicates that 95°C temperature was clearly too severe for the seed and heat might have killed many embryos resulting in poor germination.

The 85°C water soak treatment for 1 and 2 minutes gave good germination (average 85 %). This treatment for 3 minutes however resulted in decreased germination probably due to more heat.

Acid treatment gave the best result of all soaking pretreatments. A 20 minutes soak gave the best germination (96 %). However with increase in soaking period the percent germination decreased. This may be due to adverse effect of acid on embryo. Similar observations regarding hot water and acid treatment on germination of Cassia siamea were made by Kobmoo and Hellum (1984). Thus, for operational purposes in nurseries or in the field, the seeds of Cassia fistula should be put into 85°C hot water for one or two minutes and then cooled before sowing to ensure fairly good germination. The recommended temperature of 100°C for Acacia species (Bowen, 1981), is therefore not applicable to Cassia fistula. Even better germination can be obtained by pretreatment with sulphuric acid for 20 minutes.

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Table 1. Effect of various pretreatments on Germination of *Cassia fistula* seeds.

Treatment	Soaking time	Germination %
Control	Nil	16.50
Distilled water	12 hrs	16.00
	24 hrs	20.50
	36 hrs	22.00
Hot water		
95°C	1 min	70.00
	2 min	45.50
	3 min	42.00
85°C	1 min	85.50
	2 min	87.00
	3 min	78.25
Acid		
(H_2SO_4)	1 min	65.50
	5 min	88.00
	10 min	90.50
	20 min	96.00
	30 min	92.50
	40 min	90.00
	50 min	89.00
	60 min	68.75

EFFECT OF SEED TREATMENTS ON GERMINATION OF *ACACIA ALBIDA* DEL.

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SUMMARY

The effects of six seed pretreatment methods on the germination of seed from five *Acacia albida* trees from Mana Pools, Zimbabwe, were studied. The pretreatments used were sulphuric acid, manual nicking, boiling water, hot water, cold water, and storage of seed for 1 year after treatment with sulphuric acid (H_2SO_4). Fresh and one year old seeds treated with sulphuric acid and those manually nicked germinated quickly and had high final germination percentages.

Treating the seed with sulphuric acid and then storing it for one year was also found to give excellent germination. Germination following the hot or cold water pretreatment was very slow.

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INTRODUCTION

Acacia albida Del. (also known in some areas as *Faidherbia albida* (Del.) A. Chev.), is a species indigenous to Zimbabwe and many countries in Africa. It has a very wide distribution throughout Africa except in the north-west of the continent. It also occurs in Yemen, Israel, Jordan and Lebanon (Bonkoungou 1985). It occurs at altitudes from sea level up to 2500 m above sea level (NAS 1975). In Zimbabwe it occurs on flood plains and along the main river systems which include the Zambezi, the Save, and the Limpopo.

Acacia albida is one of the largest species of acacia, attaining heights of up to 30 m. The importance of *A. albida* as a fodder for wild and domestic animals and as a soil improver has long been realised in many countries. For this reason the species has attracted international interest in finding more information on its growth, its utilization and its limitations, particularly in agroforestry systems.

In trying to grow *A.albida* from seed it is necessary to break the seed dormancy by pretreating the seed. Seed that has not been pretreated will usually not germinate at all or will take a very long time before germinating because the hard seed coat is generally impermeable to water. It is believed that the seed coat of *A. albida* hardens with time (Doran *et al* 1983). Various methods to induce germination have been recommended: fresh seed can be soaked in cold water for 24 hours and old seed can be soaked in concentrated sulphuric acid for 20-60 minutes (Doran *et al* 1983); seed can be immersed in concentrated sulphuric acid for 5 minutes, then soaked for 24 hours in cold water (Edwards 1982); boiling water can be poured over seed and allowed to cool for 48 hours (Mugasha and Shoo 1980); seed can also be manually filed and briefly boiled in water and left to soak (Carr 1976).

The aim of this experiment was to test different pretreatment methods on fresh seed (approximately one month from collection) and seed stored for one year, using *A.albida* seed collected from the northern part of Zimbabwe.

MATERIALS AND METHODS

Seed was collected in September 1985 from Mana Pools National Park (29°20'E, 15°45'S; Altitude 360 m) in northern Zimbabwe. Seeds from five parent trees were used in two germination trials at the Forest Research Centre in Harare (31°05'E, 17°46'S; Alt.1500m).

First experiment, sown October 1985

One month old seed was used in the first experiment.Four pretreatment methods were used on one-month-old seed.

The pretreatment methods were:

1. Control - seed was soaked in cold water for 24 hours.

2. Boiling water - boiling water was poured over the seed and left to cool for 24 hours.

3. Sulphuric acid - 60 ml of concentrated sulphuric acid was poured on 50 seeds per stock number (parent tree) and left for 40 minutes. Acid was removed and seed was rinsed thoroughly with water and air dried. Seed was soaked for one hour in cold water before sowing.

4. Manual nicking - the seed coat was nicked on one side of the seed using scissors or a scalpel. The nicked seed was soaked in water for one hour before sowing.

Seed was sown in asbestos-made germinating trays containing granite dust. The experiment was conducted in a plastic hot house where temperature and light were not controlled. Temperature was recorded daily in the early morning and in the afternoon and ranged from 18°C to 35°C during the period of the experiment. Watering was done twice in the morning and twice in the afternoon. After the fourth watering benylate solution was applied to prevent damping off.

Each plot contained ten seeds derived from a single parent tree, arranged in a row. Two plots were put in one tray. The factorial experiment was a randomised complete block design with five replications, five parent trees, and four treatments, giving a total of 100 plots in 50 trays.

Germination counts were made daily for 189 days except Saturdays and Sundays. Each seedling that had lifted its seedcoat above the germinating medium was counted and removed. Cumulative germination counts were recorded.

Second Experiment, sown October 1986

One year after the first experiment a second experiment was conducted to determine if the same pretreatments would be effective for seed that had been stored for one year. The seed had been stored in a cold room at a temperature of 5°C.

The experiment was conducted in exactly the same way as the first except that two additional pretreatment methods were included. These were: (1) acid plus storage (seed treated with acid in 1985 was stored for a year and then soaked for one hour in cold water before sowing); and 2) seed was boiled for two minutes and left to cool for 24 hours. Germination counts were made daily for 132 days.

Data analysis

Plot means for germination percentage at 7, 15, 30, 60, 90, 120, 132, 150, and 180 days from sowing were analysed using analysis of variance techniques (150 and 180 day data were only available for the 1985 experiment and 132 day data was only available for the 1986 data). Analyses were performed on arcsin-transformed data. An inter-year analysis was also performed to examine the possibility of a year effect or a year and treatment interaction.

Replication and parent trees were considered random and seed pretreatment was considered a fixed effect.

RESULTS

1985 Results

At all assessment dates there were highly significant differences in germination percentage for the four seed pretreatments. The acid treatment (ACID) and the manual nicking (NICK) of the seedcoat were much more effective than the cold water (COLD) or hot water (HOT) pretreatments for the whole period of the germination trial. For the ACID or NICK pretreatments more seed germinated and the seed germinated much earlier than following the COLD or HOT pretreatments (Figure 1). At 30 days after sowing, over 90% of the seed had germinated for the ACID and NICK pretreatments, but less than 4% had germinated for the COLD and HOT pretreatments. Essentially all the ACID and NICK seed that did germinate, germinated by day 15. There were no significant differences between replications in germination percentage.

From 15 - 90 days after sowing, there were no significant differences among parent trees in the percentage of seed germinating. During this same period there was also no significant interaction between seed pretreatments and parent trees. Seven days after sowing and at 120, 150 and 180 days after sowing there were significant germination differences among parent trees and in some cases there was a significant interaction between parent trees and seed pretreatments. From a practical standpoint neither of these would likely be of great importance because 15 - 30 days after sowing would probably be the standard period for acceptable germination in this species.

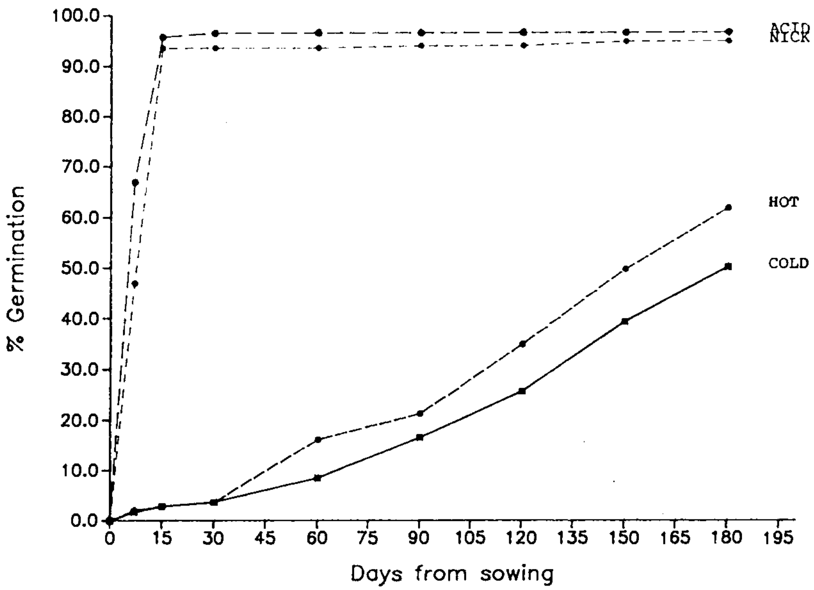

Figure 1. Germination of Acacia albida seed (1985 trial) following four seed pretreatments (Sulphuric acid = ACID, Manual nicking of seedcoat = NICK, Hot water = HOT, Cold water = COLD).

1986 and Inter-Year Results

The trend for the 1986 results was similar to that of the 1985 germination trial (Figure 2). For the ACID and NICK pretreatments, germination was faster and more seed germinated than for the COLD and HOT seed pretreatments. Essentially, all germination for ACID and NICK occurred by 15 days after sowing. For the COLD and HOT seed treatments, germination was significantly slower and still occurring at 132 days after sowing. Thirty days after sowing 4.8%, 8.8%, 97.6% and 98.0% of the seed had germinated for the COLD, HOT, NICK and ACID pretreatments, respectively. By day 132, germination of the COLD and HOT pretreatments had nearly "caught up" with the NICK and ACID pretreatments (75.2%, 82.8%, 97.6% and 98.0%, respectively).

Two additional seed pretreatments were examined in this trial. The boiling water treatment appeared to have adverse effects on the seed (only 4% germination), and this treatment has been excluded from further consideration. The acid plus storage (for one year) pretreatment (ACIDSTOR) gave results comparable to the NICK and ACID pretreatments (94.0% germination at day 15).

There was a significant replication effect from day 90 onwards, and significant or highly significant parent tree effects and parent x pretreatment interactions from day 60 onwards. These are due to the differential germination rates among the five parent trees for the COLD and HOT treatments.

The inter-year analyses (combined 1985 and 1986 data) indicated that there were highly significant differences in seed pretreatments (Table 1). There were significant differences between the two years in germination at most dates of assessment, with 1986 having greater germination (the temperatures in 1986 were generally higher due to lack of rain and cloudy days and this may be at least partly responsible for the faster germination in 1986). After the 30 day assessment it was mainly the faster germination of the COLD and HOT seed pretreatments in 1986 that accounted for the differences between the two years. The interaction of years and seed pretreatments was not significant at the 15 or 30 day assessments and there was no significant three way interaction among years, seed treatments and seedlots.

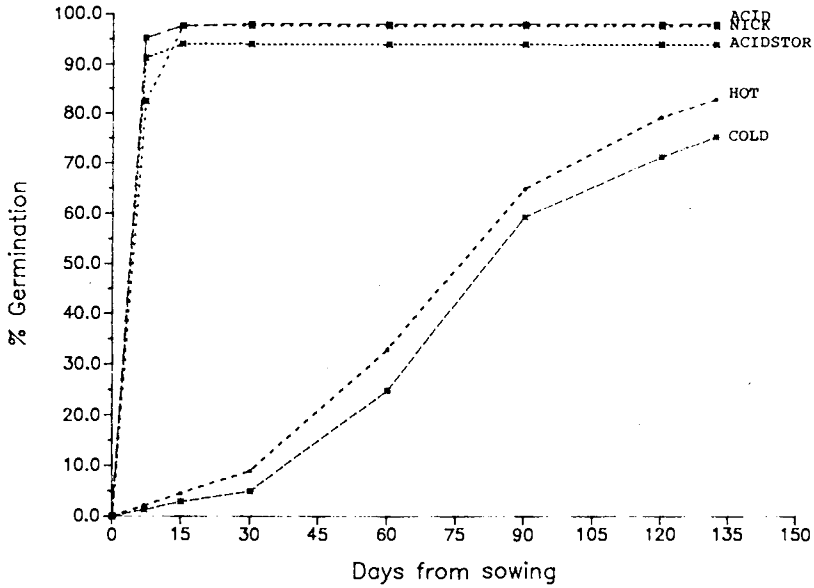

Figure 2. Germination of Acacia albida seed (1986 trial) following five seed pretreatments (Sulphuric acid = ACID, Sulphuric acid plus one years storage = ACIDSTOR, Manual Nicking of Seedcoat = NICK, Hot water = HOT, Cold water = COLD).

Table 1. Analysis of variance results of inter-year analyses of the effect of seed treatment on germination of *A. albida* seed from five seedlots.

	df	D7	D15	D31	D60	D90	D120
Year	1	**	ns	ns	**	**	**
T	3	**	**	**	**	**	**
S	4	ns	ns	ns	**	**	**
TxS	12	ns	ns	ns	ns	ns	ns
YxT	3	**	ns	ns	**	**	**
YxS	4	*	ns	ns	ns	ns	ns
YxTxS	12	ns	ns	ns	ns	ns	ns

Levels of significance: ns, not significant; *, $P < 0.05$; ** $P < 0.01$; Y=year; T= seed pretreatment; S=seedlot; D=day. Replication effect and Replication interactions not shown.

DISCUSSION AND CONCLUSION

The results show that following manual nicking or sulphuric acid treatment the seed of *A. albida* germinates much faster than after cold or hot water pretreatment. Also, treating the seed with sulphuric acid and storing it for a year does not appear to significantly affect the rate of germination. In addition, the ACID or NICK pretreatments were essentially equally effective for the five parent trees tested (all from Mana Pools, but with seed weights varying from 11.7 - 17.3 grams per 100 seeds).

Nicking is expected to give rapid germination response by permitting uptake of water into the endosperm while sulphuric acid pits the seed coat and makes it permeable to water, thereby promoting rapid germination. Doran *et al.*(1983) report that while hot water is effective for Australian acacias, sulphuric acid is more effective than hot water for African acacias. The results from these trials confirm that boiling water is not an adequate pretreatment for *A. albida* seed from Zimbabwe.

The inter-year analysis showed that where temperature and other environmental factors are not controlled there can be differences in germination responses using the same pretreatment methods when the experiment is repeated.

The experiment needs to be repeated for a longer period of time in order to determine if more severe treatments are required as seed ages. The seed coat of *Acacia albida* is believed to harden with time. For *A. albida* seed size varies greatly among parent trees within a provenance and among provenances. There appears to be an increase in seed weight the further south in the natural range that seed is collected (Sniezko, unpublished data). The weight of 100 *A. albida seeds* from Niger, Mali, Cameroun and Senegal varies from approximately 5.5 - 8.9 grams, whereas the weight of 100 seeds in Zimbabwe, Zambia and South Africa varies from approximately 13.0 - 22.0 grams. The results and recommendations made here apply to *A. albida* seeds from southern Africa. Smaller seed from other areas of Africa may require a shorter period of time in acid, or some of the less drastic methods such as soaking in hot water may be satisfactory.

Pre-sowing treatments need to be looked at before any planting program is embarked on. In so doing there will be a saving in nursery space, nursery period and seed and there will be more uniform planting stock. For *A. albida* pretreatment of seed by acid or by manual nicking will insure uniform germination.

ACKNOWLEDGEMENTS

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PRELIMINARY RESULTS ON THE STUDY OF THE INFLUENCE OF LIGHT AND TEMPERATURE ON THE GERMINATION OF ACACIA ALBIDA DEL SEEDS

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SUMMARY

Acacia albida Del. occupies an important place in reforestation programmes of several african countries, especially sahelian countries. A more and more increasing production of Acacia albida Del. in the nurseries has been realized by using seeds. The species is also integrated in direct sowing programmes. A simple experimental protocol allows us to reply at certain questions of the nurserymen.

They can know that a better germination of Acacia albida is obtained at the ranges of temperature between 25°C and 30°C, and that these seeds are able to germinate in the dark.

RESUME

Acacia albida Del. occupe désormais une place importante dans les programmes de reboisement de nombreux pays africains notamment sahéliens, ainsi assistons-nous à une production de plus en plus accrue de cette espèce en pépinière à partir de graines ou une intégration de cette espèce dans les programmes de semis directs. Un protocole expérimental simple nous a permis de répondre à certaines questions que se posent les pépiniéristes. Ils peuvent savoir qu'une meilleure germination des graines d'Acacia albida est obtenue aux gammes de températures comprises entre 25°C et 30°C et que les grains peuvent germer à l'obscurité.

.../...

1. INTRODUCTION

Acacia albida Del. became an essential species in the fight against drought in sahel. This justifies the important development projects conducted in this region. Their aim is the improvement of agroforestry actions by the regeneration of local woody species specially A. albida Del. (M E T [1], 1986). The production of this species in the nurseries is increasing from a year to another. In 1985, vegetative propagation of A. albida Del. has been experimented in Burkina Faso by C.N.S.F. [2] and in 1986 by C.T.F.T. [3] with interesting results.

But the production of seedlings from seeds remains the most used method.

. The knowledge of some aspects of light and temperature requirement for the germination of Acacia albida Del. seeds allows an improvement and a better mastery of the production from seeds of this species important for the rural world.

2. EXPERIMENTAL MATERIAL AND METHODS

2.1. Experimental material

The technical material includes : petri dishes, filter paper, an incubator, a thermohygrograph, alumunium foil, black fabric and a red lamp (25 W).

The vegetative material consists of four (4) replicates of 50 seeds each (So 200 seed for each experiment were used). The pretreatment applied is a mecanical scarification of the seeds. It consists in cuting a small part of the tegument with a razor blade Then the seeds are soaked in tap running water during twelve hours before sowing.

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1. M E T Ministère de l'Environnement et du Tourisme/Ministry of Environment and Tourism

2. C N S F Centre National des Semences Forestières/National Forest Seeds Centre

3. C T F T Centre Technique Forestier Tropical/Tropical Forester Technical Centre

2.2.1. Study of the influence of temperature

Four (4) ranges of temperature were tested : 20°C, 25°C, 20°C and 35°C. After scarification, the seed were put to germinate for seven (7) days in petri dishes, with filter paper as substratum. The relative humidity level was kept high (approximatively 80-95 %) thanks to a bowl of water.

2.2.2. Study of the influence of light

A first lot of 200 seeds was put to germinate under constant influence of white light (650 lumens) of the incubator at the same time a second lot of 200 seeds was put to germinate under constant darkness for seven (7) days. Darkness was secured by the use of black fabric, lined with aluminium foil.

3. RESULTS

The table below presents different percentages of germination for the different temperatures tested with respect to light and darkness during seven (7) days.

Summary table of the Acacia albida seeds germination percentages at different temperatures, (with respect to light and to darkness)

ıber of days after sowing	RANGES OF TEMPERATURES							
	20 ° C		25 ° C		30 ° C		35 ° C	
	L	D	L	D	L	D	L	D
1	0	0	0	1	9	4	34	28
2	7	5	73	88	85	87	93	84
3	45	26	94	93	96	91	94	90
4	86	68	94	93	96	93	94	90
5	92	83	94	93	96	93	94	90
6	93	89	94	94	96	93	94	90
7	94	89	94	94	96	93	94	90

L : light D : darkness

We have underlined the first percentages superior to 50 % in order to point out the different germination rates being important criteria to appreciate the germination of seeds.

The figures 1, 2, 3 and 4 represent the evolution of the germination rates at the four ranges of temperature (20°C, 25°C, 30°C, 35°C) during conditions of light and darkness.

Fig 1 : Evolution of germination at 20°C

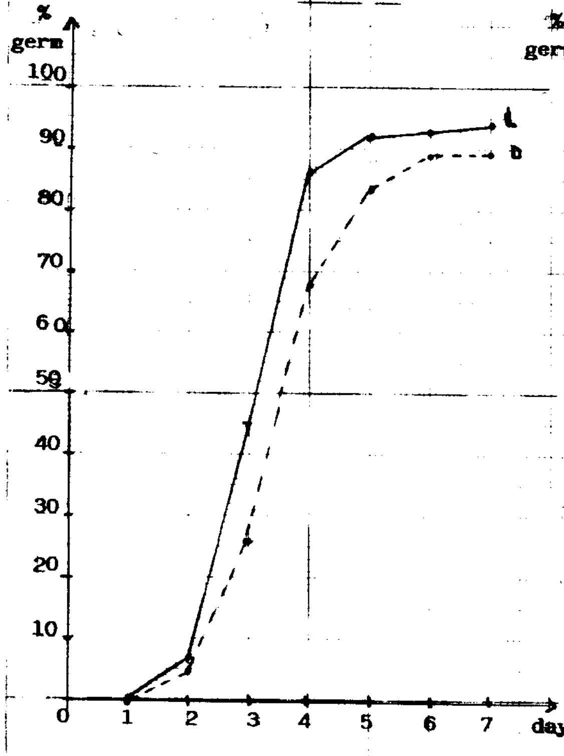


Fig 2 : Evolution of germination at 25°C

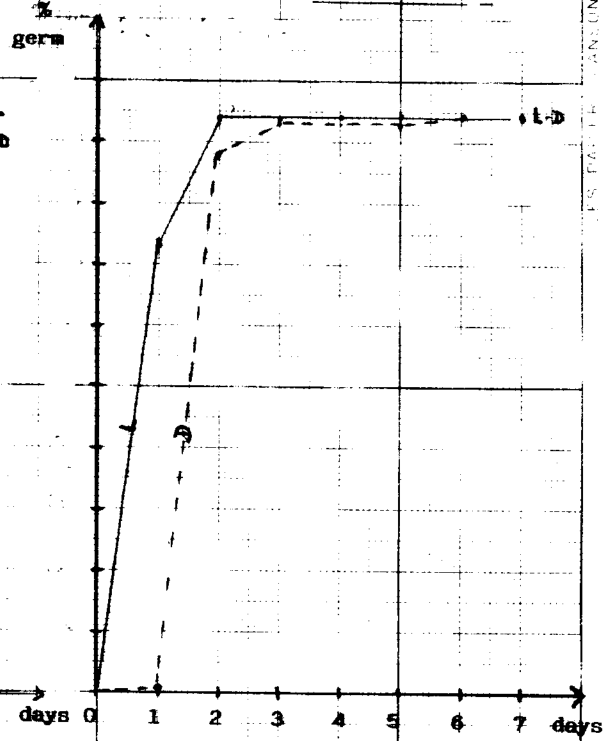


Fig 3 : Evolution of germination at 30°C

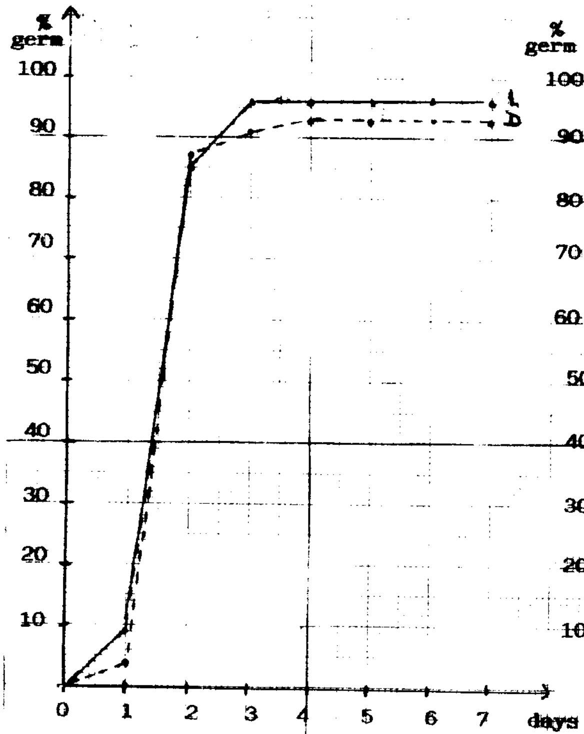
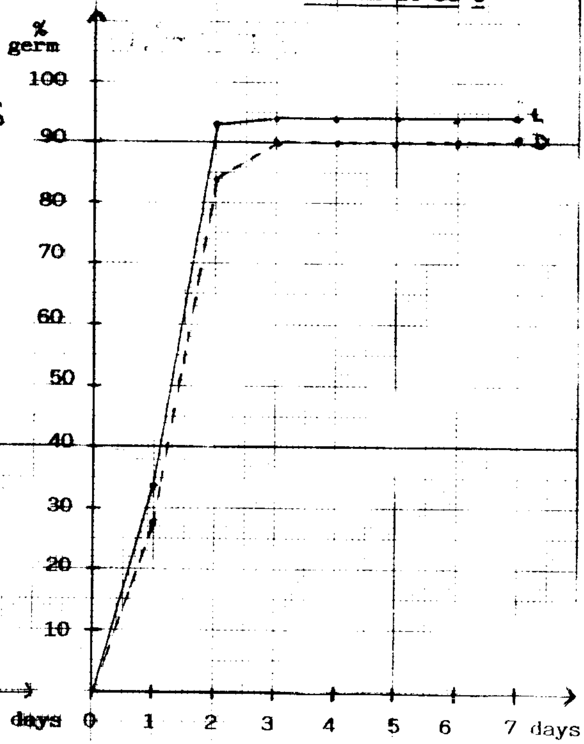


Fig 4 : Evolution of germination at 35°C



L : light D : darkness

4. ANALYSIS AND INTERPRETATION

At the ranges of temperature of the experiment (20°C, 25°C, 30°C, 35°C) ; the germination abilities are satisfactory at the end of a seven days period (these abilities are close to or above 90 %). A germination rate of 80 % at 25°C, 30°C, 35°C is reached after two (2) days. At 20°C, the rate is slower (four days are then needed to pass a germination rate of 50 %). At 35°C the germination is much accelerated since on day is enough to obtain 34 % and 28 % of germination ; but the final percentages of germination are lower than those obtained at 25°C or 30°C.

The range of temperature wich allows an optimal expression at the germination abilities is of 25°C to 30°C. Seeds of Acacia albida Del. need heat in order to stimulate their germination. Many studies have been done on this subject. Doran and Boland (1984) have found that 35°C was a temperature close to the optimum for the germination of Eucalyptus microtheca seeds. Sowing A. albida Del. seeds in December or January (cold months for many sahelian countries like Burkina Faso) would mean a spread and heterogenous germination. This is not of any interest for a propre utilisation of the nursery.

As for the effect of light, the very small differences in germination noted (this is the case for all the ranges of temperature of the experiment) between light conditions and darkness ones, allows to state that the seeds of Acacia albida Del. are very little if any at all, sensitive to light. This is verified in a nursery where, in spite of the coat of mold that cover seeds forming a screen to the light, the seeds are able to germinate if ther are no other constraints.

The results don't allow to establish a correlation between light and the ranges of temperature tested.

Complementary experiments would give more informations. So ranges of temperature above 30°C and under 20°C, with an alternance of light and darkness could be tested.

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SEED PROBLEMS IN ETHIOPIA

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A B S T R A C T

The Forestry Seed Centre is currently collecting seed in bulk quantities of a number of species and provenances that have been identified as of high potential value for planting. The centre has faced many problems to meet the increasing demand for the supply of adequate seed of relevant species and provenances. This paper discusses what has been done in the past and what remains to be done to satisfy the seed demand in the country.

INTRODUCTION

Ethiopia is a country with a population of around 42 million people, increasing at an estimated rate of 2.9% per year. Around 90% of the working people are rural and depend upon subsitent agropastoral systems for theire livelihood.

The total land area is slightly 1.2 million sq.km. and the central area of the country is occupied by alarge mountain system. Although the entire country lies within the tropics, only the lowlands have a hot climate; on the central plateau, the nearness of the equator is counter balanced by the elevation of the land producing moderate temperatures. In Ethiopia places located at different latitudes and similar altitudes tend to have the same annual temperatures, but humidity varies from as low as 20% in the north to 80% in the south-west. The rainfall decreases in all directions from the south-west highlands. Like the lowlands, the plateau and mountainous regions are subjected to long periods of severe drought.

During past centuries, shifting cultivation and traditional grazing practices, coupled with tree cutting for fuel and building needs have left much of the central plateau and highland regions denuded of closed forest. Population and live stock pressures have also led to considerable degradation of tree cover in the lowlands.

It is estimated that 200,000 ha. of natural forests are lost annually due to agriculture, grazing, and fuelwood. This is from a reserve of 3.5 million hactare in the south west of the country. If the present consumption patterns continue it is estimated that in 20 years time the total forest cover will be completely destroyed.

The integration of technically-sound and socially acceptable forestry programs into Ethiopian agropastural systems are required and should make a positive contribution to the life of the peasant farmer and his family.

To overcome deforestation problems and to meet the demand in forest products, a total area of 390,000 ha. of land has been reafforested through the state forest department, community forestry department, aid agencies and others in the last six years, and it appears that reafforestation will proceed at an annual rate of some 40,000 ha. per year for the next few years.

Draft copies of the national "Ten year perspective plan 1984 - 94" call for 3.5 million hactares of land to be reafforested by the end of 1994. Furthermore, a nation-wide reafforestation program will create 1200 nurseries. Under this program, 10% of the total land area is expected to be covered with forest trees through various means.

Tree seed is essential for all these applications. Moreover, the importance of sound seeds from high quality stands is widely recognized as the best means of ensuring fast-growing and healthy plantations capable of yeilding high quality wood.

Problems of Seed Collection and Supply

Although records of introduction of exotic species goback to 1895, it is only in the last ten years that the department has been structured into an effective unit capable of servicing the needs of both community and state department's interests. The present seed centre is structured under the Forestry Research Centre in which the scope of research ranges from species and provenance trials through silvicultural practices and nursery techniques to the collection and distribution of tree seed. Bearing in mind that seed handling is a task that requires a knowledge of both biological basis and practical handling technology, there are many requirements that need to be satisfied in order to provide adequate services for the national afforestation programmes. In addition to skilled personnel within different specialist fields, adequate funds, equipment and organization's structure for collecting and handling cones and seeds must be available when needed. The central handling of seed supplies has facilitated the country's aim at a sustained forest management to meet the demand for the supply of adequate seed of relevant species and provenances the centre has faced many problems:

1) *The major constraints of tree seed handling are lack of adequate skill, methodology and professionality. Without adequately trained staff, seed handling and research on physiology of important indigenous species is a difficult task.*

2) *At present, seed is collected from natural forests, man-made plantations planted for objcetives such as fuelwood and timber, and from seed production areas. All these areas serve as temporary or intermediate sources to meet the immediate demand of seed, there by confining the seed collection to selected superior stands until the seed center's seed orchards come into production. In the past, very little has been done in establishing seed stands.*

3) *Seed is collected by cutting or shaking branches, or from felled trees. In some cases, the use of heavy axes for seed collection from standing trees is rather cumbersome and others methods such as high prunning saw, using safety ladders should be used.*

4) *The present method of seed processing is manual. Damage to seed during extraction has occured, affecting the quality of seed, germination and storage. Sometimes this damage exceeds 20% of the total collection the seed center has made its best to improve the blowing and clearing process but other efforts must also be made. At present the seed centre is obtaining a well-designed cold storage facility. This will improve the quality of the center's seed supply. The centre has got a well-equipped seed testing laboratory. Viability tests, moisture content determination and purity analysis are routines in the laboratory. Experiments to overcome dormancy problems,mainly on indigenous species are carried out applying various techniques.*

In order to satisfy the expanding afforestation programmes, the seed centre handles more than 12,000 kg. of seed every year. This large figure is an indication of:-

a) Loss of viability of seed due to poor transportation, ie. lack of field vehicles.

b) Incorrect handling of seed in nurseries and during the transit process.

c) The absence of well-trained nursery men in many places.

Last but not least, It must be emphasized that, as in many developing countries, planners expect project seed requirements to come directly from the existing stock. Ethiopia is not an exception and the centre is not able to satisfy demand in some instances and projects have failed to fulfill their targets. An advance notice from each department could have solved the problem, but since there is no close collaboration between planners and the seed centre, the problem may exist for sometime in the future.

Inorder to overcome all these problems, the centre, in collaboration with concerved departments and international agencies has laid a basis for a plan of action:-

1. *The existing 48 m^2 area and poorly facilitated seed store is to be replaced by a large and well-spaced cold storage room.*

2. *Regarding the search for seed production stands, in the past few years the centre has demarcated a large area of land within man-made plantations and natural forests for some of the major tree species such as Cuppressus, Eucalyptus, Pinus, Grevillea and others in different bio-climatic zones. Consequently, the centre has succeeded in establishing some seed stands for pines using seed provided by the DANIDA seed centre.*

Eventhough there are no formal training facilities, using demonstration centres and other already established nurseries and planting sites, around 700 nursery formen and forest rangers have been given training on seed collection and nursery techniques.

A REVIEW OF THE LITERATURE ON STORAGE OF DIPTEROCARP SEEDS

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SUMMARY

Some species in the *Shorea*, *Hopea*, and *Dipterocarpus* genera have been shown to be capable of storage for periods of about a year or more, but others have not yet been stored for periods greater than a few weeks.

Moisture content is a crucial factor in determining storage life; seeds of most species of dipterocarp so far examined lose viability on desiccation below a relatively high moisture content. These seeds can thus be described as 'recalcitrant' in their storage physiology, as defined by Roberts (1973). By contrast, seeds of three species in the genus *Dipterocarpus* can be dried to 10-17% moisture content or lower without damage and, in addition, have greater storage life at these moisture contents than at higher ones; such seeds are said to have 'orthodox' behaviour. Seeds of 'recalcitrant' species should be stored at moisture contents above the relevant lowest-safe moisture content. Electron microscope studies show that desiccation damage is accompanied by breakdown of the subcellular structure.

Maintenance of a suitable temperature is essential for safe storage of seeds. Reduced germination following exposure to temperatures in the range 0-16°C (chilling damage) occurs in all moist dipterocarp seeds so far examined. Some authors have divided dipterocarp species according to the susceptibility of their seeds to chilling damage; seeds of *Shorea* species in the "red meranti" and "balau" groups were especially sensitive whilst all other dipterocarps studied were said to be tolerant to 4°C. Several reports indicate optimum storage of 'recalcitrant' seed at temperatures in the range 15-21°C. 'Orthodox' seeds can be safely stored at temperatures between +2° and -20°C.

Maturation of seeds (assessed by germination ability) occurs during the last few weeks on the tree, but can also occur to some extent after harvest; the process is generally accompanied by moisture loss. Some reports indicate that mature seeds store better than immature, whilst other reports suggest the reverse.

Ventilation of 'recalcitrant' seed is needed to remove toxic gases and to prevent anoxia; increasing oxygen concentrations above atmospheric levels does not, however, improve storage life. The value of fungicides in improving storage life of dipterocarp seeds has yet to be established.

Associations between desiccation tolerance and seed size, habitat of parent tree, seed desiccation rate and seed longevity have been observed. 'Orthodox' seeds have drier habitats, quicker desiccation rates and greater longevities than 'recalcitrant' seeds. Even among 'recalcitrant' seeds, desiccation tolerance appears related to the factors listed above.

A number of principles for future research are suggested.

INTRODUCTION

Loss of dipterocarp seed viability during handling and storage have hindered the setting up of species trials, enrichment programmes and plantation projects.

Early publications mentioning dipterocarp seed storage emphasize their extremely short-lived nature; Indian species were referred to by Troup (1921), Dent (1948) and Sen Gupta (1939), whilst Malayan species were examined by Barnard (1950). Subsequent published work on dipterocarp seed storage is assessed in the present review.

REVIEW

Storage will first be discussed in relation to moisture content and temperature. Subsequently, the effects of maturity, the gas environment and fungicide treatment will be considered. Finally, associations of storage physiology with other factors such as species habitat and seed size will be reviewed. Dipterocarp fruits will be referred to as 'seeds' throughout. Moisture contents are quoted on a fresh weight basis.

(1) MOISTURE CONTENT AND STORAGE LIFE

It has been known for some time that dipterocarp seeds can be damaged by drying to low moisture contents. In general, any seeds which cannot be dried below a relatively high moisture content have been described as 'recalcitrant', whilst seeds which can be dried to a low moisture content and stored have been referred to as 'orthodox' (Roberts, 1973). Effects of desiccation on the germination of dipterocarp species were described by Tompsett (1986) and Yap (1986) at the preceeding IUFRO Symposium in the present series.

(a) Classification of seeds as 'recalcitrant or 'orthodox'

A primary aim of seed storage research should be to determine whether the species under examination is of the 'orthodox' or 'recalcitrant' storage physiology type. In most of the published literature on dipterocarp seeds the detailed relationship between germination and moisture content is not reported, but in many cases it is clear that the species in question is 'recalcitrant'.

In a recent study (Tompsett, 1986, 1987) seeds of certain species in the Dipterocarpus genus were shown to possess 'orthodox' physiology. Seeds of D.intricatus, D.alatus and D.tuberculatus can be dried without damage to at least 10%, 17% and 12% moisture contents without damage; in addition, two of these species have increasing longevity as moisture contents are reduced within the range 6-20%, further confirming the 'orthodox' nature of the seed.

Seeds of most dipterocarp species have, however, been found to possess 'recalcitrant' storage physiology. Various methods have been used to quantify desiccation tolerance, so that comparisions between seeds can be made. Sasaki (1980) used the phrase 'critical moisture content' to describe the moisture content at which all seeds were dead, whilst Tang and Tamari (1973) chose the moisture content at which seeds gave 60% germination for this purpose. A third author proposed use of the term "lowest-safe moisture content", defined as the moisture content below which seeds died when a seedlot is dried (Tompsett 1986); this latter moisture content is more difficult to assess accurately than the 60% germination point of Tang and Tamari (l.c.) but it nonetheless provides useful information for the forester. In addition, Tompsett (1986) advocated the use of probit analysis to produce a slope value which accurately describes the relationship between germination and moisture content.

(b) Lowest-safe moisture content values

In early work by Tang (1971), Shorea platanoides and S.curtisii apparently dried safely to 11% and 17% moisture content respectively. No subsequent studies have shown such low values for any Shorea species; in fact, Sasaki (1980) indicates that drying is quickly damaging for S.curtisii. A summary of lowest-safe moisture content values, determined from published literature, are presented in Table 1 and show that the majority of species have values in the range 30-60%. The reasons for differences in sensitivity of 'recalcitrant' seeds are not known. As discussed above, 'orthodox' Dipterocarpus seeds can be dried **far** below 30% moisture content **safely.**

TABLE 1. Lowest-safe moisture contents (LSMC), estimated from the literature, and temperatures (temp.), moisture contents (MC), and germination (germ.) for optimum reported storage conditions are given. Seeds were supposedly mature and authorities for names are those of Ashton (1982)

	Species	Source	LSMC %	Optimum Storage Days	Temp. °C	Germ. %	MC %
(I) SHOREA (a) Section Shorea	S.robusta	Purohit et al. (1984)	-	30	13	40	-
		Tompsett (1985)	40	18	16	35	41
	S.sumatrana	Yap (1986)	>40	15	25	60	-
(b) Section Pentacme	S.siamensis	Tompsett (unpub.)	51	-	-	-	-
		Panochit et al. (1984)	-	56	15	83	40-48
(c) Section Anthoshorea	S.roxburghii	Sasaki (1980)	34	182	4	69	40
		Purohit et al. (1982)	-	105	23	50	-
		Tompsett (1985)	32	270	16	50	40
		Panochit et al. (1986)	>25	56	15	95	35-40
	S.assamica	Sasaki (1980)	-	98	4	50	-
	S.hypochra	Sasaki (1980)	-	60	4	10	-
	S.brachteolata	Sasaki (1980)	-	60	4	4	-
(d) Section Bracteolata	S.almon	Tompsett (1985)	42	32	16	18	45
	S.selanica	Tompsett (1986)	>25	-	-	-	-
	S.pauciflora	Sasaki (1980)	-	45	25	67	38-51
(e) Section Mutica	S.parvifolia	Sasaki (1980)	-	21	21	43	25-29
	S.parvifolia	Yap (1986)	>23	-	-	-	-
	S.argentifolia	Yap (1986)	35	-	-	-	-
	S.argentifolia	Sasaki (1980)	-	45	21	60	39-46
	S.acuminata	Chin et al,(1984)	≤42	-	-	-	-
	S.acuminata	Sasaki (1980)	-	30	21	70	38-43
	S.acuminata	Yap (1981, 1986)	>40	30	25	70	38-46
	S.singkawang	Yap (1986)	55	-	-	-	-
	S.macroptera	Yap (1986)	38	-	-	-	-
	S.lepidota	Yap (1986)	27	-	-	-	-
	S.dasyphylla	Sasaki (1980)	-	14	21	24	40-46
	S.leprosula	Sasaki (1980)	-	30	21	45	29-35

	Species	Source	LSMC %	Optimum Storage Days	Temp. °C	Germ. %	MC %
	S.curtisii	Yap (1981)	-	30	25	20	-
	S.curtisii	Tang (1971)	17	-	-	-	-
	S.curtisii	Sasaki (1980)	>35	38	25	67	35
	S.platyclados	Tang (1971)	11	-	-	-	-
	S.platyclados	Yap (1981)	-	58	25	80	-
(f) Section Ovalis	S.ovalis	Yap (1986)	27	-	-	-	-
	S.ovalis	Sasaki (1980)	<32	92	21	87	36-37
(g) Section Doona Ashton	S.trapezifolia	Tompsett (unpub.)	37	-	-	-	-
	S.congestifolia	Tompsett (unpub.)	≥40	-	-	-	-
(II) DIPTEROCARPUS	D.obtusifolius	Tompsett (1987)	<50	-	-	-	-
	D.turbinatus	Tompsett (1987)	45	161	16	8	41-44
	D.baudii	Yap (1981)	-	30	14	25	-
	D.humeratus	Maury-Lechon et al.(1981)	-	56	15	10	26
	D.tuberculatus	Tompsett (1987)	12	-	-	-	-
	D.alatus	Tompsett (1987 and unpub.)	≤17	315	6	44	11-15
	D.alatus	Amata-Archachai and Hellum (in press)	-	67	15	30	29
	D.intricatus	Tompsett (1987)	10	100	31	50	10
(III) HOPEA	H.hainanensis	Song et al. (1984, 1986)	30	365	18	80	35-38
	H.mengerawan	Tompsett (1986)	37	-	-	-	-
	H.utilis	Yap (1986)	>20	-	-	-	-
	H.helferi	Tang and Tamari (1973)	30	40	15	85	48
	H.odorata	Tang and Tamari (1973)	45	-	-	-	-
	H.odorata	Mori (1979)	-	55	10-15	0-10	-
	H.odorata	Yap (1981)	-	30	25	50	-
	H.odorata	Sasaki (1980)	-	45	4	5	53
	H.wightiana	Sasaki (1980)	-	60	4	5	-
	H.subalata	Sasaki (1980)	-	51	4	40	32-43
	H.nervosa	Sasaki (1980)	-	330	25	19	-
	H.ferrea	Sasaki (1980)	-	60	4	2	33-35
	H.ferrea	Tompsett (unpub.)	30	-	-	-	-

	Species	Source	LSMC %	Optimum Storage Days	Temp. °C	Germ. %	MC %
(IV) PARASHOREA	P.tomentella	Tompsett (unpub.)	43	-	-	-	-
	P.malaanonan	Tompsett (unpub.)	42	-	-	-	-
	P.densiflora	Yap (1981)	-	60	25	90	54
(V) VATICA	V.cineraea	Yap (1981)	-	25	60	65-86	-
	V.mangachapoi	Song et al. (1983)	>31	-	-	-	-
	V.umbonata	Mori (1979)	-	60	10-15	10-50	-
	V.umbonata	Yap (1981)	-	60	14	20	-
(VI) COTYLELOBUM	C.burkii	Tompsett (1986)	30	-	-	-	-
(VII) NEOBALANOCARPUS	N.heimii	Yap (1981)	-	50	14	80	28-47
(VIII) DRYOBALANOPS	D.lanceolata	Schaffalitzky de Muckadell and Pilim (1983)	60	-	-	-	-
	D.aromatica	Tang and Tamari (1973)	37	-	-	-	-
	D.aromatica	Yap (1981)	34	16	14	50	38-40

(c) Desiccation rates of seeds

It is possible that the rate of seed desiccation may influence its effect on viability; seeds dried quickly might give greater or less germination than seeds dried slowly to the same moisture content. However, in the case of the 'recalcitrant' seed of Araucaria hunsteinii, there are no such differences (Tompsett 1982). No intensive study of this sort has been carried out on dipterocarp seed, but Amata-Archachai and Hellum (in press) found that immature fruits of D. alatus clearly dried quicker than mature fruits; they suggest that the difference could be because of the death of the immature seeds. The faster loss of moisture by immature seeds could also be explained by their smaller size; the ratio of surface area to volume of small seeds is greater than that of large seeds, enabling quicker moisture loss. In this connection Tamari (1976) found small seeds of S.parviflora (0.3g) gave low viability whilst large seeds (0.5g) gave higher viability. One explanation for the latter finding is that the smaller seeds had dried quicker and thus lost more viability than larger seeds prior to testing.

A clear-cut case of differences in desiccation rates among seeds of species in the same genus has been reported by Tompsett (1986, 1987). Rates for Dipterocarpus seeds varied greatly and depended on their size and structure; at one extreme D.intricatus seed dried to 7% moisture content within a week, whereas at the other extreme seed of D.obtusifolius still retained 30% moisture content after 5 weeks in the same drying room environment. Likewise, Yap (1986) found S.parvifolia seeds dried quicker than those of two larger-seeded species of Shorea, but he believed the difference in rates to be related to pericarp thickness.

Yap (l.c.) also believed that seed viability depended on the temperature used for desiccation, irrespective of other factors, but the absence of statistical analysis casts doubt on this conclusion. He also noted dried seeds took longer to germinate than fresh seeds and thought the delay was caused by the need for repair of tissue damage resulting from desiccation; the delay could also be partly caused by the longer period to reach the fully imbibed state starting from low moisture contents.

Differences in desiccation rates such as those discussed may possibly affect both initial viability and subsequent storage life of the seed. Further studies are needed to assess these effects.

(d) Basic causes of desiccation damage and short storage life.

If the basic causes of desiccation damage could be determined, a way might be found to reduce the effect, enabling better survival of the seed. Nautiyal and Purohit (1985a, 1985b, 1985c) found that the outer part of S.robusta seed (seed coat) dried earlier than the inner part (cotyledons and embryonic axis); they concluded that constriction of or premature desiccation of the embryo shortens seed life in this species. This seems an unlikely explanation, since the more long-lived species S.roxburghii has very similar seed coat structure. The same authors reported that the quantity of nutrients leaking from the seed increased as moisture content and germination ability declined; they concluded that cellular membranes in the seed had lost their semi-permeability.

Whether this apparent loss of semi-permiability was a primary result of desiccation, or whether it was one aspect of a general loss of metabolic capability of the seed could not be assessed from the data obtained. A small decline in the absolute concentration of nutrients in the seed was observed, but the significance of this decline was not clear.

Some authors have confused the effects of desiccation itself with the effects of ageing, which can occur at constant moisture contents. In studies by Song et al.,(1983) on Hopea hainanensis it is clear that desiccation effects are being examined. At 36% moisture content the ultrastructure was intact, but on desiccation to 26% moisture content, which severely reduces germination percentage, various changes were observed. Vesicles appeared in the cytoplasm, vacuolar membranes ruptured and cell contents became less distinct. Cell walls and cytoplasm became separated and nuclear membranes could not be distinguished from the nucleolus. These changes illustrate a general deterioration of cellular structure rather than an effect confined to the cell membrane. In a further study (Song et al., 1986), desiccation to 31% was shown to disturb the ribosomes and endoplasmic reticulum, but these changes were reversed on re-hydration.

(d) Pre-germination during storage

A problem associated with storage of moist seed is germination before removal for testing (pre-germination). This problem was encountered with S.roxburghii seed stored at 16°C with about 40% moisture content (Tompsett, 1985). Provided desiccation and mechanical damage to the radicle are avoided, viable seedlings can still be produced by a high proportion of the pre-germinated seeds. Maury-Lechon et al., (1981) recommended drying dipterocarp seeds to half the original moisture content on collection; this would prevent pre-germination in storage, but their experiments did not include undried controls so the benefit is not established.

(e) The use of storage media

Storage of 'recalcitrant' seeds in media such as peat, sawdust and sand has been carried out to maintain a high moisture content, but storage in thin polythene bags has been found to be more successful for non-dipterocarp seeds (King and Roberts, 1979). Song et al (1984) achieved excellent results with a coconut dust medium for storage of Hopea hainanensis over a period of one year.

(f) Conclusions

In summary, 'recalcitrant' seeds should be kept at moisturre contents above their lowest-safe values, whilst 'orthodox' seeds should be kept at 10-17% moisture content in the short term and at lower moisture contents in the long term. More work is needed to assess the optimum moisture contents required for seed of particular species.

(II) EFFECT OF TEMPERATURE ON STORAGE LIFE

The most marked feature of the effect of temperature on the storage of dipterocarp seeds is the incidence of chilling damage, which is severe in certain cases; Tang (1971) found that *S.curtisii* could be fatally damaged by exposure to only 16 hours of 4°C, indicating extreme susceptibility to chilling temperatures. Sasaki (1980) used this feature to divide seeds into two groups according to the extent of their susceptibility to damage. He assessed damage on the basis of reduction in germination ability but it appears that more subjective methods were also used; there are references in the report to changes in brittleness and coloration of the cotyledons following chilling treatment. In this review chilling damage is considered firstly, and then the optimum temperatures for seed storage are discussed.

(a) Chilling damage and grouping of dipterocarps

Sasaki (1980) considered seeds of *Shorea* species in the "yellow and white meranti" groups, *Hopea*, *Dipterocarpus*, *Vatica* *Dryobalanops*, *Balanocarpus* and *Parashorea* to be tolerant to 4°C, whereas seeds of *Shorea* species in the "red meranti and balau" groups were stated to be intolerant to temperatures below 15°C. He also separately classified *Anisoptera* as a tolerant genus (Sasaki, 1979).

Yap (1981) later proposed a three-group classification: firstly, seed of species in the *Dipterocarpus*, *Dryobalanops*, *Neobalanocarpus* and *Vatica* genera were said to be intolerant to temperatures below 14°C; secondly seed of *Shorea* species in the sections Mutica, Pachycarpae and Brachypterae were considered intolerant to temperatures below 22 to 28°C; and finally, seed of Anthoshorea-section *Shorea* species and of *Hopea* and *Parashorea* could be cooled to 4°C but were recommended to be stored at 14°C.

Further details of responses to chilling temperatures are given in Table 1.

(b) Characteristics of chilling damage

These differences in chilling tolerance of seeds among dipterocarp species are quantitive rather than qualitative; seed of the 'tolerant' species *S.roxburghii* eventually suffers damage at 2 to 5°C relative to seed at warmer temperatures (Purohit *et al*., 1982; Tompsett, 1985). Another example of chilling damage occurring over a lengthy period is that for *H.hainanensis* seed; at 5°C almost all seeds were dead after 6 months, but at 15-20°C no loss of viability had occurred (Song *et al*., 1984).

Increased resistance to chilling damage as maturity approached was observed for *S.siamensis* by Panochit *et al.* (1984); germination declined to zero and 25% for seed collected

4 and 2 weeks respectively before maturity after storage for 28 days at 2°C, whereas mature seed still gave about 60% germination after 56 days storage. A similar effect was noted for S.roxburghii (Panochit et al., 1986)

Studies on S.robusta seed have revealed other characteristics of chilling damage (Tompsett, 1985). Seeds on 1% agar gel were fatally damaged at all temperatures up to 11°C and some limited damage was noted at 16°C. Partial loss of germination ability was observed when seeds were placed in chilling temperatures at a constant 40% moisture content; subsequently little further loss took place for several days. The effect was greater at 6°C (60% germination loss) than at 11°C (40% loss).

It should be noted that not all tropical tree seed at high MC is susceptible to chilling damage; Araucaria angustifolia, for example, can be stored for about two years at 2°C without losing all viability (Tompsett, unpublished).

(b) The optimum temperature for storage

The longest known periods of storage of dipterocarp seeds so far achieved extend to about a year without loss of viability in the case of dried seed of Dipterocarpus alatus and D.intricatus (Tompsett, unpublished) and moist seed of Hopea hainanensis (Song et al, 1984). The Hopea seeds were kept at 15-20°C with about 36% moisture content, whilst the Dipterocarpus seeds were kept at between -20°C and +6°C with 7 to 15% moisture content. In the case of the Dipterocarpus seeds, storage for several decades should be possible **(for these species)**.

The 'recalcitrant' seed of S.roxburghii is relatively long lived, having stored at over 50% germination for 9 months at 16°C with 40% moisture content (Tompsett, 1985). Sasaki (1980) claimed 7 months storage for this species, but unfortunately the number of seeds used in the germination test was not reported.

Tang and Tamari (1973) believed a period at 15°C had 'conditioned' Hopea helferi and H.odorata seeds so that they could tolerate 10°C on transfer after 5 weeks. Unfortunately, necessary control treatments at 10°C or at 15°C throughout were not included in the experiment.

Table 1 includes best recorded storage temperatures for species where more than one level was tested. Seeds stored at warm temperatures often lost moisture and viability due to the low r.h. conditions rather than in response to the high temperature itself. A genuine assessment of temperature effects can only be made when moisture contents and the gas environment are held constant.

In general, Tang and Tamari (1973) thought 15°C a suitable temperature for storing many dipterocarp species. Sasaki (1980) recommends the wide use of 21°C "for practical purposes", despite the chilling tolerance he found in certain species. Tompsett (1985) concluded that 21°C was provisionally the best choice for three species of Shorea, but pre-germination was enhanced in this treatment relative to cooler temperatures

(III) MATURITY OF SEED AND STORAGE ABILITY

The question of seed maturity will be dealt with in three parts. Firstly, the progress of the seed to maturity on the tree will be considered, then the continuing maturation of seeds after harvest in certain species and finally the effect of maturity on storage ability. There is also a note on field assessment of maturity.

(a) Maturation on the tree

Sasaki (1980) showed clearly increasing seed maturity of S.roxburghii (synonym for S.talura) during the final 3 weeks on the tree before 100% germination was achieved. During this period the time between sowing and radicle emergence decreased progressively and moisture content apparently declined from over 60% to 50% (these latter data seem suprisingly high). A similar decline in moisture content with maturation was observed by Panochit et al. (1986) for the same species, but in this case the change was from 40% to 30%. In yet another example of natural maturation Panochit et al. (1984) showed moisture content decreasing from 59% to 49% as germination ability increased from 33% to 92% in S.siamensis.

It is of interest to consider the relationship of maturity (time of reaching maximum germination) to the time of natural seed fall. Seed from Malaysia was mature 3 or 4 weeks before abscission in the case of S.ovalis (Sasaki, 1980), S.leprosula and Dryobalanops lanceolata (Schaffalitzky de Muckadell and Pilim, 1983). On the other hand seed from Thailand did not mature until the time of seedfall in the case of S.roxburghii (Panochit et al., 1986); it appears likely that the same late maturity applies in the case of S.siamensis (Panochit et al., 1984). The reason for these differences is not known, but Thai seed was from drier habitats

(b) Maturation after harvest

Tang and Tamari (1973) were the first to report post-harvest maturation of dipterocarp seeds. They found that Hopea helferi and H.odorata seeds blown down prematurely by a high wind increased in germination over a period of about a week in storage at 15°C. Unfortunately, no data points are reported; the results are presented in diagrammatic form only. It is also a pity that no moisture contents are presented for this experiment.

Four further relevant studies have been reported. Panochit et al., (1986) found germination of immature S.roxburghii seed increased when moisture content was reduced over 4 days from near 40% to about 30%. Using the same species, Purohit et al (1982) found that reducing moisture content strongly increased germination, but they considered the fresh seed dormant rather than immature. Amata-Archachai and Hellum (in press) noted an increase in germination ability of D.alatus during drying at 23°C over 7 days as moisture content was reduced from 59% to 31%. Finally Panochit et al. (1984) found that storing immature S.siamensis seed for a week increased germination; strangely, no loss of moisture was reported in this latter case, despite retention of the seed in a drying room for 4 days. The extent to which desiccation is essential for the after-ripening effect is not yet clear.

(c) Effect of maturity on storage life

Sasaki (1980) believed that immature dipterocarp seeds stored less well than mature seeds, but this conclusion is not entirely clear from the data he presents. Panochit et al. (1986) showed that S.roxburghii seeds collected 2 weeks before seedfall stored much better than those collected at natural seedfall. However, seeds of S.siamensis collected 4 weeks before maturity could not be stored at all, whilst more mature seed could be kept well for 56 days (Panochit et al., 1984). The influence of the degree of maturity on seed storage life requires further clarification.

(d) Judging maturity in the field

Sasaki (1980) suggested wing browning should be used to assess readiness of seeds for harvest, whilst Amata-Archachai and Hellum (in press) believed this criterion may only apply to Shorea and observed that maturity of Dipterocarpus alatus occurred before the wings turned brown.

(IV) THE EFFECT OF GAS ENVIRONMENT ON STORAGE LIFE

It has been known for some time that ventilation of 'recalcitrant' seeds was essential to maintain viability. Sasaki (1980) noted the importance of ventilation of dipterocarp seed to preserve viability of, for example, S.curtisii. The extreme longevity of 'recalcitrant' Hopea hainanensis seed was achieved by maintaining oxygen levels above 10% (Song et al.,1984).

Tompsett (1983) assessed the effect of various oxygen concentrations on the storage life of the 'recalcitrant' seed of Araucaria hunsteinii and found that longevity declines as oxygen concentration is decreased within the range 0-21%. In agreement, a nitrogen atmosphere decreased seed longevity of H.odorata, but, surprisingly, seemed to increase seed longevity of Dipterocarpus oblongifolius (Yap, 1981); the latter study would have been more convincing if it had been subjected to statistical analysis. Raised oxygen levels betwen 21% and 100% did not enhance storage life of D.turbinatus (Tompsett, unpublished). Concentrations of carbon dioxide and ethylene above those in the atmosphere did not increase storage life of 'recalcitrant' A.hunsteinii seed (Tompsett, 1983), so these gases were not used in the experiments on D.turbinatus.

The need to replenish oxygen used up, and to remove toxic gases produced in the course of metabolism should be remembered when storage conditions are considered.

(V) EFFECT OF FUNGICIDES ON STORAGE LIFE

Jensen (1971) emphasised the need to protect moist dipterocarp seeds against fungal attack. Yap (1981) believed some seeds, such as those of Neobalanocarpus heimii, have increased storage life when treated with fungicide, but this was not established because fungicide-free control treatments were not included in the experiment. In fact, one report suggests that longevity of H.helferi seed is actually reduced by fungicide treatment (Tang and Tamari, 1973). Experiments by Arentz (1980) on the 'recalcitrant' seed of A.hunsteinii employing 2 fungicides at 3 concentrations showed no benefit; fungi were restricted to the seedcoats and did not penetrate the endosperm of viable seeds. Whilst seeds of some other 'recalcitrant' species have supposedly survived better with fungicides, this has yet to be shown clearly for dipterocarps.

(VI) ASSOCIATION OF STORAGE PHYSIOLOGY WITH SEED CHARACTERS AND TREE HABITAT

Various associations have been noted for dipterocarp seeds. The lowest-safe moisture content (LSMC), defined as the moisture content below which some germination loss occurs on desiccation, is associated with various properties of the seed and its parent tree. Seed size, seed desiccation rate, seed longevity and the habitat of the parent species have all been found to be related to storage physiology. It should be noted, however, that the present conclusions are based on the relatively few species that have been examined and further work is required.

(a) Storage physiology and seed size

For three Shorea species a relationship has been noted between seed size and desiccation tolerance; LSMC values increase as size increases from the small, desiccation-tolerant S.roxburghii to the larger, desiccation-intolerant S.almon (Tompsett, 1985). A similar relationship was found in the Dipterocarpus genus (Tompsett, 1987) but in this case embryo size is more important; two small-embryoed species (D.intricatus and D.tuberculatus) had very low LSMC values and were shown to be 'orthodox' in storage physiology, whilst two species with large embryos (D.obtusifolius and D.turbinatus) were shown to have high LSMC values and 'recalcitrant' physiology. Other species fit this pattern (Tompsett, 1986). In addition 'orthodox' seeds tend to be globular, whilst 'recalcitrant' seeds have tubercles or other projections from the calyx which may enhance desiccation rate (Tompsett, 1987)

Sources of information on dipterocarp seed size and weight for use in future studies of this type are Ashton (1982), Tang and Tamari (1973) and Smitinand et al. (1980).

(b) Storage physiology in relation to habitat and longevity

Seed of three Shorea species from different habitats have different desiccation tolerances. The low-rainfall area species S.roxburghii has seed which can be dried safely to 35%, whereas the monscon or rain forest species S.almon and S.robusta cannot be safely dried below 40% moisture content (Tompsett, 1985). The seed with the greatest desiccation tolerance (S.roxburghii) is also the seed with the greatest longevity.

A more extreme example is found in the case of the genus Dipterocarpus; two dry-zone, deciduous species, D.intricatus and D.tuberculatus, have 'orthodox' seeds, whilst two species with distributions into the relatively wet, evergreen areas have 'recalcitrant' seeds (Tompsett, 1987). Longevity of 'orthodox' seeds is expected to be very great, whilst 'recalcitrant' seeds cannot be stored in the long term at present.

As with other factors, these patterns have been found to extend to seeds of other species; trees from low rainfall and sandy-soiled areas tend to have relatively great longevity and low LSMC values (Tompsett, 1986).

(c) Storage physiology in relation to seed desiccation rate

The 'orthodox' seeds of Dipterocarpus intricatus and D.tuberculatus can dry to below 10% in 2 weeks, whereas the 'recalcitrant' seed of D.obtusifolius remains above 28% moisture content even after 3 weeks in the same drying conditions (Tompsett, 1987). This situation may have evolved because 'orthodox' species can benefit from desiccation by enhanced storage life; if the wet season arrives late, viability is nonetheless preserved under natural conditions. Conversely, 'recalcitrant' seeds are damaged on desiccation and so their slow desiccation rate is protective. The differences in desiccation rates observed are related to seed size (small seeds dry faster) and probably also to seed anatomy.

(VII) GENERAL PRINCIPLES FOR FUTURE RESEARCH

Initially, when a new species is to be examined, a desiccation experiment should be carried out to assess if the seed is 'orthodox' or 'recalcitrant'. Seed should preferably be dried in more than one way and an undried control should be included in the experiment.

If the seed is 'orthodox', the exact extent to which it can be dried should be assessed; if possible, relate the results both to laboratory germinations and to nursery germinations. If the seed is 'recalcitrant', the LSMC value and susceptibility to chilling damage should be assessed.

Attention should be given to maintaining constant moisture contents during storage experiments. Moisture content should be expressed on a wet weight basis. Make a proper, separate analysis of moisture content on each sampling occasion; do not merely re-weigh the same batch of seed to estimate moisture content. Consider estimating the component parts of the seed separately. Record the desiccation rate of the seed in a standard environment.

Temperature control is important; provision of standby generators and good maintenance of cooling equipment will enable scientifically accurate results to be obtained.

Use adequate numbers of seeds for germination tests and at least 5g (small seed) or 10g (large seed) of material for moisture content determination. Sample frequently during the experiment. Record seed anatomy. Analyse the results statistically, unless they are totally clear and indisputable. Assess the extent of parasite infestation and use the values obtained to make adjustments so that the results presented apply to the number of uninfested seeds sown.

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ACTIVITIES OF ASEAN-CANADA FOREST TREE SEED CENTRE

BY

PISAL WASUWANICH

INTRODUCTION

ASEAN-Canada Forest Tree Seed Centre Project is under cooperation between Association of South East Asian Nations (ASEAN) and Canada. The Centre was located at Muak-Lek District, Saraburi Province, Thailand. It is about 150 km. from Bangkok to northeastern part of Thailand.

An agreement of the project (Memorandum of Understanding) was signed by both sides on the first of May 1984. Due to the agreement, the project lasted for 3 years; however, it was extended to the end of September 1987 instead of April 1987 in order to coincide with Thai fiscal year. Research activities of the project were actually started in May 1986 after completion of building construction and some equipment installation. Since the research activities had been begun in the later part of the project period, both ASEAN and Canada started considering to have Phase II of the project. Then, the project duration was prolonged upto the end of December 1987 for preparation of a proper project document for the Phase II. It was decided that the Phase II will be from January 1988 to December 1992.

Considering the project activities including construction, equipment installation and research activities, the project period which will end in December 1987 should be appropriately called an establishment phase and the Phase II is an implementation phase.

OBJECTIVE

The objective of the Project is to assist in the establishment of the ASEAN-Canada Forest Tree Seed Centre and develop its capacity to provide technical assistance to ASEAN countries in their forest plantation programmes.

FUNCTIONS

1. To establish a well-equipped regional forest tree seed centre in Thailand which will serve as a training centre on seed research for ASEAN countries

2. To assist in the development of forest tree seed orchards in ASEAN countries in order to provide adequate supply of quality seed of selected species used in afforestation and reforestation work.

3. To strengthen ASEAN technical competence in nursery and forest plantation research and development through fellowships leading to graduate degrees.

The function No.1 and No.3, have been already fulfilled. However, the Centre has to be additionally equipped for some work. The function No.2 has not yet been fully achieved because the Centre work, as directed by Project Steering Committee (PSC) which is a governing body of the Centre, should emphasize firstly on physiological quality of seeds rather than genetic quality. However, provenance trial and gene conservation establishment are partly done. The Centre quite agrees to the PSC members' direction, because the Centre has to conduct research work of many species. Tree improvement work for all species could not be successfully done within a short period of time.

ACTIVITIES OF THE CENTRE

There are many activities of the Centre. They are both indicated in the project document and created during implementation of the project. Main activities and activities which will be useful for the regional and the international cooperation are presented.

1. Project Steering Committee Meeting

The Project Steering Committee (PSC) is a principal governing body of the Centre, consisting of 7 members, one from each ASEAN countries and Canada. Its authority will emanate from the agreement among ASEAN member countries. The representative of the host country will be ex-officio chairman of the Committee.

The Committee will be responsible for all activities of the Centre, setting policy and operational guidelines to be followed by the Centre with respect to the operational aspects of the Centre, reviewing and approving an annual plan of operation, an annual budget, progress and reports.

The Committee will meet once a year or more as required.

2. Canadian Expertise

During the project period, there are several Canadian experts on both short term and long term basis participating in activities of the Centre, mostly on technical matter. They help the Centre staff in planning and supervising research work. These experts will also give supervision as requested to other ASEAN countries. Some of experts conduct their own research work at the Centre. Fields of expertise cover seed production, seed technology, tree improvement and seed health. All experts are very knowledgable and working very hard.

3. Trainings

Trainings for ASEAN authorities under the project are consisted of short term and long term basis both in ASEAN countries and in Canada. All are financially supported by Canada.

The long term training is a post graduate course which is primarily for professional counterparts in the Centre and for professionals working in forestry agencies in ASEAN countries. Fields of the post graduate study comprises forest ecology, silviculture, forest pathology, forest entomology, plant physiology, forest management, forest economics and forest botany. It is expected that up to the end of December 1987 there will be at least 2 professionals each from Indonesia, Malaysia, the Philippines and Thailand graduating master degree from Canadian Universities. These graduates will be persuaded to work at the Centre from 6 to 12 months through fellowship programme. By this meams, the graduates will familiarize with research methodology and activities of the Centre and with the Centre staff. It is observed that this will be beneficial to cooperative research work considerably.

There are two kinds of the short term training, one is organized in ASEAN countries and another is held in Canada. Two short term training courses in Canada have already been organized and were totally participated by 17 ASEAN professionals. The training covered seed work, tree improvement and nursery technology.

Up to now, three short term training courses on (1) Forest Tree Seed Collection and Handling, (2) Production of Improved Seeds and (3) Forest Tree Seed Testing were organized in ASEAN countries. The (1) and the (3) were held at the Centre and the (2) in Bogor, Indonesia. There were 35 ASEAN professionals attending these training courses.

4. Research Fellowship

This is to promote ASEAN seed workers or researchers to conduct their own research work at the Centre or to conduct cooperative research work with the Centre staff. Research Fellows will be given a round trip air ticket, allowances and medical fee. However, their salaries have to be still paid by the organizations where they belong to. Furthermore, the Centre also provide with research material. Up to now there were 7 Research Fellows participating in this activity.

According to our observation, Research Fellows possessing bachelor degree would like to be trained at the Centre and those possessing master degree prefer to conduct their own research work or to participate in cooperative research programmes. Apparently, friendship created by both Research Fellows and the Centre staff together at the Centre leads to successful cooperation, even after Research Fellows return homes.

5. Establishment of Working Group

It is found that there are several experienced and knowledgeable seed workers or researchers available in ASEAN countries. An opportunity should be given to them to meet and work together for particular issue for the benefit of the region. Also, technology from one country could be applied to other countries and vice versa. An Working Group on Seed Certification was established under the project in April 1985 with the following terms of experience:

(a) To assist the Director of the Centre to produce an ASEAN Register of Seed Sources. This is to be a Centre publication to updated every two years. This register is in summary form and does not replace the much more detailed registers which each country should maintain.

(b) To develop guidelines for preparation of standard documentation for preparation of seed registers in ASEAN countries.

(c) To develop guidelines for preparation of standard procedures for testing species not included in the ISTA rules. The Working Group will also coordinate the preparation of standard seed testing procedures for presentation to ISTA for inclusion in their rules for ASEAN species. The first need is to determine the current state of the art in testing these species, and eventually to recommend types of tests to be used.

It is observed that the Working Group could complete the given assignment rapidly and efficiently. And its decision is properly followed up. Because of these advantages, in the Phase II of the project more Working Groups on seed bank and seed technology, seed ontogeny and seed production, seed origin and genetic resources, vegetative propagation, pine and dipterocarps, will be established.

6. **Register of Seed Sources for ASEAN Forest Plantation Programmes**

This is a very successful task performed by the Working Group on Seed Certification. A reason to start this work is to know existing seed sources with its production in ASEAN countries so that required organizations could be explored for seed exchange and trade. Moreover, the register gives us further information on quantity of genetically improved seeds which are very useful to the Centre task to assist ASEAN countries in establishment of sources for good quality seed.

Seed sources include seed orchards, seed production area, natural stands and plantations. It should be worried that due to forest destruction at an alarming rate, an appropriate measure for seed source protection should be seriously established, especially for natural stands or plantations.

The register has not yet been completed. It will be finalized at the third meeting of the Working Group and soon published. It is hoped that the register will be useful to other organizations and people involved in forest plantation and research.

7. **Establishment of Seed Bank**

Seed Bank has already established in the Centre and attached to Seed Technology Section. Seeds of over 25 species are supplied free of charge on research basis. However, the available seeds were collected from small plantations and arboretums, not from the registered seed sources. Number of mother trees are from 10-30.

An attempt of the Seed Bank is to pool seeds collected from seed sources for ASEAN forest plantation programme. It is expected that the seeds from these sources will be much required by ASEAN countries and others.

8. **Publications**

There are two publications issued by the Centre, a technical paper called "The Embryon" and a Newsletter. The Embryon is produced once or twice a year but the Newsletter is published occasionally. Both publications will be distributed according to our mailing list comprising over 150 addresses.

Besides the above publications, the Centre sometimes issues booklets and reports which are considered to be useful to receivers. A survey report on Teak in ASEAN countries and a booklet of Seed Sources for ASEAN Forest Plantation Programme will be published and distributed soon.

9. **Research Work**

Research work of the Centre will be conducted by staff in all sections, Seed Ontogeny, Seed Origin, Seed Technology, Seed Health and Field Station. They are consisted of short term research work and long term research work. The former one is done in laboratories at the main office and in nursery adjacent to the main office. The latter is established at the Field Station which is about 60 km. from the main office.

Research work is performed with species selected by PSC members as follow:

Core species

- Swietenia macrophylla
- Acacia mangium
- Gmelina arborea
- Pinus caribaea
- Acacia auriculaeformis
- Dipterocarp spp.
- Pterocarpus macrocarpus

Other species

Pinus merkusii
Eucalyptus urophylla
Agathis loranthifolia
Shorea stenoptera
Albizia facaltaria
Araucaria husteinii and *Araucaria*
Eucalyptus camaldulensis
Casuarina equisetifolia
Leucaena leucocephala
Melia azedarach
Azadirachta indica

Emphasis is firstly placed on the core species. If they are not available, those from other species will be explored. However, it is very difficult for the Centre to conduct research work according to the core and the other species at the initial stage because only some of them are native to Thailand and most of them are not available at the project site. Thus, research work at the beginning was mostly carried out with available species in the project area.

Research work of the Centre covers the following fields:

Flower and seed development

Dipterocarpus alatus
Pterocarpus macrocarpus
Hopea odorata

Seed production

Leucaena leucocephala
Acacia auriculaeformis
Casurina equisetifolia

Seed maturation

Dipterocarpus alatus
Pterocarpus macrocarpus
Shorea roxburghii
Shorea siamensis

Seed extraction

Gmelina arborea
Azadirachta indica
Some leguminous species

Seed storage

Ailanthus triphysa
Azadirachta indica
Others

Seed germination

Acacia catechu
Hopea odorata
Hopea ferrea
Acacia auriculaeformis
Peltophorum dasyrachis
Ailanthus triphysa

Seed testing

Biological test
Cassia siamea
Pterocarpus macrocarpus
Swietenia macrophylla
Others

X-ray test
many species

Seed entomology

serveral species

Provenance trials

Pterocarpus macrocarpus
Casuarina equisetifolia
Acacia mangium
Dipterocarpus alatus

Seed stand establishment

Eucalyptus camaldulensis
Dalbergia oliveri
Pterocarpus macrocarpus
Acacia auriculaeformis

Screening test

Over 40 species

Gene conservation

Eucalyptus camaldulensis
Pterocarpus macrocarpus
Dalbergia oliveri

10. Research work the Centre (Phase II)

Research work will be carried out by staff of the Centre like in the Phase I, however, the Centre sections are to be reorganized to have following sections instead:

TABLE I : Planning for Research and development of the Centre Work.

Species	RESEARCH AND DEVELOPMENT SECTIONS																															
	Seed Ontogeny & Seed Production										Seed Origin & Genetic Resources									Seed Technology & Seed Bank									Nursery & Vegetative Propagative			
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4
1. Dipterocarps	o	o	-	o	-	-	o	-	o	o	o	o	o	-	-	-	o	o	o	o	o	o	o	-	o	o	o	o	o	o	-	o
2. Acacias	o	o	-	o	-	-	o	o	o	o	o	o	o	o	-	-	o	o		o	o	o	o	o	o	o	o	o	o	o	-	o
3. Eucalypts	o	o	-	o	o	o	o	-	o	o	o	o	o	o	-	-	-	o		o	o	o	o	o	o	o	o	o	o	o	-	o
4. Albizia falcataria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	o	o		-	-	-	o	-	-	-	o	o	-	-	-	-
5. Pines	o	-	-	-	-	-	-	-	o	-	-	-	-	-	-	-	o	o	o	-	-	-	-	-	-	-	o	-	-	-	-	-
6. Tectona grandis	o	-	-	-	-	-	-	-	o	o	-	-	-	-	-	-	o	o	o	o	o	o	o	-	-	-	o	o	-	-	o	-
7. Swietenia marcrophylla	o	o	-	o	-	-	o		o	o	o	o	o	-	-	-	o	o	o	o	o	o	o	-	o	o	o	o	o	o	-	o
8. Pterocarpus spp.	o	o	-	o	-	-	o	o	o	o	o	o	o	o	-	-	o	o	o	o	o	o	o	-	o	o	o	o	o	-	-	o
9. Meliaceae	o	o	-	o	-	-	o	o	o	o	o	o	o	o	-	-	-	o	o	o	o	o	o	-	-	o	o	o	o	o	-	o
10. Rhizophora spp.(Mangrove)	-	-	-	-	-	-	-	-	-	o	o	o	o	-	-	-	o	o	o	o	o	o	o	-	o	o	o	o	o	o	-	o
11. Bamboos	o	-	-	o	-	-	o	o	o	o	o	o	o	-	-	-	o	o	o	o	o	o	o	-	o	o	o	o	o	-	-	o
12. Rattans	o	o	-	o	-	-	o	o	o	o	o	o	o	o	-	-	o	o	o	o	o	o	o	-	o	o	o	o	o	o	-	o

Remarks : 1. Detail description of the numbers given in columns under research and development sections is shown in Table II.

2. o shows activities to be primarily conducted.

TABLE II : RESEARCH AND DEVELOPMENT ACTIVITIES IN EACH SECTION OF ASEAN-CANADA FOREST TREE SEED CENTRE

SEED ONTOGENY AND SEED PRODUCTION SECTION	SEED ORIGIN AND GENETIC RESOURCES SECTION	SEED TECHNOLOGY AND SEED BANK SECTION	NURSERY AND VEGETATIVE PROPAGATION SECTION
1. flower induction	1. tree	1. production	1. seed propagation
2. sporogeny	2. stand	2. collection	2. vegetative propagation
3. pollen, ovule, flower	3. provenance	3. handling	3. micropropagation
4. syngamy	4. seed orchards	4. testing	4. nursery techniques
5. embryogeny	5. hybrid-seed	5. storage	
6. seed, fruit	6. mutation	6. distribution	
7. dormancy	7. gene bank	7. sowing	
8. germination	8. seed scurces certification	8. seed testing certification	
9. production	9. health	9. health	
10. health			

Remark : The activity numbers given in each column in the sections are corresponding to the number shown in Table I.

TABLE III : SPECIES SELECTED FOR RESEARCH AND DEVELOPMENT ACTIVITIES OF ASEAN-CANADA FOREST TREE SEED CENTRE

1. Family Dipterocarpaceae
    - Anisoptera thurifera
    - Dipterocarpus Species
        - Dipterocarpus alatus
    - Hopea Species
    - Parashorea Species
        - Pinanga brandis
    - Shorea Species
        - Shorea alba
        - Shorea albida
        - Shorea almon
        - Shorea contorta
        - Shorea leprosala
        - Shorea polysperma
        - Shorea stenoptera

2. Family Leguminosae
    - Acacia Species
        - Acacia auriculaeformis
        - Acacia mangium

3. Family Leguminosae
    - Albizia Species
        - Albizia falcataria
        - Albizia lebbek

4. Family Papilionaceae/Leguminosae
    - Pterocarpus Species
        - Pterocarpus indicus
        - Pterocarpus macrocarpus

5. Family Myrtaceae

    <u>Eucalyptus</u> Species

        <u>Eucalyptus</u> <u>alba</u>

        <u>Eucalyptus</u> <u>camaldulensis</u>

        <u>Eucalyptus</u> <u>deglupta</u>

        <u>Eucalyptus</u> <u>urophylla</u>

6. Family Pinaceae

    <u>Pinus</u> Species

        <u>Pinus</u> <u>caribaea</u>

        <u>Pinus</u> <u>kesiya</u>

        <u>Pinus</u> <u>merkusii</u>

        <u>Pinus</u> <u>oocarpa</u>

7. Family Verbenaceae

    <u>Tectona</u> <u>grandis</u>

8. Family Verbenaceae

    <u>Gmelina</u> <u>arborea</u>

9. Family Meliaceae

    <u>Azadirachta</u> <u>indica</u>

    <u>Melia</u> Species

        <u>Melia</u> <u>azadirach</u>

        <u>Swietenia</u> <u>macrophylla</u>

10. Mangroves

    <u>Rhizophoraceae</u> (mainly)

11. Bamboos

12. Rattans

Seed ontogeny and seed production section
Seed origin and genetic resource section
Seed technology and seed bank section
Nursery technology and vegetative propagation section
Field Station

Planning for research and development activities is shown in Table I. Detail of research and activities, and species are indicated in Table II and III respectively.

Seed Problems in Mozambique

by: Pedro Alfredo Wate

Centro de Experimentacao Florestal

Mozambique

INTRODUCTION

Initiation of the establishment of forest plantations in Mozambique dates back to 1920.

Early plantations of Casuarina equisetifolia were carried out mainly for sand dune fixation and their area reached about 2.8 thousand ha by 1950.

The majority of these plantations were carried out by the colonial government, however some were established by the private sector. In that time the largest plantations were concentrated in Maputo and Manica Provinces.

At independence, the area planted with Pinus spp. was 13,600 ha, Eucalyptus spp. 6,000 ha and 400ha were occupied by other species of a lesser importance.

In the 1930's and 40's some stands of native species were established near Maputo. In these stands, whose area reached 600ha, Pterocarpus angolensis, Afzelia quanzensis and Millettia stulhmanii were planted. However, they have not performed very well due to poor management.

A National Afforestation programe was started in the early 1970's. Since its initiation at least 21,450ha of exotic species, mainly Eucalyptus and Pinus have been established. The National Afforestation Programe aims to produce fuel, fence posts, poles and industrial timber.

Besides this programe, small afforestation programmes for protection purposes have been carried out by peasants organized in cooperatives.

The total planted area is now about 41,450ha mostly with exotic species.

Each year the National Afforestation Programe uses about 100kg of Eucalyptus and Pinus seed which cost approximately US$13,000. In order to minimize seed costs, the Forest Research Centre has started the local seed collection of exotic seed. Collection from some native species also took place but on a much smaller scale.

Research has been developing slowly since 1981 when the first species and provenance trials (Eucalyputs) were established in representative areas of the country's Northern, Central and Southern regions. The creation of the Forest Research Centre was instrumental to the initiation of research activities.

The establishment of the first seed Production Area took place in 1986 in the Mozambique area (Southern Mozambique). Two more areas were established in 1987 in Michafutene and others in Nampula Province (Northern Mozambique).

Plantations in Mozambique

Recent plantations in Mozambique date from 1977 when the new afforestation policy was introduced giving high priority to the supply of fuelwood to the major urban centres. In this regard, 46% of the current plantation program aims at fuelwood production and plantations are mainly located around three major cities; Maputo , Sofala and Nampula. Because of the shortage of information about the most adaptable species to the different regions of the country, many mistakes have been made. Large stands have been planted with E.saligna and E.Grandis with poor results. After species trials E.camaldulensis (Gilbert River and Petford) and E.tereticornis (Kennedy River) have shown to be the most suitable for afforestation programmes.

Since 1984, these provanances of E.camaldulensis and E.tereticornis have been more widely planted than any others.

Before the results of species and provenance trials set up in Bandula region were known, Pinus patula and P.taeda were the most widely planted species below 1000m with the result that mortality rate was high. Due to these results, the situation has changed and mainly Pinus oocarpa and P.caribaea were planted.

Existing field Trials and Seed Production Areas

In 1982, four provenance trials with Eucalyptus spp. were established on five sites covering the southern latitudes 15° - 26°, at altitudes below 150m a.s.l. Rainfall varies between 100 and 1200mm.

After two years, results on three test sites (height growth and survival) indicate that the best species/provenances seem to be E.tereticornis, E.Camaldulensis. All these provenances originated from Northern Australia.

More recently (1986/87) three seed Production Areas of E.Camaldulensis (Gilbert River, and Petford) E.tereticorais (Kennedy River) were established in Michafutene. In Nampula, two 5.0 ha stands were also established with the following species and provenances: E.camaldulensis (Petford) and E.camaldulensis (Gilbert River).

All these species/provenances have been selected as the best with regard to height growth and survival.

SEEDS ARE THE BIOLOGICAL POTENTIAL IN ARGENTINE FORESTRY

Ing.Agr. Dora Yacubson

LUCIANO has said: "The tree was man's first temple", CATON added:"It's necessary to spend a lot of time in constructing, but not an instant must be differed for planting".

In spite of the positive criterion which CATON showed his thought,it's not strange that contemporany and previous civilizations to him worshipped the tree,not as a capital good put as gods receivers of virtues and some other times offering them to their gods.This worship must have appeared as a derivation of the perception of the beauty of trees,that with its poetry has impressed the senses and the mentality of primitive races.

Thus in the legend,the myth or in history THE TREE has been vinculated to man in all periods and civilizations.

If we want to follow the changes that result in the transmission of life in the tree,we must start from the study of its structural basic units : THE SEEDS.

Not all of them survive in the struggle for existance, any notable change in the environment:humidity,temperature,light, soil(composition),may create bad conditions for germination.
That struggle for surviving is reflected in the incredible varieties of shapes,structures and sizes of the seeds.

The quantity and quality of its production would have decreased if it weren't for the continuous investigations made by the Fitotecnia and Plant Genetics.The improved species are superior to the wild original types and would go down if they were abandoned to the incertain and natural mediums of dispersion.

The proverb:"Man will harvest what he sows" is an indubitable truth.
To sow seeds that won't sprout or that are of low viability is a waste of time and money.That's why it's essential to guarantee the quality of the seeds,specially with the forest seeds,because of the quantity of money involved in,for a determined industrial application the planter requires a guarantee of production.

The realizations of analysis qualitative and quantitative in tree seeds in laboratories "ad hoc",must be an imposed rule in every private or public forest enterprise.

INTRODUCTION

The term SEED is currently applied after numerous consultations performed among specialists involved to the study of vegetable seeds, to indicated "the dispersion of the germinating unit of the fecundated ovule".

This definition is far away from the strict botanical meaning ofthe same, since it must be considered that "a seed is the result offecundated ripe ovule which contains an embryonal plant, stocked reserve elements and layers or protective coverings".

In this sense this collaboration from Argentina presented to the International Symposium of Forest Seed Problems in Africa has as a fundamental reason the consideration of :

I)International Scientific Background:regarding forest seeds discussed in many meetings in different countries since 1972 up to date.
Up to 1972 scientists and forest botanical technicians in entire world used to analysed separately the problems of seeds in general and forest seeds in particular, applying several methods for the determination of viability, authenticity, purity, sanitary conditions, etc. following the Rules of ISTA en general.
Not until 1973 I.U.F.R.O. in their Committee of Forest Seed Problems considered in an international programme the forest seeds in their research, scientific, experimental and cultural aspects.

The first Meeting was held with delegates and specialists from 26 countries and it took place in Bergen(Norway)where their dealt with Problems of Seed Processing:a)Seed-crop b)Drying of fruits c)Storage d)Analytical tests e)Research and experimentation performed in Asia, Africa, developing countries and in Latin-America.

In 1976 a new Symposium was celebrated in Japan unther the tytle: "Physiology in Germination of Forest Seeds. Nine countries attended that meeting and the following subjects were considered:

a)Tropical seeds germination b)Ecophysiology of germination-
c)Dormancy in forest seeds d)Germination in treated and untreated seeds

In 1978 a meeting was held in the U.S.A.(Macon and Starkville):

1)One "workshop"which developed laboratory experimental tests about current techniques and fast determinations of viability in frutic and forest seeds, where the following methods were considered:a)Embryo excision b) Colorimetric method with Tetrazolium c)Use of X Rays.
2)During the same meeting it was discussed about:"Flowering and development of Fruit and Seeds in trees" covering the following items:a)Flowering Biology and Fertilization b)Stimulation and production of seeds c)Repining of seeds d)Fruit and seeds insects e)quali

ty of seeds.

These two research centers in Macon and Starkville are in coordination with states,extension and experimental agencies,universities,collector and forest companies that cooperate in the performed of integral studies in such a way that the foresters can be assured of the quality and quantity of his production,and that the planned plantation cover the aims required by the industry.

In 1980 a meeting was held about"Problems of Tropical Forest seeds" in San Felipe Bacalaar Quintana Roo in Mexico.

The fundamental objective was to informed the attendants the methodology followed by ISTA and IUFRO.In this meeting experimental tests with tropical seeds were made corresponding to: germination,colorimetric method,sampling and purity,storage and the use of X Rays.

Those practices were directed by specialists from different countries:England,Sweden,Canada,U.S.A. and Argentina.

In 1983 "Working Party Meeting"was held in Ottawa-Canada,in together with the 20th. ISTA Congress.

In 1984 Thailand was the center of "International Symposium on Seed Quality of Tropical and Subtropical Species".The objectives were:1)to bring together scientists from developed and developing countries from various fields of seed science so that they can share experiences and interact with decision makers.

2)To promote cooperation in research and development of tree seeds among scientists and related institutions.

3)To findthe proper methods of improving seed quality.

4)To maximize the productivity of superior phenotypical trees by using seeds from genetically improved materials

Austria was the center of "International Symposium on Seed Problems under Stressful Conditions" in 1985.

II)Current methodologies: applied in fast determinations of forest seeds viability.

As a counterpart with the classic slow germination method of stoves or germinators,fast method are applied to determine the viability in forest seeds.These techniques are:a)Embryo excision b)Colorimetric method c)Use of X Rays.

The three techniques presented have the characteristics of effecting the analytical determination in a much shorter time than the one used by ordinary germinators and therefore the economic advantages are greater because this reduces the storage time of seeds and the possibility of their dehydration or attack of "fungi" or insects that may appear in the conservation places.

III)Possibilities of increasing,integrating and complementing for a forest seed production with the feasibility of founding of a FOREST SEED CENTRE IN SOUTH AMERICA.

It is likely the creation of a CENTRE OF FOREST TREE SEEDS IN SOUTH AMERICA,to be diffused inside or outside the countries with projection to other continents.

Functions of the Center:a)It would coordinate,record and control the purveyance of forest seeds,improved and selected,and catalogued produced in the countries,pursuant to the rules of ISTA and IUFRO.
b)It would plan and collaborate in the formation of seed orchards, in ecologic zones more suitable to the forest with species required by wood and cellulose industry.
c)It would perform the analytical determinations in the laboratory "ad hoc"drawing up the origin and quality certificate of all seeds distributed in the countries.
d)It would compile and concentrate all scientific antecedents concerning to the national and international order about forest seeds interchange of samples of seeds with other european,american and asiatic centers.

Main Office :

For the choosing of a Main Office among the notifying countries it is suggested may be placed in Argentina,Brazil or Chile,since they are the countries which make forestations on a large scale and for the same industrial purposes and also they have the same aims and necessities of forest tree seeds.

Offices :

To be subsequently determined in all notifying countries. It would proper,in national or provincial Forest Experimental Stations or establishments of forest,wood or cellulose enterprises in which the seeds are gathered from their plantations,belonging to grain holder trees,selected trees(plus)and seed orchards.

IV)Advise the enforcing of current Rules for the application of National Seed Law N°20.247 to forest seeds and complementary regulations about nursery plants and other parts of them(stalks, shoots,etc)

a)"RULES FOR THE PRODUCTION,MARKETING AND INTRODUCTION" "OF FOREST SEEDS".

b)"RULES FOR THE PRODUCTION,MARKETING AND INTRODUCTION" "OF NURSERY PLANTS AND/OR THEIR PARTS OF PROPAGATION".

Due to the need of adjusting the propagation,production,commerce and distribution of forest seeds within Seed-Law N°20.247 and its pertinent reglamentation,we are advising that they were approuved by Re-

solution N°389 of June 18-1986 and Resolution N°156 of February 25-1987 in what refers to Rules a) and b).
With reference to Rule b) it was considered absolutely necessary to require that complementation as it is included in Law N° 20.247 and its Decree N°1995 regarding the propagation organs.

The Rules mentioned were prepared by one Advising Forest Committee and the highest office in the country:"THE NATIONAL COMMISSION OF SEEDS",also the representations of National and Provincial Officers,private Sector and forest or paper companies and specialists in this matter.
For this reason we attaching the mentioned Rules and Resolutions which are already into effect.
The authenticity,origin,quality and viability of forest seeds will be obtained throught the application of the above Rules,to achieve better and larger production,improuved plantations,more wood and paper which will help cover the existent déficit in the rest of the world.

V)Needs of Seeds

In the Argentina Republic there are almost 800.000 hectares cultivated with quick growing tree species:pines,eucalypts, willows,poplars,etc.

The Conifers has expanded during the last decade,corresponding to the middle of the area occupied by plants for wood.This need must increase each year for the great demand of long fiber for the paper industry.

The harvested seeds that are sold are of the "commercial type"extracted from specimens fenotypically chosen,of good forest appearance,straight trunk,branches equitatively distributed,of good sanitary conditions and ages from 15 to 25 years old(conifers) and from 10 to 20 years old in leave-forest-tree-latifolies.

Just a few years ago it started the development of seed orchards for conifers for the obtaining of improved seed but they are still in the first stages of preparation.

In the case of seeds and cuttings of cultivated eucalypts, willows and poplars,the quantity obtained by the state and private enterprises satisfy the need required.Only in the case of conifers we have to resort to importation every two or three years.In 5-10 years more we will have enough quantities of seeds to fulfil the requirements and objectives that we want to obtain.

FINAL CONSIDERATIONS :

The tree seeds constitute richness,symbol and birth.

Those are many things but any one of them,its quantity, shape and structure is important for its main:to assure the continuity of the life of the tree so many benefits of which relates to huma

nity.
Taking into account other aspects but related to man's survival : we have the usefulness and beauty of the seeds and the reason why we sow the control and care of their vital germs,because the grains constitute the main "Food in the world".

The indians of some areas in America collect tree seeds of almost 250 belonging to more than 30 botany families among which we find almost 50 varieties of pines,walnuts,oaks and leguminous that constitute the basis of their food.

Moreover the forest seeds contribute to the manufacture of industrial products,elaboration of scents,therapy,cosmetics and drinks.But the principal beauty of most of them lies in the perfection of their shapes,surfaces,brilliancy and also in their colours.

But there is still another potential beauty in the seeds when they fulfil their last mission:"To produce a new plant","a new tree",that will have its own beauty.That's the greatest of everything the whole beauty,the grace fulness of the stem,the shape,the colour, the fragrance of their flowers and the sweetness of their fruits.

And the seed which is the first and last link completes the cycle of the most "sublime expression of the vegetable kingdom: THE TREE.

To plant trees is the Argentina needs and the TREE means for us more paper,more books,documents,information,recreation,poetry and Democracy and the Seed Biological Potential in Argentina's Forestry contributes to obtain that benefits for the Community.

POSSIBILITIES FOR THE PERFORMANCE OF FEASIBILITY STUDIES FOR THE ESTABLISHMENT OF FOREST SEEDS CENTER IN SOUTH AMERICA

Ing.Agr.Dora Yacubson

It is likely the creation of a "CENTER OF FOREST TREE SEEDS IN SOUTH AMERICA",with the formation of an integral laboratory pertaining to analytical quali-quantitative determinations besides those imposed by I.S.T.A and I.U.F.R.O. certification,quality and origin control, varietal purity of all forest seeds to be diffused inside or outside the countries with projection to other continents.

MAIN OFFICE:Laboratory of Forest Seeds whose location shall be determined in due time,it is suggested may be placed in Argentina,Brazil or Chile ,since they are the countries which make forestations on a large scale and for the same industrial purposes and also they have the same aims and necessities of forest tree seeds.

OFFICES: to be subsequently determined in all notifying countries. It would be proper,in national or provincial Forest Experimenta Stations or establishments of forest,wood or cellulose enterprises in which the seeds are gathered from their plantations,belonging to grain holder trees,select trees(plus)and seed orchards.

FUNCTIONS OF THE CENTER:

a)It would coordinate,record and control the purveyance of forest seeds,improved and selected,prosecuted and catalogued produced in the countries,pursuant to the Rules of I.S.T.A. and I.U.F.R.O.

b)It would plan and collaborate in the formation of seed orchards,in ecologic zones more suitable to the forest with species required by wood and cellulose industry.

c)It would perform tha analytical determinations in the laboratory "ad hoc" drawing up the origin and quality certificate of all seeds distributed in the countries, upon the application of present methodologies of viability internationally used and imposed by I.U.F.R.O.during their technical meetings in Norway,Japan,U.S.A.México,etc

d)It would compile and concentrate all scientific antecedents concerning to the national and international order about Forest Seeds,interchange of information and samples of seeds with the other european,american and asiatic centers of seeds.

e)Supply and research associations and forest enterprises or planters requiring from small samples of improved seeds proceeding from seed orchards.

f)Fixing the price for the realization of analytical determinations of viability granted by authorized seed plots and nurseries.

g)Connection and extension of this Center with other european and american or asiatic centers as long as they have the same aims and necessities of forest tree seeds.

Only in this way they will have knowledge and guarantee of all forest tree seeds, that are propagated in the world, whose authenticity and quality guarantee a best and great wood and cellulose production for the benefit of man and the whole society.

AMERICAN ASSOCIATION OF FOREST SEEDS PRODUCERS

Ing.Agr.Dora Yacubson

During the II°American Congress of Forest Policy and Rights, performed in the Convention Center of Salvador (Bahia-Brazil) in March 1981, in the final resolutions corresponding to Commission N°2 of "Cultivated Forests", it was unanimously approuved within the agenda developed a motion which is transcribed as follows:

1)Propose the formation of an American Association of Forest Seed Producers through the integration of the respective national associations.

2)The object of the Association will be to adopt the mechanism for the obtention of an adequate exchange of information, technology and products existing in the respective countries, with regard to forest seeds.

3)To the indicated effects it is propose the designation of two coordinators, to enable the functionality and coordination between the entities and interested persons.

For this reason the author of the motion Ing.D.Yacubson from Argentina and Dra M.Swioklo from Brazil are appointed as coordinators of the American Association of Forest Seed Producers.
Representatives from Argentina, Brazil, Chile, Colombia, Guatemala and Venezuela in total 24 participants who integrate Commission N°2 analyzed and approuved that Proposal which obtained the total acceptance of the highest authorities.

In order to integrate the Directing Commission of the American Assoc.of For.Seed Producers,it is proposed to constitute it with two participants from each country in the technical-agronomic-juridical orders and it is form by:

ARGENTINA : Dora Yacubson - F.M. Etcheverry
BRAZIL : Herval de Souza - Marialva Swioklo
CHILE : Jorge Correa Vivero- Enrique Gallardo
COLOMBIA : Rafael Rodriguez - Augusto Muñoz
GUATEMALA : José Ernesto Matheu- Jorge Spiegeler
VENEZUELA : Carlos Bracho -

The members of the Commission who accept such designation will be distributed the positions that they consider most adequate to their especific functions to facilitate functioning of the same and the resolutions of problems inherent to these objectives.

In this respect it is proposed to call a meeting during the sessions of Congress for the presentation of the Statutes and join ideas for their distribution in all participating countries.

This Association will function through its representatives who will act as coordinators among all the members of the Commission which as it is integrated by technical,juridical specialists will be able to solve all the problems inherent to exchange,propagation and difussion of forest seeds,documentation,technology and methodology used in the American countries.
The authenticity,cerfification,fiscalization proposed by ISTA "International Seed Testing Association" and IUFRO "International Union of Forest Research Organizations" in their Forest Seed Committee will contribute to obtain better crops,improved plantations,better wood and more paper that will be required in the year 2000.

All persons,officials or private organizations may take part in this Association and they have to be vinculated to such specialties,interested in propagating the recognized xylotechnological tree species required by the wood and paper industries.

GENERAL DISCUSSION ON FOREST SEED PROBLEMS IN AFRICA

Session Report and Recommendations

(Chairman: Dr. R.D. Ayling)

Conference participants broke up into the following working groups, to discuss problems and make recommendations. All participants joined together to list recommendations and to hold discussions on the various topics.

1) SEED PHYSIOLOGY
   (S. Chipompha, Chairman)
2) SEED ORIGIN AND CONTROL
   (Gert Rode, Chairman)
3) EXCHANGE OF INFORMATION
   (Dan Michaelsen, Chairman)
4) TRAINING
   (William Elam, Chairman)

1) SEED PHYSIOLOGY

(I) Research

Research is needed on the following problems:

(a) Seed viability, seed germination, and seed storage with particular reference to tropical species.

(b) To investigate and establish optimum environment for seed germination (light, temperature, moisture, etc.)

(c) To find causes of seed dormancy and methods to break it.

(d) To work out rapid methods for determining seed viability especially of tropical species (x-ray radiography, and/or biochemical methods).

(e) To develop an index of maturity to help determine seed collection time.

(f) To undertake studies to stimulate flower and fruit production.

Recommendation No. 1

Research work on the above problems should be undertaken or intensified without delay.

(II) Information:

There is a lack of knowledge among seed researchers concerning who is doing what research in Africa. Also there is lack of exchange of results or cooperative efforts.

Recommendation No. 2

i) Obtain list of participants (and their addresses) that are interested in seed physiology. Include other researchers in Africa. Photocopy and distribute list through IUFRO. If possible this list will include what species the researchers are working on.

ii) Copy and circulate relevant portions of SEED ABSTRACTS to members.

iii) Hold regular symposia and training workshops. The two could be combined to save on resources. Donor aid agencies could possibly help with funding. Venue and time of meetings left open.

Comment: Write to Dr. Kamra or Dr. Bonner with ideas on possible meetings.

2) SEED ORIGIN AND CONTROL

Problem: Seed production areas and seed orchards.

Definition: For seed orchards stick to the international definition of seed orchards.

Recommendation No. 1: Seeds should be collected from defined seed sources (seed stands, seed orchards, and wild populations) and information should be given on whether tested or not tested.

Recommendation No. 2: Only certified seeds should be sold within and out of countries.

Recommendation No. 3: Establishment of seed sources should be according to international rules and specifications.

Recommendation No. 4: Each country should have a seed data form that contains the basic information needed. This information should be for internal and external use.

Recommendation No. 5: Collection from a wild population should be from at least 25 trees from a defined area selected (marked and mapped) and if possible to be not related. Should try to keep the collected seed lot for further testing.

Recommendation No. 6: If you collect from local farmers (from marked trees) bulk and divide into equal quantities and then distribute to farmers.

Recommendation No. 7: A controlling body should be established to check for proper design and management of seed sources.

Comment: A recent article in Commonwealth Forestry Review by Dr. Burley provides a good review of the problems.

3) EXCHANGE OF INFORMATION

There is currently insufficient exchange of information among countries within Africa.

Recommendations:

1) A newsletter should be produced twice a year covering all aspects of tree seed problems and related activities in all African countries and giving the following information:
   (a) Names of institutes, addresses and functions
   (b) Country reports
   (c) Abstracts of relevant papers
   (d) List of workshops, symposia etc.
   (e) List of seed suppliers and species

2) Study tours within Africa should be organised by an appropriate authority to gain firsthand knowledge of the existing situation in each of the countries.

3) Joint venture research work should be encouraged.

Comment: The newsletter should be called "African Seed News". Mr. Patrick Milimo from Kenya offered to produce it.

4) TRAINING

Recommendations:

1) There is a need to conduct short courses on tree seed technology to be held at one or more regional centres in Africa. Emphasis should be on indigenous species and on combining theory and practice. The courses should be primarily meant for technicians. Follow-up visits by the trainer to the trainees work locations should be encouraged.
2) There is a need for assistance in training professionals for higher degrees, and in institutionalizing training in the regions in Africa.

Comment: Majority of training should be in Africa with appropriate technology. Bring expertise for giving training here.

PRELIMINARY RESULTS ON THE STORAGE OF SEEDS OF *ALLANBLACKIA STUHLMANNII* (ENGL.) ENGL. GUTTIFERAE

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ABSTRACT

Experiments were conducted to determine the best storage temperature regime and packaging materials that would make seeds of *Allanblackia stuhlmannii* maintain their germinability for a long period in storage. The results showed that the seeds lose their germinability rapidly if stored at freezing temperatures (-3 - 0°C) and/or if packed in cotton cloth bags. They keep better at room temperature (16 - 25°C) if packed in polyethylene bags. Under these conditions they can retain up to 50% of their initial germinability for six months.

Keywords: *Allanblackia*, seed storage

INTRODUCTION

Allanblackia stuhlmannii (Engl.) Engl. is a tall evergreen tree, 12 to 36m high, with a clean bole to about 9m. The species is climax and is known to occur naturally in the montane rain forests in the Usambara, Nguru and Uluguru mountains in Tanzania. It is not known to occur elsewhere (Bamps et al.,1978).

The seeds of this tree have a high market value. They are collected for both local consumption and for export. The seed yields an edible fat used for cooking, lighting and as an ointment for pains in the limbs (FAO, 1983). The heartwood of the timber polishes well and is suitable for furniture, while the sapwood is used for general construction and joinery (Bryce, 1967). A. stuhlmannii is an attractive tree and is suitable for ornamental planting owing to the pleasant scent given off by the large beatiful red flowers.

The tree has been over-exploited in its natural habitats to the extent that it can no longer recover through natural regeneration. This is a serious situation because this endemic species is now in danger of extinction. The Government of Tanzania has reserved this species and there are plans to reafforeste the open areas in the forests with the same species. The efforts to implement this have secured modest success due to poor storability and prolonged germination period of the seeds (Mugasha, 1982). The seeds have been reported to lose all viability within the first 6 months when stored at ordinary room temperature (Shehaghilo, 1980) but the packaging materials were not mentioned, There is no any other published information on how to store seeds of this species.

A. stuhlmannii trees bear an abundant seed crop at intervals of 1 to 2 years so enough seeds have to be collected in a good year and stored to cover requirements in intermediate years of poor seed production. The objective of this study was to determine the best storage temperature and packaging material that will make seeds of A. stuhlmannii retain viability for a long period in storage.

MATERIALS AND METHODS

Ripe, freshly fallen fruit of Allanblackia stuhlmannii were collected in February, 1980 and February 1981. Collections were made from 5 healthy trees growing naturally at Kwamkoro Forest Reserve (38^o 36'E longitude, 5^o 09'S Latitude at 1000 m a.s.l.) in Tanga Region, Tanzania.

The fruit is reddish brown, cylindric - oblong, 16 to 34cm long 15 to 17cm wide and weighs about 2.5 to 5.8kg. Each fruit contains 60 to 140 seeds. The fruits were cracked gently to release seeds. The seeds are four angled, about 4cm long and 3cm wide with fleshy arils.

The fruit pulp on the seed coat and arils were removed by washing in water. The cleaned seeds were immersed in water and those which floated on the surface were discarded. Seeds which sank to the bottom were presumed to be viable. They were removed from the water and spread out on hessian sheeting material in the shade for two days to dry off water on the surface of the seed coat and immediately used for experimentation. Seeds which were collected in February 1980 were used for experiment No.1 and those collected in 1981 were used for experiment No.2. At the commencement of each experiment the moisture content of the seeds was 60%(wet weight basis) as determined by oven-dry method (ISTA, 1985).

Experiment No. 1

The experiment was a Randomised Block Design with 4 blocks. Four treatments of storage temperature regimes were used Viz: (1) Room temperature (16 - 25°C), (2) 3 ± 1°C, (3) 0 ± 1°C and (4) - 3 ± 1°C. Each observation plot had 20 seeds packed in sealed polyithylene bags. The thickness of the polyethylene material was 10 mil i.e. 250 microns. The seeds of room temperature treatment were kept in an open store. The rest were kept in a refrigerator at their respective temperatures.

After every one month seed samples were tested for germination in Copenhagen Tanks (Jacobsen Apparatus). The seeds were laid on top of three layers of Whatman No.1 filter papers on glass platforms with wicks dipping into water. The temperature was maintained constant at 25 ± 1°C. The apparatus was exposed to natural daylight. A seed was considered germinated when the radicle or the epicotyl had pierced the seed coat. Because the germination was very slow, cumulative germination counts were made at 4 months after the the commencement of the germination test. Seeds which were obviously dead and decayed were removed every time when they were seen.

Experiment No.2

A split - plot design with 4 blocks was used. The major treatments involved 2 temperature regimes (1) Room temperature (16 - 25°C) and (2) Chilling temperature (3 ± 1°C). The minor treatments involved 3 types of packaging materials: (1)Polyenthylene bags (250 microns thick), (2) Glass vials, and (3) Cotton cloth bags. Each observation plot had 20 seeds which were packed in the respective material and sealed. The seeds were kept in an open store and in a refrigerator as required for room temperature and chilling temperature respectively.

After every 4 months seed samples were tested for germination as described for experiment No.1. As controls, 80 fresh seeds (four replicates each having 20 seeds) were put for germination in the Copenhagen Tanks at the commencement of each storage experiment in order to determine the initial germinability of the seeds.

RESULTS AND DISCUSSION

Germination results are expressed as percentages to total number of seeds per observation plot. Cumulative germination percentages were transformed into arcsin angle values prior to analysis of variance. In the first experiment seeds which were stored at room temperature (16 - 25°C) showed a significant ($P < 0.05$) higher cumulative germination percentages than seeds which were stored at other temperature regimes through the storage period when compared by Duncan's New Multiple Range Test(Figure 1).

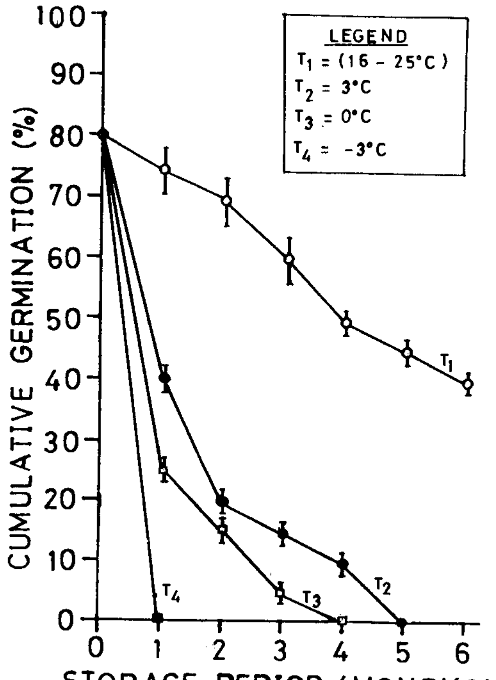

Figure 1: Effect of storage temperature on the germination of *Allanblackia stuhlmannii* seeds. Bars represent ± standard deviation from a mean of four replicates.

At -3°C, 0°C and 3°C, the germinability was completely lost after storage for 1, 4 and 5 months respectively, when the seeds were packed in polyethylene bags. Under room temperature (16 - 25°C), on the other hand, germinability dropped from 80% to 40% after 6 months storage in the same packaging material (Figure 1).

In the second experiment there was a clear tendency of variation between cumulative germination percentage and both storage temperature and packaging material (Figure 2).

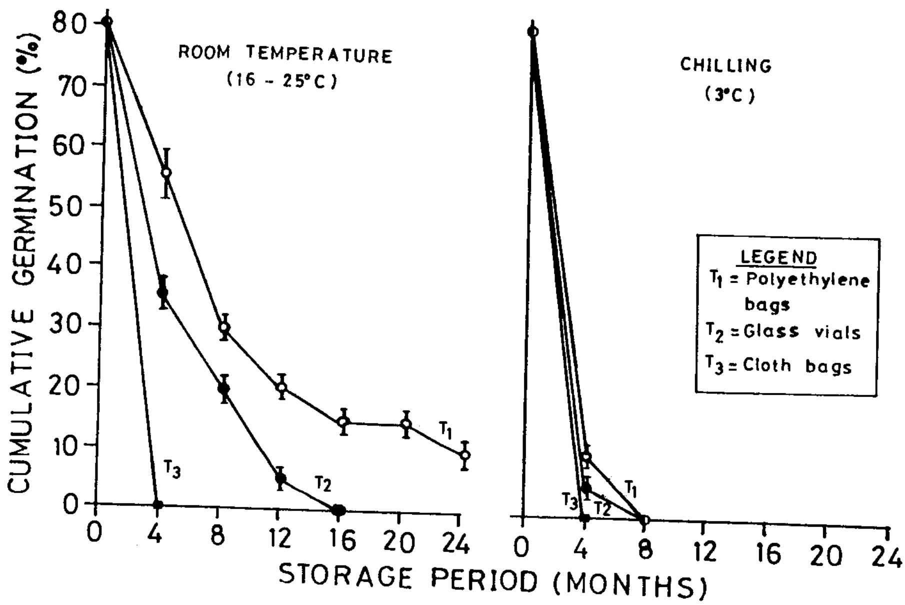

Figure 2: Effect of storage temperature and packaging materials on the germination of *Allanblackia stuhlmannii* seeds. Bars represent ± standard deviation from a mean of four replicates.

As for experiment No.1, seeds retained their germinability better when stored at room temperature (16 - 25°C) than at chilling temperature (3°C). Seeds packed in polyethylene bags retained their germinability better than those packed in either glass vials or cotton cloth bags (Figure 2).

Infact seeds packed in cotton cloth bags lost all their germinability within the first four months regardless of storage temperature. Analysis of variance at four months storage period showed a significant ($P < 0.05$) interaction between temperature and packaging materials. This is an indication that both conditions jointly affect seed viability in storage.

At room temperature, the decrease of seed germinability was rather slow. Those packed in glass vials lost all their germinability after 16 months (1 1/3 years) while those packed in polyethylene bags retained at least 10% of their germinability even after 24 months (2 years) although many of them germinated during storage.

Large hardwood seeds with high moisture content(Recalcitrant seeds) such as Acer sacharinum, Castanea dentata, Fagus grandifolia, Juglans nigra and Quercus robus (Wang, 1974) and Symphonia globulifera (Corbineau and Come, 1986) generally lose their germinability in storage due to dehydration. They also lose their germinability when packed in air tight containers due to inhibited respiration which leads to anaerobic respiration and accumulation of toxic compounds in the cells of the seeds (Korneeva, 1966). Similar conditions could have affected seeds of Allanblackia stuhlmannii in the present study because they are also large (3 x 4 cm) hardwood seeds and contain high moisture content (60% wet - weight basis).

The rapid loss of germinability in seeds which were packed in cotton cloth bags was perhaps caused by dehydration because cotton cloth bags are freely permeable to moisture and gases. Those which were packed in glass vials lost their viability probably because of inhibited respiration. Seeds which were packed in polyethylene bags gave better germinability than seeds packed in either glass vials or cotton cloth bags because the polyethylene material (250 microns thick) which was used was not completely impermeable to water vapor and gases (Justice and Bass, 1979). So there was a slight exchange of moisture and gases between the enclosed and the outside atmosphere.

The observed adverse effect of cold storage on A. stuhlmannii seed germinability is similar to that reported by Msanga (1980) for seeds of Maesopsis eminii; Ezumah (1985) for seeds of Azadirachta indica and Corbineau and Come (1986) for seeds of Symphnia globulifera. The present findings suggest that seeds of some tropical species may not confirm to the rule that low storage temperatures enhace seed longevity (Roberts, 1979). However, the present findings confirm previous reports that recalcitrant seeds of some tropical hardwood species are quickly killed by chilling damage if temperature is reduced too low, just as they are quickly killed if moisture content is reduced too low (King and Roberts, 1979). The phenomenon of chilling injury is shown by various disorders leading to death (Lyons, 1973; Graham and Patterson, 1982).

The relatively high temperature and high moisture content which have been found suitable for storability of A. stuhlmannii seeds correlate with the fact that the species inhabits moist tropical forests where high temperature and high humidity are prevalent through the year. The species seems therefore to have adapted itself to these climatic conditions.

CONCLUSION

Allanblackia stuhlmannii seeds die rapidly if packed in cotton cloth bags and/or if stored at freezing temperature (-3 - 0°C). They can keep well in polyethylene bags at room temperature (16 - 25°C). Under these conditions the germinability dropped gradualy with time until after 24 months period when 10% of the still viable seeds had germinated during storage.

Further investigations are needed to determine optimum temperature and moisture content which will make the seeds retain viability for a long period without germinating during storage.

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