ENHANCING THE SUSTAINABILITY OF TREE SEED SUPPLY THROUGH THE PARTICIPATION OF RURAL PEOPLE

P.B. Milimo

c/o GTZ - House, PO Box 47051, Nairobi, Kenya.

ABSTRACT

Evidence suggests that tree seed centres cannot sustainably meet seed demands without subsidies, especially those of lesser known indigenous tree and shrub species. Two main reasons are responsible for this shortfall: first, rural people who are the main actors in the on-firm tree planting are seldom involved in the planning of tree seed centres; and second, the planners have failed to recognize tree and shrub seeds as a commercially viable commodity. This has often meant that seed acquisition ignores incorporating firmer research and indigenous knowledge.

Some of the factors that must be addressed in order to create a sustainable tree seed industry are: that rural people be helped to get organized so that they are properly integrated into the overall rural development plans; that provisions be made fir training rural people in technical aspects of seed science and technology in order to ensure quality; and, that mechanisms be created to co-ordinate government and NGO activities with a view of improving seed supply through revenue generation.

1. INTRODUCTION

The increased emphasis on non-industrial tree planting, especially of multipurpose species has meant that information to support seed collection and distribution be made available. The change in emphasis from industrial to on-farm forestry has also brought about difficulties in the supply and huddling seed of lesser known tree and shrub species. As a consequence, most Tree Seed Centres are faced with the problems of not being able to meet the demand for the expanded list of lesser known tree and shrub species on one hand and on the other fighting to raise adequate funds to support their operations.

The number of seed centres has increased tremendously since the last conference in Burkina Faso and yet more new seed centres will continue to be built in order to meet the ever increasing tree and shrub seed demands. Implications of the proliferation of seed centres are that competition for scarce resources has increased, a factor which has brought into sharp focus questions of sustainability, efficiency and integration of seed centre activities with other development issues. Considering long lists of the lesser-known tree and shrub species that

seed centres are expected to meet, there is an urgent need to prioritize the species and hence the information needed for this exercise. Also, there is need for all seed scientists to make themselves familiar with the emerging international agreements (e.g. Convention on Biological Diversity, the FAO undertaking on PGR and GATT), for example through networking, in order to be able to reconcile some of the conflicting interests and aims of these conventions.

This paper argues that the future of on-farm tree crop establishment depends on whether strategies designed to alleviate seed shortages must develop a parallel approach comprised of two strategies instead of one currently in operation: one, strengthening of the current centralized system; and two, also create a more decentralized system that recognizes and incorporates local people. The paper attempts to establish the relationship between tree and shrub seed and a variety of other activities that relate to on-farm and plantation forestry, and conservation.

2. TREE SEEDS FOR WHOM?

Tree seed demand is divided into two major categories: one for plantations; and two for on-farm multiple tree and shrubs. The national seed centre Kenya is not only well equipped but also has long experience in meeting the seed needs of plantation forestry which usually involve a limited range of species, for example, *Cupressus lusitanica, Pinus patula* and *Eucalyptus grandis*. Yet, plantation management history in East Africa is replete with experiences that demonstrate the dangers of overdependence on a few species (the *Cupressus macrocarpa* stem canker in the 50s; the *Pinus radiata* needle blight disease; and more recently, the cypress aphid epidemic). These problems and many others have brought into sharp focus the dangers of building a forestry industry on a narrow species base. To broaden the plantation species base, information on the availability of seed for the target species and their performance under local conditions could become limiting factors.

In regard to seed supply to meet demands for non-industrial stands in farm forestry, the question of how to meet the wood and non-wood demand of a large and steadily growing population and the dangers it poses to the conservation of biodiversity are relevant. Although, the dangers of increasing demands on the conservation of biodiversity in Kenya were long recognized and attempts made to address the problem formulated (creation of the rural afforestation program in 1971), this has had limited success (Kenya Forestry Master Plan, 1994). Some of the problems responsible for the limited success in encouraging rural people to become self sufficient in wood and non-wood tree and shrub products are: (a) a harsh environment; (b) problems that relate to the farmers' inability to grow trees and shrubs; and, (c) problems that are beyond the farmers' ability to control, for example, limited access to resources and information. There is a strong relationship between utilizable products and tree/shrub retention on farms. Most of the trees utilized by rural people, especially for their non-wood products are indigenous.

A greater component of the on-farm tree and shrub species are indigenous. Indigenous tree and shrub species have advantages and disadvantages compared to exotic ones, since less extension inputs may be needed and higher survival rates and growth are expected as species are already adapted to the local environmental conditions (Milimo,1994).

3. WHAT IS THE PROBLEM WITH THE CURRENT SYSTEM?

The problem with the current seed procurement and supply arrangements is that they cannot currently and/or potentially meet all the demands (Table 1), especially those of the lesser-known multi-purpose trees and shrubs; and, that they are not sustainable long-term since they depend heavily on financial subsidies. That seed centres are faced with financial problems not only have implications for seed quantity but also quality Constraints to seed acquisition limit reforestation efforts and conservation efforts.

To resolve these problems, a strategy that comprised of a parallel approach that first strengthens the existing centralized seed centres and second, develop mechanisms for creating a more decentralized system that not only recognizes but also incorporates indigenous knowledge.

Seed demand by the Forest Department alone in relation to supply by the KEFRI Seed Centre for 1993-94 was in the deficit by about 93 to 99%. Considering the fact that it is easier for the seed centre to meet orders from the Forest Department than from NGOs and individual farmers due to the high range in species diversity and also requests of the lesser known tree and shrub species, it is speculated that the actual deficits could be much higher.

Table 1. A summary of tree and shrub seed supply, demand (Kg) and per cent supply deficit from 1993 to June 1995. This data only covers orders placed by the Forest Department (Source: Kenya Forestry Seed Centre, KEFRI).

	1993	1994	June 1995
Supply	412.0	1660.0	1040.0
Demand	27,078.6	23,510.9	4,290.7
Deficit (%)	98.5	92.9	75.8

One problem facing Kenya's seed industry today is that of the proliferation of organizations importing seed without control. Part of the problem is that more than one government ministry and numerous individuals are directly involved in seed acquisition and reforestation. Despite their good intentions, lack of coordination does not only pose dangers in regard to seed quality but also potentials for negative effects yield. For example, yield results in plots of *Eucalyptus grandis* raised from different seed lots at Turbo, Kenya, have shown a mean annual increment (MAI) range between 18 for the poor landraces to about 65 m^3/ha for genetically improved material (Milimo, unpublished). This large range in MAI corresponding to different seed lots clearly demonstrate the impact seed quality may have on yield. Therefore lack of control and coordination in seed procurement and hence seed quality may have adverse effects on attaining self sufficiency in wood and non-wood products as it has implications for the area to be cleared for on-farm and plantation establishment and hence conservation of biodiversity; and financial implications to the tax payer.

4. TRADITIONAL FARMING SYSTEM AND CHARACTERISTICS OF TREE DOMESTICATION

Fruit trees

The emphasis for conservation in Kenya is in the semi-arid areas where high livestock densities and increasing subsistence farming pose a major threat to the fragile ecosystem. Therefore, it is important that strategies aimed at ameliorating the impacts of human activities and how they interact with environmental stability be well understood. Since this paper advocates the involvement of rural people in tree and shrub procurement, a clear understanding of their lifestyle and how best this may be harnessed in the seed supply is important. Among aspects of rural lifestyle that are relevant to tree seed supply are customs and how they influence seed exchange among different communities.

Indigenous and/or wild fruits and seeds are an important component of rural life in most parts of the world. In a survey of farming systems in Moyale district of Kenya, Milimo et al. (1995) observed that wild fruits were consciously left on the cropland at the time of first clearing for crop production by the Borana tribes people (see Table 2). Some of these fruits (e.g., *Berchemia discolor* are already being marketed in many parts of semi-arid Kenya and therefore their promotion will be easier since they are already popular. In Moyale district for example, most of the women go to the bush to collect *Cordia sinensis* and *C. ovalis* fruits for feeding as a substitute and/or a supplement to maize meal, further strengthening the value of the indigenous plants. However, despite the potential importance of indigenous fruits in the livelihood of rural people, seed of most or all of these species (e.g., Table 2) do not feature on KEFRI's list of available seeds (Kamondo, pers. comm.). The omission of seeds of indigenous species at the stores is due to three factors: one, the traditional but restricted view of forestry; two, lack of feel for the needs of rural people; and three, lack of information on nutritional quality of wild fruits, variations within and between provenances and hence problems of identification, selection and domestication.

Tree planting and management

Species commonly planted in the semi-arid areas are *Cassia siamea, Leucaena leucocephala, Parkinsonia aculeata* and *Azedarachta indica*. Also, several native tree and shrub species are left growing at the time of clearing the land for crop production around livestock kraals and in homesteads. Two species are commonly planted around kraals. These were *Euphorbia terucalii* and several *Commiphora spp.* (species with the ability to root when stem branches are placed in contact with the soil).

Past experience has shown that farmers will spend money on tree crops that can be sold for cash (ICRISAT Sahelian Centre, 1995). Some of these fruits are highly valued because they are sold for cash on local markets. Recognizing the potentials of indigenous fruits, efforts have recently been initiated to study and gain a better understanding of within and between provenance factors responsible for differences in yield and fruit quality (Maghembe et al., 1994). Some of the aspects to be resolved by these initiatives are: (a) to develop cheap methods for propagation of indigenous fruits; and (b) to develop a clearer understanding of genotype x interaction (G x E) of the fruit species of interest. However, issues concerning intellectual property rights and how they relate to conservation and sustainable development are not adequately addressed by the initiatives outlined by present proposals on indigenous

Table 2. List of useful native plants and native fruits (asterisks) of Moyale district in Boran and scientific names (Source: Milimo et al., 1995).

** Badan*
Balanites aegyptiaca
Balanitaceae

Amess
Commiphora ellenbeckii
Burseraceae

Dadacha
Acacia tortilis
Mimosaceae

Amaress
Acacia brevispica
Mimosaceae

Idhado
Acacia senegal
Mimosaceae

Buraa
Acacia goetzei
Mimosaceae

Walensu
Erythrina melanacantha
Papilionaceae

** Adhe*
Salvadora persica
Salvadoraceae
Adama
Euphorbia endelubrum
Euphobiaceae

Chana
Haplocoelum foliolosum
Sapindaceae

** Jajab*
Berchemia discolor
Rhamnaceae

** Galcacha-hareh*
Boscia coriaceae
Capparaceae

** Ogomdi*

Andarak
Lannea elata

Kurkurra
Zizyphus mouritania

Amess
Commiphora kua
Burseraceae

Ano
Euphobia tirucalli
Euphorbiaceae

** Aroresa*
Grewia bicolor
Tiliaceae

Napo
Croton megalocarpus
Euphobiaceae

** Mader*
Cordia ovalis
Boraginaceae

Baresa
Terminalia brownii
Comretaceae

Roka
Tamarindus indica
Caesalpinaceae

Q'obo
Calatropis procera

Odha
Ficus sycomorus

** Bururi*
Vangueria madagascariensis

** Dagams*
Carissa edulis

Karrari (Wako = seeds)
Sterculia africana
Sterculaceae

** Deka*
Grewia tembensis

Sigiso
Acacia reficiens
Mimisaceae

** Chersi*
Dobera glabra
*Salvadoraceae**

fruits. For example, former involvement should not start and stop at their identification of plants with desired characteristics but should also consider incorporation of farmers' views of research priorities and methodologies. Mechanisms to integrate farmers in all the aspects of domesticating indigenous fruits should include data analyses, sharing of research results, monitoring and evaluation.

Although the reproductive biology of most of the indigenous species is not well understood by conventional scientists, local communities for which the findings of research are meant to support possess a wealth of knowledge on the species (see Table 2). Therefore, it makes economic sense, at least long-term to have farmers select and collect their own seed and sell and/or exchange with other farmers and even tree seed centres the excess of the species that are not locally available. However, care must be taken by developers of such seed procurement programs to ensure that all aspects of seed science and genetic principles are incorporated through training, otherwise gains to be made through reduced seed procurement costs may be compromised by inferior genetic material.

5. EXAMPLES OF COMMUNITY INVOLVEMENT IN GENETIC CONSERVATION AND SUSTAINABLE SEED SUPPLY SYSTEMS

Despite the availability of technologies to enhance agricultural production, Kenyan farmers, especially those inhabiting dry areas, seldom apply them. According to Mushita (1993), landuse planning legislation, colonial landuse policies and agricultural policies are responsible for marginalization of indigenous farming systems. All these have emphasized export exotic crops at the expense of traditional indigenous foods. No wonder, the question of how to enable subsistence farmers to become self sufficient in food production has been a subject of much discussion locally and internationally.

Considering the current and potential problems that the tree seed centres experience, it may be time we went back to the original instructions. One approach towards resolving the problems that are and will be faced by tree seed centres is to attempt to understand how traditional communities have always remained sustainable in food supply. Some of the traditional mechanisms that may serve as models for adoption, possibly after modification are presented below. The examples from Zimbabwe and Kenya are presented to support the view that traditional knowledge and the participation of rural people represent an unexploited potential in creating self sufficiency of tree and shrub seeds.

Zimbabwe

In Zimbabwe, a project to investigate small-scale farmer management of genetic resources in which 5000 households participated was conducted (Mushita, 1993). This study investigated germplasm collection; identification of crop-variety characteristics preferred by farmers; crop improvement, seed multiplication, distribution and supply, storage and utilization practices; agronomic trials designed to compare the overall performance of traditional and improved crop varieties and responses to fertilizer. These activities were further followed by meetings among farmers to exchange information and seed. This study found that farmers were still cultivating open pollinated varieties despite the extensive promotion and marketing of hybrids. Mushita (1993) explains this observation by the relationship of varieties grown to soil and vegetation types, resulting in a careful selection of varieties to match environmental conditions.

Tree Shed Clubs of Africa (TSCA)

This is a club in Kenya for young environmentalists which serves as 'an open educational institution' (Gathirimu and Mukunga, 1994). Members of the club are secondary school students and their teachers. Each member of TSCA is required to perform certain activities that relate to their educational requirements in school but also have a strong bearing on conservation. In terms of the clubs' relevance to the syllabus, there is a close link between activity and the subjects taught - most activities are related to subjects like geography, agriculture and biology.

Each member of TSCA is required to identify five indigenous tree species around school and home, collect their seed, carry out germination tests, plant and nurse the seedlings and write reports about their activities. Through these reports, the activities of the club are evaluated in addition to conservation activities, creating opportunities for further strengthening of the programme.

In regard to the theme of the present paper, there are potentials for incorporation and utilization of the TSCA for seed collection and supply to areas of demand and/or to central stores at KEFRI. The club has started collaborative work with GTZ in the area of integration of tree crops into farming systems, and potentials for collaboration with other organizations (e.g. KEFRI Seed Centre) are good. The TSCA has several advantages: one, the club has a wide membership across the country, and two, it is already involved in seed collections testing, germination and storage. All that remains is to build on the already existing foundation (Gathirimu and Mukunga, 1994).

6. ACKNOWLEDGEMENTS

I wish to thank the Integration of Tree Crops into Farming Systems Project (ITFSP) for support and for making valuable comments during the preparation of this paper and allowing me time to travel to Arusha, Tanzania, to present the paper. Financial support for participation at the conference was kindly provided by Danida (Tanzania).

7. REFERENCES

Anon. 1994. Kenya Forestry Master plan.

Gathirimu, T. and Mukunga, J.K. 1994. Tree Shed Clubs of Kenya. New World Printers Ltd. 138 pp.

ICRISAT. 1995. Green revolution for the Sahel. Spore Bimonthly Bulletin of the Technical Centre for Agricultural and Rural Cooperation; No. 58.

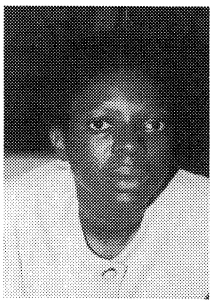
Maghembe, J.A., Kwesiga, F., Ngulube, M., Prins, H. and Malaya, F.M. 1994. Domestication potential of indigenous fruit trees of the miombo woodlands of southern Africa. Tropic trees: the potential for domestication and the rebuilding of forest resources. R.R.B. Leakey and A.C. Newton (eds.); 220-229 pp.

Milimo, P.B. 1994. The chemical composition of *Melia volkensii* Gurke: an unrealised browse potential for semi-arid agroforestry systems. J. Sci. Food Agric. 64: 365-370.

Milimo, P.B., Adano, S., Bashuna, S., Chanchalo, D.U., Kago, J., and Orre S. 1995. Farming system survey report of Moyale district. MoALD&M/MDP/ITFSP,30 pp.

Mushita, T.A. 1993. Strengthening the informal seed system in communal areas of Zimbabwe. Cultivating Knowledge: genetic diversity, farmer experimentation and crop research; de Boef, W., Amanor, K., Wellard, K. (Eds.). International Technology Publications.

THE GERMINATION OF TERMINALIA SERICEA BURCH. EX DC



M. Mkandawire

Forestry Research Institute of Malawi
P.O. Box 270, Zomba, Malawi

ABSTRACT

In preliminary studies to determine an effective pretreatment method for the seed of *Terminalia sericea* the germination percentage was very low (0-15%). Recommendations emanating from the study included the use of freshly collected seed in determining effective pretreatments.

The present study was aimed at determining the most appropriate pre-germination treatment and length of soaking time in order to ensure uniform, rapid and high germination percentages in the nursery.

Seeds of *T. sericea* were pretreated using hot water, sulphuric acid and nicking methods. Seeds were sown in the nursery on a sand medium.

The control achieved higher germination percentages than acid and hot water pretreatments. The maximum mean germination percentage achieved by hot water treatment was 3.3, sulphuric acid treatment was 43.3% and nicking treatment was 74%. However, control in nicking treatment gave second highest germination percentage.

From this study, it is therefore recommended that freshly collected seed be used without pretreatment but where small seedlots are used, seeds should be nicked and sown directly.

The cause of germination problems of *T. sericea* does not seem to be associated with seed dormancy. It could be due to insect infestation since the seed is highly susceptible to insect attack in the field. Further research could be directed towards this area.

1. INTRODUCTION

In Malawi fast population growth has exerted pressure on natural resources, in many areas leading to their extinction. Trees and other natural resources are disappearing at a fast rate and this has brought great concern to the government and other organisations to find ways of combating it.

In 1975 the Government of Malawi embarked on a tree planting programme involving the general public. The public were encouraged to plant fast growing exotic trees. But due to other environmental, pest and disease problems the emphasis has now changed to planting indigenous species which are resistant to pest and diseases and are adaptable to local conditions.

In most cases the raising of indigenous species has been giving problems due to limited knowledge on the proper methods of propagation. Some species show some dormancy when sown in the nursery; this may be due to embryo and seedcoat dormancy or mechanical injuries during processing.

Among the species which have shown this problem is *Terminalia sericea*. *Terminalia sericea* Burch ex DC is one of the most important indigenous species belonging to the family Combretacaea. Its synonyms are *T. brosigiana* Engl. et Diels; *T. bubu* De Wild. et Ledoux; *T. fischeri* Engl.; *T. nyassensis* Engl. In the local language (Chewa) it is known as Naphini. This polygamous species is found naturally in Southern Africa. It is characteristic of deeper coarse textured and somewhat poorly drained light sandy clay soils. It is adaptable to drought areas, moderately cold areas and also resistant to termite attacks.

The seed of *Terminalia sericea* has a light winged woody exocarp that help in seed dispersal.

Terminalia sericea is used for various purposes such as soil conservation, ornamental purposes and production of medicines (diabetes, chest pains, antidote), tannins (from bark), fibres, carvings, charcoal, fuelwood, building materials, tool handles and fodder (leaves and shoots) etc. (ICRAF 1989; Kitchin and Pullinger, 1982: Shorter, 1989).

Terminalia sericea has galls on its twigs, which are caused by the caterpillar of a moth, *Oxycophina pexa*, which is in turn parasited by an insect of the order *Hymnoptera* (Kitchin and Pullinger, 1982). It may be this same insect which bores into the seed and eats up the embryo.

Terminalia sericea has a low germination percentage under natural conditions and pre-germination treatments are not well documented.

Problem Statement

In preliminary studies on effective pretreatment method for the seed of *Terminalia sericea*, the germination percentage was low (0-15%) (Nyando, 1993). Recommendations emanating from the study included the use of freshly collected seed in order to determine effective pretreatment methods. In this report a study was conducted to determine the pretreatment methods and the length of soaking time which would enhance quick and uniform germination of seed in the nursery.

2. MATERIALS AND METHODS

Seed of *Terminalia sericea* was collected on 13th August, 1993 from its natural localities within Zomba municipality. The fruits were shaken off from the tree and collected on a tarpaulin sheet on the ground. The seed was dewinged by pounding in a mortar after a process of alternate drying both in the shade and in the sun. The seed was then graded manually by

removing those with holes presumably made by the weevils. Data of each pre-treatment was analysed separately by one way analysis of variance using Minitab Version 8.

Cutting tests

One sample of 20 seeds which had holes in the exocarp was cut open using a pair of secateurs. Another sample of 20 seeds which had marks believed to have been made by insects was also cut open.

Pretreatment tests

Samples of 20 seeds each were subjected to fourteen treatments; hot water for 5 different lengths of time, sulphuric acid for 5 different lengths of time, nicking, nicking and soaking in cold water for 2 different lengths of time. The experimental design used was a completely randomised block design replicated three times. There were three controls and the seeds were sown in a sand medium in a nursery bed. Germination counts were made daily.

Pre-germination treatments

HWl Sample of 20 seeds serving as a control.
HW2 Sample of 20 seeds soaked in hot water for 30 seconds.
HW3 Sample of 20 seeds soaked in hot water for 60 seconds.
HW4 Sample of 20 seeds soaked in hot water for 90 seconds.
HW5 Sample of 20 seeds soaked in hot water for 120 seconds.

SAl Sample of 20 seeds serving as a control.
SA2 Sample of 20 seeds soaked in sulphuric acid for 1 hr.
SA3 Sample of 20 seeds soaked in sulphuric acid for 2 hrs.
SA4 Sample of 20 seeds soaked in sulphuric acid for 3 hrs.
SA5 Sample of 20 seeds soaked in sulphuric acid for 4 hrs.

SCl Sample of 20 seeds serving as a control.
SC2 Sample of 20 seeds nicked with a secateur.
SC3 Sample of 20 seeds nicked with a secateur and soaked in cold water for 6 hours.
SC4 Sample of 20 seeds nicked with a secateur and soaked in cold water for 18 hours.

3. RESULTS AND DISCUSSION

Cutting Tests

One hundred percent of the seed which had holes were empty. Only five percent of the randomly selected seed with marks of injury had a maggot of the insect which is presumed to be responsible for embryo damage in the field. The holes are presumed to be exit holes. It is also presumed that the adult insect bores into the fruit and lays eggs while the fruit is still green; this may explain the presence of maggots in the fruits with marks. The maggot develops and when it changes into an adult it bores through the seed exocarp and makes its exit. This may also explain the total absence of the embryo and the presence of holes on some of the seeds. However, since this was just an observation during the course of the experiment, the observation should be substantiated with relevant data in this field.

Germination Percentages:

Hot Water Treatment

The control achieved the highest germination (71.67%). The treated seed did not produce good results. Seeds soaked in hot water had poorer germination (highest was 3.3%) than the control. Germination decreased with length of time the seed had stayed in hot water (Table 1). The length of the soaking time in hot water seemed to have a scalding effect on the seed embryos which were killed by the high temperatures.

Table 1. Germination results for seeds soaked in hot water

Treatment	Mean germination percentage
Control	71.67
30 Sec.	3.33
60 sec.	2.00
90 sec.	1.33
120 sec.	1.00
Pooled SD = 4.67	

Sulphuric acid Treatment

The control had the highest germination percentage (68.67%). The germination percentage showed a trend of decreasing order with the increasing period of exposure to the acid (Table 2). It may be presumed that the acid injured the embryos.

Table 2. Germination results for seeds soaked in sulphuric acid

Treatment	Mean germination percentage
Control	68.67
1 hour	43.33
2 hours	39.00
3 hours	28.33
4 hours	18.67
Pooled SD = 5.22	

Nicked Seeds Treatment

The seeds which were nicked with a secateur and never soaked in water showed a higher germination percentage than the control, (although this was not significant at 5% significant level). The seeds which were nicked and soaked had significantly lower germination percentage than the control or the seeds which were just nicked but not soaked. Probably, soaking did not induce the necessary conditions for germination in the seed. However, the seeds which were soaked for 6 hours gave a better germination percentage than the seeds which were soaked for 18 hours (Table 3). It is presumed that soaking for a long time might have diluted the chemicals which promote seed germination resulting in poor seed germination.

Table 3. Germination results for seeds nicked with a secateur

Treatment	Mean germination percentage
Control	61.00
nicked	74.33
nicked and 6 hours soaking in cold water	55.67
nicked and 18 hours soaking in cold water	45.00
Pooled SD = 7.24	

4. CONCLUSION AND RECOMMENDATIONS

As has been observed in the experiment, nicking of the seed without soaking gave a higher mean germination percentage than the other pretreatments used. Controls also gave higher germination percentage than hot water and acid treatments. The results of this study indicate that germination problems of *Terminalia sericea* may not be associated with seedcoat dormancy. It could be more of a problem of insect infestation than dormancy since the seed is highly susceptible to insect attack in the field. There is a need to carry out research on this in order to identify the insect and also determine the optimal time of seed collection when the insect population is low.

Further research could be directed towards the effect of storage in order to determine the optimum storage conditions which would maintain high germination capacity of the seed for a long time.

At the moment it is recommended that fresh seed should be used to achieve a high germination percentage. Nicking without soaking should be used on small seedlots and for large seedlots seeds could be sown without pretreatment.

As has been noted in the study, nicking requires skills and equipment in order to achieve good results. Since these are not readily available to farmers in villages, it is recommended that they should use unpretreated seed.

5. REFERENCES

ICRAF. 1989. ICRAF Multipurpose Tree and Shrub Database.

ISTA. 1991. International Seed Testing Association, Tree and Shrub Seed Handbook. International Seed Testing Association, Zurich, Switzerland.

Kitchin, A.M. and Pullinger, J. 1982. Trees of Malawi with Some Shrubs and Climbers. Blantyre Print and Publishing, Blantyre, Malawi.

Maghembe, J.A. and Seyani, J.H. 1990. Multipurpose Tree Species used by Smallholder Farmers in Malawi: Results of an ethnobotanical Survey No. 42. AFRENA Report, Agroforestry Research Network for Africa.

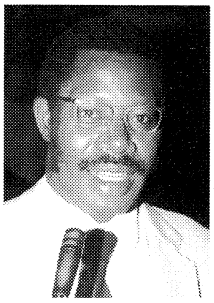
Nyando, E. 1993. Studies on germination of *Terminalia sericea*. A dissertation submitted in partial fulfilment of the requirements for Bachelor of Science Degree, Chancellor college, Zomba, Malawi (unpublished).

Palgrave, K.C. 1981. Trees of Southern Africa. C. Struik Publishers, Capetown. Republic of South Africa. pp 1-3.

Pitman, N. and Palmer, E. 1972. Trees of Southern Africa covering all known indigenous species in Republic of South Africa, Botswana and Lesotho. A.A. Balkemia, Capetown. Republic of South Africa. 1-3 pp.

Shorter, G. 1989. An Introduction to the Common Trees of Malawi. Wildlife Society of Malawi, Malawi. 74 pp.

EFFECT OF FRUIT RIPENESS STAGES AND SEED MOISTURE CONTENT ON STORABILITY AND GERMINATION OF NEEM (AZADIRACHTA INDICA) SEED



Heriel P. Msanga

National Tree Seed Programme
P.O. Box 373, Morogoro, Tanzania

ABSTRACT

Neem seed extracted from green fruits at maturity size; greenish-yellow fruits; and yellow fruits have initially very high moisture content (40%) and high germination capacity (85 - 90%). After drying the seeds in the oven at 40°C down to 12% moisture content the germination capacity dropped to 50%, 63%, and 60% for seeds extracted from green: greenish-yellow, and yellow fruits respectively. After storage for 8 weeks the germination capacity was reduced to 19-26%, 29-36%, and 31-34% respectively. Within a fruit ripeness stage these values did not significantly differ according to whether the seeds were initially dried down to 38%, 25% or 12% moisture content. Seeds extracted from green fruits have a lower desiccation tolerance capacity and cannot keep their viability as long as those from the other two ripeness stages. It is advisable to store Neem seed with an initial, relatively high, moisture content as long as the packaging material provides optimal condition for ventilation.

Keywords: Fruit ripeness, seed extraction, seed moisture content, seed storability, *Azadirachta indica*, seed germination, recalcitrance

1. INTRODUCTION

Neem (*Azadirachta indica*) is a fast growing, medium-sized tree which may reach 20 m. It has been cultivated in India for centuries and is today widely planted in Africa. Plantations of this species are now pan-tropical in semi-arid regions. In Tanzania it has been recommended for very dry areas and poor soils, 0-1,500 m a.s.l. It is used for soil conservation, ornamental, shade, windbreak, insecticide, oil, soap, bee forage and fuelwood (Mbuya et al., 1994). The tree is highly valued throughout Tanzania for medicinal uses. It is reputed to cure 40 diseases; whence the Kiswahili name Muarobaini.

Seed and seedlings are in high demand for planting in Tanzania. In 1995, 350 kg of Neem seed were sold, making it one of the most highly demanded species from the National Tree Seed Programme (NTSP).

Neem seed does not store well and may lose viability before reaching the nursery, especially if infrastructure in the country is weak. It is believed that seeds of Neem are intermediate between orthodox and recalcitrant (Poulsen, pers. comm.). According to Chaney and Knudson (1988) the endocarp of Neem seed is a physical barrier to water and/or gases exchange and the loss of seed germination capacity develops as the cartilaginous endocarp dries and hardens. According to Bellefontaine and Audinet (1993) the seed can be dried to a low moisture content between 4 and 7% and stored for long time under cold storage. On the other hand, short term storage seems to be possible for 4-12 months if the moisture content of the seed is reduced fast down to 20% (Tompsett, pers comm.). Another method recommended is to lower the moisture content after processing to about 30% and keep the seeds aerated at 16°C (Poulsen, pers. comm.).

The NTSP has tried to implement these methods but has obtained contradictory results. Therefore NTSP has started a series of experiments with the objective of studying the effects of fruit ripeness stages and seed moisture content on storability.

2. MATERIALS AND METHODS

Seed collection and extraction

Fruits at three ripeness stages were collected from the crowns of more than 30 trees at Chamwino (35°50'E, 6°20'S at 1,030 m.a.s.l. in Tanzania. The ripeness stages were: (A) green at maturity size, (B) greenish-yellow, and (C) yellow. The green fruits were after-ripened by spreading them out in the shade in layers, 3 fruits deep, for 3 days.

Fruits from the three ripeness stages were depulped in a coffee depulper. Large quantities of water was applied during extraction to facilitate the process. After depulping, fruit skins were separated from the seeds by floatation in water. Finally the seeds were washed in running water to remove remaining flesh, and surface dried for 2 days in the shade in a monolayer on wire mesh trays. Then the seeds were dried in an oven at 40°C down to 3 levels of moisture content: (a) 38%, (b) 25% and (c) 12%. When the target moisture contents were reached, seeds were packed in cotton bags (1 kg per bag) and stored at ambient temperature (22-34°C).

Every two weeks for 8 weeks, samples were drawn and tested for moisture content by the low constant temperature (103°C for 17 hrs) method (ISTA, 1993) and for germination in sand in the germination room.

By the end of the 8 weeks, the seed moisture content had fallen to around 10%.

Experimental design

The experiment was a 3 x 3 factorial in a Randomised Block Design with 4 replicates. The main factors consisted of 3 ripeness stages. Each factor was subdivided into 3 moisture content levels mentioned above.

Seed sowing and data collection

Seeds were germinated in sand. One hundred seeds per plot (Aluminium bowl) were distributed on top of the sand without touching each other and them covered with sand to a uniform depth of 1 cm. Water was applied manually so that the medium was kept moist all the time without becoming water-logged. The bowls were kept in a germination room with continuous artificial daylight and ambient temperature (25 - 30°C) under controlled RH of 80%.

The criterion for germination was visible protrusion of the cotyledons, hypocotyl, epicotyl and foliage leaves on the surface of the sand. Germination was recorded daily until no further germination occurred.

Germination phases were also assessed. The number of days from sowing to commencement of germination, and the number of days from sowing to completion of germination were recorded.

Data analysis

At each assessment, the number of germinated seeds was expressed as a percentage of all seeds sown per plot. In addition, germination value (GV) was calculated using the formula of Djavanshir and Pourbeik (1976). GV is a composite value which combines both germination speed and total germination and provides an objective means of evaluating the results of germination tests.

$$GV = (\Sigma DGs/N)\ GP/10$$

Where	GV	=	Germination value.
	GP	=	Germination percent at the end of the test.
	DGs	=	Daily germination speed, obtained by dividing the cumulative germination percent by the number of days since sowing.
	ΣDGs	=	The total obtained by adding every DGs figure obtained from the counts.
	N	=	The number of counts, starting from the date of first germination.
	10	=	Constant.

For statistical analysis, cumulative germination percentage figures were transformed into arcsin values.

Analysis of variance was performed using INSTAT statistical package for micro-Computers. Means and standard deviations were calculated for each treatment and Duncan's multiple range test (Gomez & Gomez 1983) was used to determine significance of treatment means.

3. RESULTS AND DISCUSSION

All seeds extracted from fruits at the three ripeness stages had initially very high moisture content (40%) and high germination capacity (85 - 90%). Analysis of variance before seed storage showed a significant (P 0.05) difference in germination between the three fruit ripeness stages and between the three seed moisture content levels, and a low interaction between the two factors. Ouédraogo et al. (1985) obtained similar results in which very high germination capacity was obtained from seeds extracted from barely ripe fruits as well as from ripe fruits.

After drying the seeds to 12% moisture content the germination percentage dropped to 50%, 62% and 60% for seeds extracted from green, greenish-yellow and yellow fruits respectively (Tab. 1; Fig. 1). The low germination percentage obtained by seeds extracted from green fruits indicates that these seeds suffered more from desiccation injury than the other two stages.

The period from sowing to commencement of germination was 8-12 days for freshly extracted seeds. After storage for 8 weeks it increased to 14-16 days, indicating reduced seed vigour (Table 2).

After storage for 8 weeks the germination percentage and germination value were seriously reduced with significant differences between the three fruit ripeness stages but there was no significant (P 0.05) difference between the three seed moisture content levels and no significant interaction between the two factors. (Table 1; Figure 2). Seeds extracted from greenish-yellow and yellow fruits maintained better germination percentage (29 - 36%) and germination value (2.6 - 3.6) compared with seeds extracted from green fruits with germination capacity 19 - 26% and germination value 1.1 - 2.1. This means that seeds extracted from green fruits deteriorated faster in storage compared with seeds extracted from the other two ripeness stages. This suggests that the endocarp was still soft and thereby causing the majority of the seeds to suffer from mechanical injury during fruit depulping.

The reduction in germination with time after storage of the seed extracted from the three ripeness stages is illustrated in Figure 3. After 8 weeks of storage, the germination percent, germination energy, and germination value within a fruit ripeness stage did not notably differ according to whether the seeds were initially dried down to 38%, 25% or 12% moisture content (Table 1). During this period the moisture content of the seed had dropped from their initial respective values to around 10 %.

The difference in pattern of germination of the seed before and after storage is seen when figures 4 and 5 are compared.

These results agree with Webb et al. (1984) and Ezumah (1986) that Neem seed has the reputation of rapidly losing its germinative capacity falling to near zero after 1 - 2 months. Nagaveni et al. (1987) obtained contradictory results for Neem seed having a germination rate of 80% for the first four months.

The present findings do not confirm the results presented by Tompsett (pers. comm.) and Bellefontaine and Audinet (1993). The present findings however agree with the results obtained by Maithani et al. (1989) and Wolf (1993) that it is not possible to dry the seeds without loss of viability under practical conditions. It is evident from the present investigation that physiological maturity occurs before the major changes in colour of the fruits. However,

seeds with maximum germination capacity and life span can be obtained when fruits have turned yellow. In practice, it is not possible to collect only yellow fruits, whereas mixed greenish-yellow and yellow fruits can be collected. Where there is a competition with birds, even green fruits at maturity size can also be picked and after-ripened before extraction.

In conclusion, Neem seed cannot keep adequate viability for a long time. According to the results of this experiment it can generally be considered that after 8 weeks storage, germination percent is around 30 - 36%.

Table 1. Effect of fruit ripeness stages and initial seed moisture content on germination of *Azadirachta indica* seed before and after storage for 8 weeks

Fruit ripeness stage	Seed moisture content (%)	Germination (%)		Germination energy (%)		Germination value (GV)	
		Before	After	Before	After	Before	After
Green at maturity size	38	85a	26a	68	24	38.6	2.1
	25	68b	21a	62	17	18.7	1.4
	12	50c	19b	50	15	6.4	1.1
Greenish-Yellow	38	90a	36a	80	33	48.2	4.0
	25	72b	33a	55	30	22.1	3.3
	12	62c	29b	57	24	12.2	2.6
Yellow	38	87a	34a	70	31	46.9	3.6
	25	65b	31a	63	29	17.9	3.0
	12	60b	32a	54	25	9.9	3.2

In a column, within a fruit ripeness stage, means followed by the same letter are not significantly different at the 0.05 level

Table 2. Effect of fruit ripeness stages and initial seed moisture content on germination periods for *Azadirachta indica* seed before and after storage for 8 weeks

Fruit ripeness stage	Initial Seed moisture content (%)	Germination periods (days)					
		From sowing to commencement of germination (x)		From sowing to completion of germination (y)		Differential (y-x)	
		Before	After	Before	After	Before	After
Green at maturity size	38	8	14	22	30	14	16
	25	10	16	26	32	16	16
	12	12	16	28	32	16	16
Greenish-Yellow	38	8	14	20	30	12	16
	25	10	14	24	30	14	16
	12	12	16	28	30	16	14
Yellow	38	8	14	20	30	12	16
	25	10	14	24	30	14	16
	12	12	16	28	30	16	14

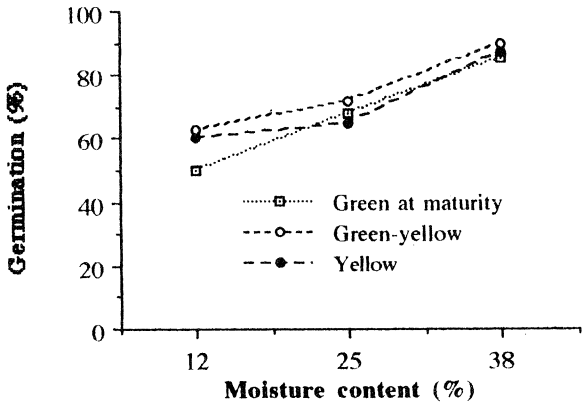


Figure 1. Effect of fruit ripeness stages and seed moisture content on germination of *Azadirachta indica* seed before storage

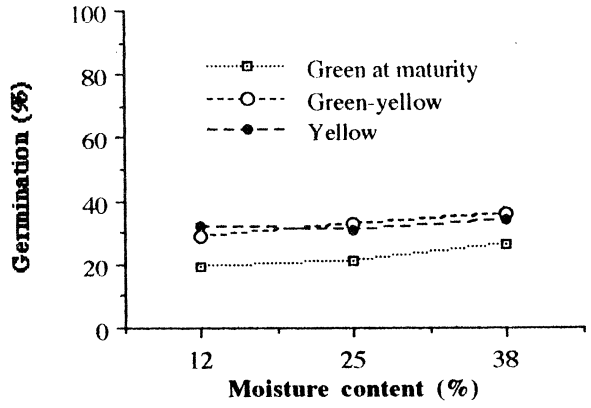


Figure 2. Effect of fruit ripeness stages and initial seed moisture content on germination of *Azadirachta indica* seed after storage for 8 weeks

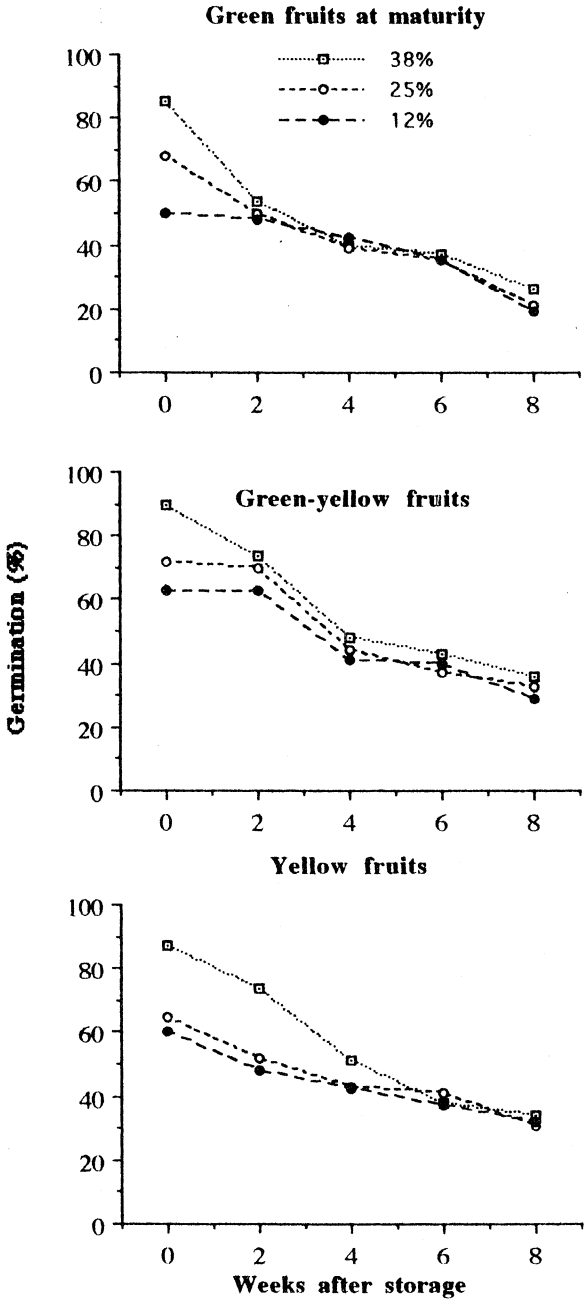


Figure 3. Effect of fruit ripeness stages and initial seed moisture content on storability of *Azadirachta indica* seed

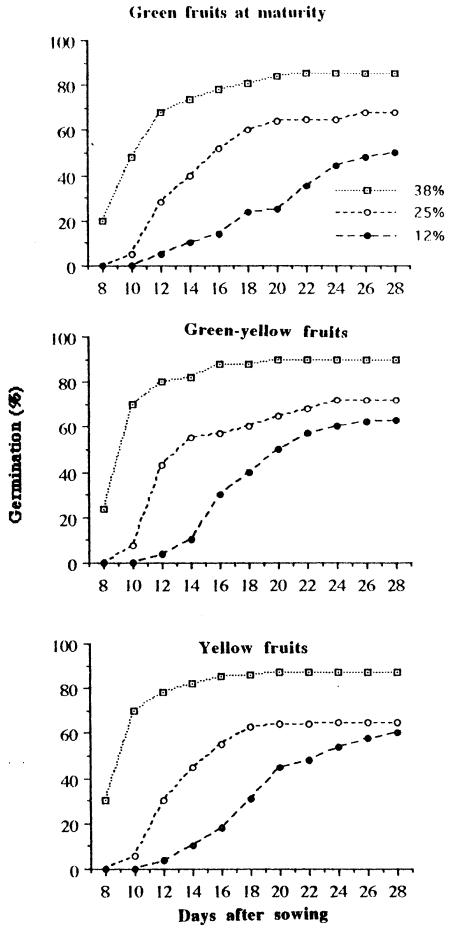


Figure 4. Effect of fruit ripeness stages and initial seed moisture content on storability of *Azadirachta indica* seed before storage

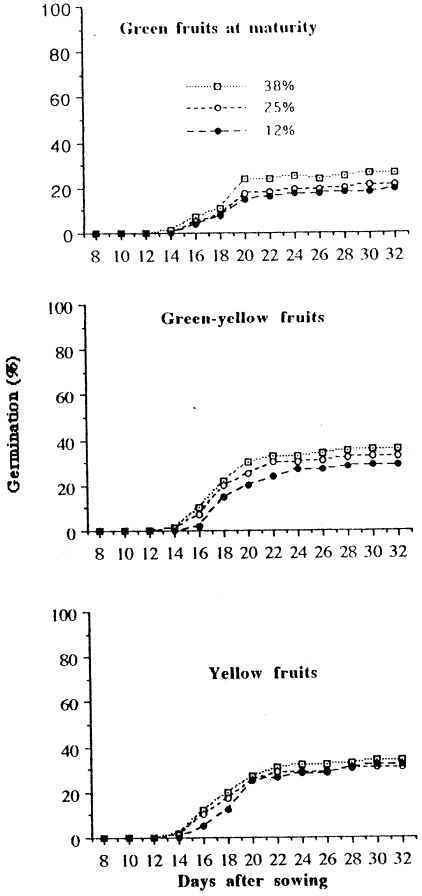


Figure 5. Effect of fruit ripeness stages and initial seed moisture content on germination of *Azadirachta indica* seed after storage for 8 weeks

4. ACKNOWLEDGEMENTS

I am grateful to the staff of the National Tree Seed Programme, Morogoro, Tanzania who encouraged me to undertake this study. I am indebted to Dr. Karen Poulsen of Danida Forest Seed Centre, Humlebaek, Denmark for making useful suggestions during the preparation of the experimental outline. I wish to thank Dr. Sally E.T. John of the SADC Tree Seed Centre Network, Harare, Zimbabwe for making English and technical corrections of the first half of this paper. Dr. Ancelm Mugasha of the Sokoine University of Agriculture, Morogoro, Tanzania assisted in making statistical analysis.

I acknowledge with thanks the financial support from CIDA through the SADC Tree Centre Network to attend this IUFRO symposium.

5. REFERENCES

Bellefontaine, R. and Audinet, M. 1993. La conservation de graines de Neem (*Azadirachta indica* A. Juss). *In*: L.M. Some, and K. de Kam (Editors). Tree Seed problems with special reference to Africa. Proc. IUFRO. 23-28 November 1993. Ouagadougou p. 268 - 274.

Chaney, W.R. and Knudson, D.M. 1988. Germination of seeds of *Azadirachta indica* enhanced by endosperm removal. International Tree Crops Journal 5:153 - 161.

Djavanshir, K. and Pourbeik, H. 1976. Germination value. A new formula, Silvae Genetica, 25:79 - 83.

Ezumah, B.S. 1986. Germination and storage of Neem (*Azadirachta indica* A. Juss). Seed Science and Technology, 14:593 - 600.

Gomez, K.A. and Gomez, A.A. 1983. Statistical procedures for Agricultural Research. New York, John Wiley and Sons. 680 pp.

ISTA. 1993. International Rules for Seed Testing. Seed Science and Technology. 21: Supplement.

Maithani, G.P., Bahuguna, V.K., Rawat, M.M.S. and Sood, O.P. 1989. Fruit maturity and interrelated effects of temperature and container on longevity of Neem (*Azadirachta indica*) seeds. Indian Forester, 115:81 - 97.

Mbuya, L., Msanga, H.P., Ruffo, C.K., Birnie, A. and Tengnas, B. 1994. Useful trees and shrubs for Tanzania. Identification, propagation and management for Agricultural and Pastoral Communities. Technical Handbook No. 6. SIDA's Regional Soil Conservation Unit. Nairobi, 542 pp.

Nagaveni, H.C., Ananthapadmanhaba, H.S. and Rai, S.N. 1987. Note on the extension of viability of *Azadirachta indica*. Myforest, 23:245-255.

Ouédraogo, A.S., Some, L.M., Bance, C. and Bellefontaine, R. 1985. A specialised Technical Institution for Forest Seed in the Sahelian and Sudanian Zones: Direction des Semences Forestieres, Burkina Faso, FAO, Forest Genetic Resources Information No. 14. Rome P. 10-14.

Webb, D.B., Wood, P.J., Smith, J.P. and Henman, G.S. 1984. A guide to species selection for tropical and sub-tropical plantations. OFI, Oxford, 256 pp.

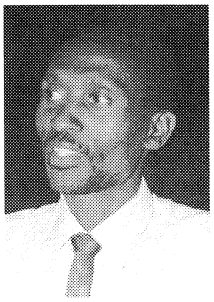
Wolf, H. 1993. Neem-collection, drying and storage. Preliminary results. Paper presented at a workshop on cooperation of African Tree Seed Centres. Malindi, Kenya. 24 July - 8 August 1993. 9 pp.

ACCOUNT ON GERMINATION CHARACTERISTICS OF THE MAIN COMMERCIAL TIMBER TREES OF THE MIOMBO WOODLANDS IN TANZANIA

E. Munyanziza[1] and H.P. Msanga[2]

[1]Department of Forest Biology
Sokoine University of Agriculture
P.O. Box 3010 Morogoro, Tanzania

[2]The Danida/Tanzania National Tree Seed Programme
P.O. BOX 373, Morogoro, Tanzania



E. Munyanziza

ABSTRACT

Observation on germination characteristics of major miombo trees was made in the greenhouse in Morogoro, in the cool highlands of Tanzania and in the laboratory in Wageningen at different temperatures. In Morogoro, seeds of *Brachystegia boehmii* Taub.. *B. microphylla* Harms. *B. spiciformis* Benth. and *Julbernardia globiflora* (Benth.) Troupin completed germination in less than two weeks without treatment. *Afzelia quanzensis* Welw. seeds took around three weeks. Nicking and soaking reduced germination in *A. quanzensis* to around 10 days. All seeds germinated. In the cool highlands and in the laboratory at temperatures lower than 16°C seeds of *A. quanzensis* failed to germinate. *Pterocarpus angolensis* D.C. seeds displayed dormancy. Hot wire scarifier applied to seeds raised germination rate from less than 20% in unscarified seeds to more than 90%. In Morogoro the germination of scarified seeds of *P. angolensis* in the greenhouse was further enhanced by showers falling outside.

Keywords: Miombo seeds, germination, scarification, weather conditions

1. INTRODUCTION

The miombo woodlands cover a considerable area of Africa. In Tanzania they constitute the largest single vegetation (Temu, 1979). Major genera are *Julbernardia* and *Brachy-stegia* (Lind and Morrison, 1974). *Afzelia quanzensis* and *Pterocarpus angolensis* appear as canopy associates and they have timber of excellent quality (Bryce, 1967). These two tree species have been cut to vulnerable levels. Today they are protected by the Tanzanian government. The rapid decline of the miombo woodlands due to timber harvesting and charcoal production (Chidumayo, 1987; Abeli, 1990) raises a lot of concern. Knowledge on effective management of miombo is imperfect (Abeli, 1992), and techniques for their artificial propagation are still lacking (Mgeni and Malimbwi, 1990; Refsdal, 1992). From the year 1991 till now, studies

sponsored by the International Foundation of Science have been undertaken in Morogoro (Tanzania) in order to contribute to the knowledge needed for managing miombo trees in their natural habitat and raising major tree species in artificial plantations and agroforestry. The objective of this paper is to bring together available information gathered on seed germination.

2. MATERIALS AND METHODS

2.1 *Brachystegia* species and *Julbernardia globiflora*

Seeds with well-filled testa, without any apparent damage were used. Sowing was done within the top half centimetre of the media in polythene pots or in seedbeds prepared with miombo soil, sand or a mixture of both. These experiments were set up in Morogoro during the short or the long rainy period (November-January or March-June). More than 126 seeds were sown of *Julbernardia globiflora*; 56 of *B. boehmii*; 126 of *B. microphylla*. Watering was done twice a day. Germination characteristics were noted and they will be reported below.

2.2 *Afzelia quanzensis*

Germination in the field and in the greenhouse in Morogoro

Well-filled and polished seeds free from fungal growth were scarified, soaked in water for 12 hours and their aril removed. Scarification consisted in making two cuts in the seedcoat near the aril using a sharp razer blade. Seeds were then directly raised in the field in the root zone of adult trees of *A. quanzensis* or other miombo trees or in plastic pots in the greenhouse. They were watered twice a day. Germination count was made until all seeds had finished germination. In the field, naturally dispersed seeds or artificially introduced ones were observed for their germination under natural conditions during the short rains. No watering was done.

Germination in the cool highlands of Arusha and Mazumbai

Two zones with high rainfall, low temperatures and different vegetation types were chosen for this study. In Mazumbai, the experiment was conducted in montane rain forest (Härkönen et al., 1993, for brief description of the vegetation). In Arusha, the experiment took place in exotic *Pinus patula* Schiede & Deppe plantations. In both ecosystems, small germination plots (50 X 50 cm) were prepared. Undecomposed organic matter was removed. Small openings were made in the canopy in order to allow light penetration. Plots were then sown with *Afzelia quanzensis* seeds, treated as above. There were 14 plots in each zone, 7 with addition of mycorrhizal soil from Morogoro, 7 without addition. In each plot, seven seeds were sown. In Mazumbai, the experiment started in November and ran till January. In Arusha it ran between September and February. Regular observations and germination counts were made. The very aim of this experiment was to assess the performance of *A. quanzensis* and its natural mycorrhizal fungi in the cool and moist highlands.

Germination in the laboratory at different temperatures in Wageningen, the Netherlands

Germination studies were conducted in the laboratory. Seeds were treated as above and germinated at three temperature levels, namely 10, 15 and 25 °C. Each treatment covered a

total of 70 seeds i.e 10 seeds in 7 replications. Daily observations during three weeks ensured germination counts.

2.3 ***Pterocarpus angolensis***

Scarification and soaking treatments in the greenhouse

Seeds were mechanically extracted from the pods by hammering with a stone. Visually injured seeds or those covered by fungal growth were removed. The rest were subjected to four pre-sowing treatments distributed over three blocks. Each treatment consisted of 45 seeds. The following treatments were applied:

a. Seeds were soaked for 16 hours in water before being sown shallowly: seeds were gently pushed into the germination substrate (sand in square pots) until their upper surface was level with the top of the substrate. Seeds were then covered by a very thin layer of the substrate which still allowed the seed to be partially seen (S).

b. Seeds were soaked for a total of 16 hours: 2 phases of 8 hours soaking, each followed by 24 hours air drying in the greenhouse before shallow sowing (AS).

c. Seeds were scarified with a hot wire and sown shallowly (ShS), as in (a).

d. Seeds were scarified as in (c) and placed on the surface of the germination sub-strate. They were then gently pushed into the substrate, until half of the seed (in flat position) was sunk into the substrate. The upper part of the seed was not covered and was kept uncovered till the end of experiment (SpS).

Seeds were watered every day. Germination counts were made daily. Variations in the cumulative germination percentages over 21 days were subjected to analysis of variance, and the significant means sorted out using Duncan New Multiple Range test. The experi-ment was conducted during the long rains and ran from 23/4/1993 to 16/5/1993. It took place in the greenhouse of the Sokoine University of Agriculture, Morogoro.

3. RESULTS

Julbernadia globiflora and all species of *Brachystegia* used in this study completed germination within two weeks. The germination rate was 100%.

In Morogoro, irrigated scarified *Afzelia quanzensis* seeds completed germination in less than two weeks. All seeds germinated. Germination of unscarified seeds took from three to four weeks. In Mazumbai, no single seed of *A. quanzensis* germinated. In Arusha 12 seeds germinated after 45 days. The first leaves failed to come out from the cotyledons which usually remained closed up. Seedlings collapsed a few days later.

In the laboratory, only seeds sown at 25°C germinated (figure 1). Germination started five days after sowing and was completed four days later. No seed germinated at 10°C and 15°C.

In the laboratory, only seeds sown at 25°C germinated (figure 1). Germination started five days after sowing and was completed four days later. No seed germinated at 10°C and 15°C.

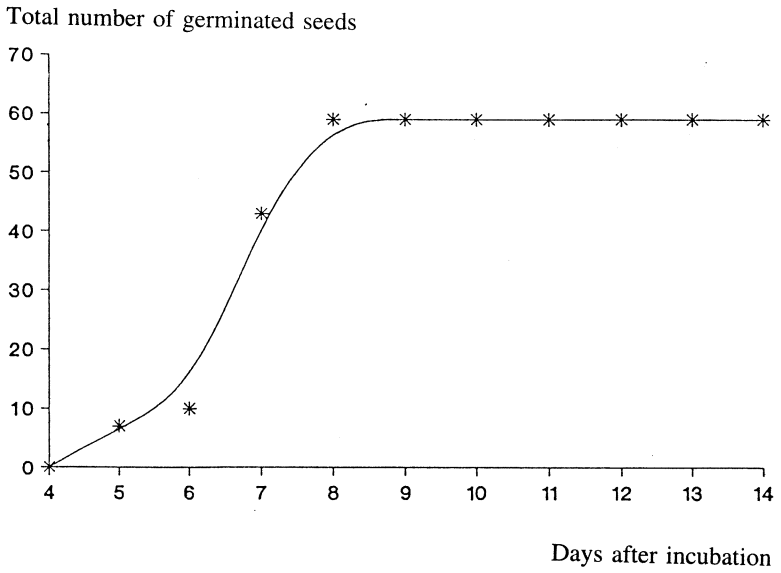


Figure 1. Germination of *Afzelia quanzensis* in the laboratory at 25°C. Seventy seeds had been sown. Germination percentage at 10 and 15°C was 0.

Injured seeds of *Pterocarpus angolensis* expanded in size during the soaking process, while non-injured ones remained practically unchanged.

Germination in this species started on April 26 and was observed up to May 16, 1993 (figure 2). It was sustained in scarified shallowly sown seeds, widely spaced and irregular in soaked non-scarified seeds and remarkably influenced by the rain outside for superficially sown scarified seeds. In other words, the germination of seeds in this last treatment, was always initiated after one or two days of rain and no further germination was initiated once the rain had stopped. These patterns of germination are depicted in figure 2. The total germination percentages were in the following order: ShS = 93% > SpS = 84% > AS = 29% > S = 16%

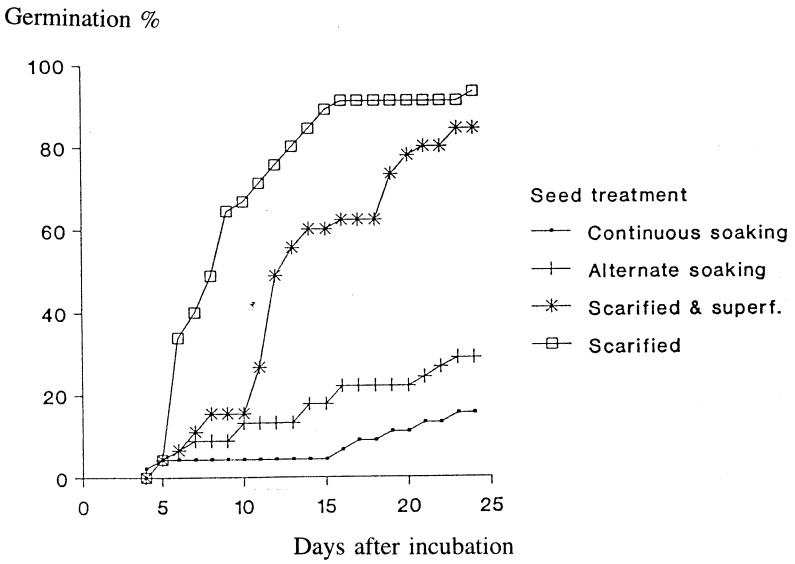


Figure 2. Germination pattern of *Pterocarpus angolensis* in the greenhouse.

Scarification significantly enhanced cumulative germination percentages in *P. angolensis* compared to other treatments ($P < 0.05$). Alternating soaking and drying enhanced germination compared to one continuous soaking but the difference was not statistically significant.

4. DISCUSSION

Seeds of *Julbernardia globiflora*, *Brachystegia boehmii*, *B. microphylla* and *B. spiciformis* germinated readily. The same observation was earlier made in these genera (Ernst, 1988; Chidumayo, 1991). Their germination under natural conditions can only be inhibited by limited rainfall, wildfires (Munyanziza et al. in prep.) and damage by insects and fungi. According to our own field observations, short rains induce germination in these species.

Failure of *Afzelia quanzensis* seeds to germinate in the cool highlands and in the laboratory at 10 and 15°C was due to the low temperatures. These highlands are subjected to low temperatures (Barmforth *ex* Lundgren, 1978; Lundgren, 1978) falling some time below 15°C. Proper temperature is one of the requirements for seed germination (Willan, 1985; Albrecht, 1993).

Miombo trees grow in warm areas (Lind and Morrison, 1974; Celander, 1983) and naturally germinate any time during the period from October to end of May of the following year. Different species germinate at different periods within this temporal range depending on the level of their dormancy and their moisture requirements. Most species usually germinate during the short rains of October to January. On average, this period is the hottest of the year.

Unlike *Julbernadia globiflora*, *Brachystegia* species and *Afzelia quanzensis*, *Pterocarpus angolensis* seeds do not necessarily react to watering or short rains. The natural ger-mination of this species has been found to be 2% (Boaler, 1966). Low germination rates were also found in South Africa (Van Daalen, 1991). There are four main causes of low natural germination (Munyanziza, 1994): (a) the seeds of this species are sensitive to fires; (b) the shape of the fruit prevents it from getting into contact with the soil; (c) the fruit has a hard endocarp; and (d) the seedcoat is impermeable to water and the species needs long periods of rain for germination. As the present study showed, breaking the seed dormancy by scarification of the seedcoat with a hot wire enhanced a very high germination percentage. Scarification has been used to break seed dormancy induced by a hard seedcoat or a hard pericarp. In Malawi, Ngulube (1989) reported successful germination of *Albizia* and *Caesalpinia* species after scarifying the seeds. In Denmark, Stubsgaard (*ex* Sandif, 1988) did scarification with a branding tool and reported a very high germination rate for *Acacia* seeds. Sandif (1988) working on various leguminous trees achieved similar results. Scarification done with a hot wire or electric burner is more effective than the common scarification methods in that seeds are homogeneously treated. Homogeneity in seed treatment implies shorter germination periods. This is important in nursery management.

In our experiment, alternate soaking and drying of seeds of *Pterocarpus angolensis* en-hanced germination percentage compared to one continuous soaking, though the means were not statistically different. Probably longer exposure of seeds to this treatment would have brought significant differences. Alternate soaking and drying simulates the real conditions to which seeds are exposed in the miombo woodlands. Alternating conditions of germination has been reported to induce germination of seeds (Khan and Tripathi, 1987). However, in the miombo woodlands, the period between two consecutive rains may be very long. If the rain stops at a critical time in the germination process, germination may abort.

Outside rain influenced the germination of scarified, superficially sown seeds. Every rainfall following a dry spell initiated new germinations in the greenhouse, but only for the seeds treated by scarification and superficial sowing. This dependence on unpredictable factor explains the irregular germination of the species studied here, especially in nature, because it concerns dependence upon an unpredictable factor. It is no small wonder that *P. angolensis* regenerates sparsely in nature. Neither covered scarified seeds, nor covered non scarified seeds responded to outside rain. The former had their moisture requirements ensured while the latter were certainly hindered by an impermeable seedcoat.

5. ACKNOWLEDGEMENTS

The International Foundation for Science has generously sponsored the implementation of the work presented here. Its theoretical part has been sponsored by The Wageningen Agricultural University. Professor Oldeman has supervised this work. We thank the Faculty of Forestry of the Sokoine University of Agriculture and her scientists and the Danida/ Tanzania National Tree Seed Program for their cooperation during the field work.

6. REFERENCES

Abeli, W.S. 1990. Harvesting timber in the natural forests. *In*: Mgeni A.S.M., Abeli W.S., Chamshama S.A.O. and Ishengoma R.C. (eds.). Proceedings of the SUA/AUN seminar.

The management of natural forests in Tanzania. Faculty of Forestry Record no 43. pp. 85-94.

Abeli, W.S. 1992. Forest engineering research priorities. *In*: Abeli W.S., Mgeni A.S.M., Chamshama S.A.O., Iddi S. and O'kting'ati A. (eds.). Proceedings of 1990 SUA/ AUN seminar. Forestry research in Tanzania. Faculty of Forestry Record no 53. pp. 52-61.

Albrecht, J. 1993. Forest seed handling. *In*: Pancel L. (ed.). Tropical forestry handbook vol.1, Springer-Verlag Berlin Heidelberg. pp. 381-462.

Boaler, S.B. 1966. The ecology of *Pterocarpus angolensis* D.C. in Tanzania. Overseas Research Publications, 12. H.M.S.O., London.

Bryce, J.M. 1967. The Commercial Timbers of Tanzania. Tanzania Forest Division, Utilisation Section, Moshi.

Celander, N. 1983. Miombo woodlands in Africa - Distribution, ecology and patterns of land use. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Chidumayo, E.N. 1987. A survey of wood stocks for charcoal production in the miombo woodlands of Zambia. For. Ecol. Manag. 20: 105-115.

Chidumayo, E.N. 1991. Seedling development of the miombo woodland tree *Julbernardia globiflora*. J. Veg. Sci. 2: 21-26.

Ernst, W.H.O. 1988. Seed and seedling ecology of *Brachystegia spiciformis*, a predominant tree component in miombo woodlands in South Central Africa. For. Ecol. Manag. 25: 195-210.

Härkönen, M., Buyck, B., Saarimäki, T. and Mwasumbi, L. 1993. Tanzanian mushrooms and their uses 1. *Russula*. Karstenia 33: 11-50.

Khan, M.L. and Tripathi, R.S. 1987. Ecology of forest trees of Meghalaya: seed germination, and survival and growth of *Albizia lebbeck* seedlings in nature. Ind. J. For. 10: 38-43 (Cited from Forestry Abstracts 49: 184).

Lind, E.M. and Morrison, M.E.S. 1974. East African Vegetation. Longman, London.

Lundgren, B. 1978. Soil conditions and nutrient cycling under natural and plantation forests in Tanzania highlands. Swedish University of Agricultural Sciences, Uppsala.

Mgeni, A.S.M. and Malimbwi, R.E. 1990. Natural resources of Tanzania and their management needs. *In*: Mgeni, A.S.M., Abeli, W.S., Chamshama, S.A.O. and Ishengoma, R.C. (eds.). Proceedings of the SUA/AUN seminar. The management of natural forests in Tanzania. Faculty of Forestry Record no 43. pp. 67-76.

Munyanziza, E. 1994. Miombo trees and mycorrhizae. Ecological strategies, a basis for afforestation. PhD thesis, Wageningen Agricultural University.

Ngulube, M.R. 1989. Seed germination, seedling growth and biomass production of eight Central-American multipurpose trees under nursery conditions in Zomba, Malawi. For. Ecol. Manag. 27: 21-27.

Refsdal, T. 1992. Management of indigenous forests versus plantation forestry. *In*: Abeli, W.S., Mgeni, A.S.M., Chamshama, S.A.O., Iddi, S. and O'kting'ati, A. (eds.). Proceedings of 1990 SUA/AUN seminar. Forestry research in Tanzania. Faculty of Forestry Record no 53. pp. 76-78.

Sandif, M. 1988. Burnt offerings: an evaluation of the hot-wire seed scarifier. Commonw. For. Rev. 67: 285-292.

Temu, A.B. 1979. Estimation of millable timber volume in miombo woodlands. Division of Forestry Record no 7, University of Dar es Salaam, Morogoro, Tanzania.

Van Daalen, J.C. 1991. Germination of *Pterocarpus angolensis* seeds. S.A. For. J. 158: 33-36.

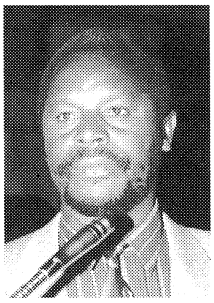
Willan, R.L. 1985. A guide to forest seed handling with special reference to the tropics. F.A.O. Forestry Paper 20/2. FAO, Rome.

EFFECT OF SEEDCOAT SCARIFICATION ON GERMINATION OF ACACIA POLYACANTHA SEED

W. Mussa[1], S.M.S. Maliondo[1] and H.P. Msanga[2]

[1]Sokoine University of Agriculture
Department of Forest Biology
P.O. Box 3010, Morogoro, Tanzania

[2]National Tree Seed Programme
P.O. Box 373, Morogoro, Tanzania



S.M.S. Maliondo

ABSTRACT

Two physical seedcoat scarification methods and hot water treatment were studied to determine their effect on germination of *Acacia polyacantha* seed at the National Tree Seed Programme, Morogoro. The seeds were physically scarified by hot wire and seedgun followed by soaking in hot water for 24 hours prior to sowing. The scarified seeds were either soaked or not soaked (control).

The seeds were allowed to germinate in the nursery. The results showed that treating *Acacia polyacantha* seeds with hot wire and soaking in hot water for 24 hours stimulated germination. However, soaking in this case should not exceed 24 hours, as it may lead to detri-mental effects. The data also showed that soaking of seeds scarified by seedgun at a crack percent of 15 and speed index of 6 gave poor germination and should not be used. For un-scarified *Acacia polyacantha* seeds, soaking is highly recommended but soaking should exceed 24 hours with frequent changes of the water to avoid microbial activities.

Keywords: *Acacia polyacantha,* seedcoat, seed scarification, seed germination, seedgun, hotwire

1. INTRODUCTION

Acacia polyacantha (Falcon's claw Acacia) is a flat topped tree up to 15m high. It is indigenous to Tanzania and is common along rivers and in rich alluvial valleys, but is also found throughout the country. *Acacia polyacantha* is truly a multipurpose species. The timber is used for mine shaft and building material. The stem is used for hut construction and fuelwood. The roots are used for treatment of gonorrhoea. The leaves provide fodder for animals.

The cultivation of *Acacia polyacantha* on farms is desirable but has been difficult because of limited knowledge about germination of its seed. The seed is almost rounded and flattened. The colour is light green, shining, compressed with a hard seedcoat. The size is about 4mm

by 6mm. The germination of its seed is not well understood. In nurseries it shows sporadic germination over a long period up to 40 days (Watkins, 1960). To date there is no published work on how to germinate seed of this species although scanty information is available in publications dealing with aspects of its silviculture.

The objectives of this study were to investigate the effect of mechanical seedcoat scarification and to study the effect of hot water treatment on germination of *A. polyacantha* seed.

2. MATERIALS AND METHODS

The experiment was conducted at the National Tree Seed Programme at Morogoro. It is situated at 6°50'S latitude and 37°39'E longitude, and altitude of 410m above sea level. The mean annual rainfall is 908mm and the mean monthly temperature is 27°C.

Seeds collected earlier from Iringa were obtained from NTSP store. Normal seed storage procedures including viability test were followed before storage. Viability according to ISTA (1985) was about 90%.

Pure sand with reasonably uniform particles and free from very small and large particles was used as germination medium while tap water was used to moisten the sand.

Seed pretreatment

Hot wire, seedgun and hot water treatments were used to pretreat the seeds before sowing (Stubsgaard, 1986; Msanga et. al., 1993).

A working sample of 1800 seeds was obtained from the seed lot. This was divided into 3 equal parts which were treated by hot wire, by seedgun and left untreated, respectively.

Hot wire, seedgun and non-treated seeds were then divided into two groups each; one group was soaked in hot water for 24 hours while the second was not.

Hot water treatment consisted in pouring boiling water onto the seeds and leaving it to cool. The proportion of seeds to water was 1:5 by volume.

Experimental design

Seeds were sown in the nursery in a completely randomized design with 6 treatments and 3 replicates each. The six treatments were allocated at random to 18 plots and allowed to germinate in the nursery (i.e. 100 seeds x 6 treatments x 3 replicates = 1800 seeds sown).

Data collection

The number of germinating seeds were recorded daily until no new germination occurred. At this stage, height of the seedlings (above the root collar) was measured to the nearest cm. The number of days for commencement of germination, completion and germination period was also determined.

Data analysis

The number of seeds having germinated at 10 and 18 days after sowing, was expressed as percentage of all seeds sown per plot. Germination energy was calculated. The germination value was determined by using the formula for evaluating results of germination tests (Djavanshir and Pourbeik, 1976) as shown below:

$$GV = \frac{DGs}{N} \times (GP \times 10)$$

Where,

GV = Germination value

DGs = Daily germination speed, i.e.

$$= \frac{\text{Total germination percent}}{\text{Number of days since beginning of the test}}$$

N = Number of days since beginning of germination

GP = Germination percent at test conclusion. i.e.

$$= \frac{\text{Number of germinated seeds}}{100}$$

10 = Constant

In the analysis of variance the experiment was treated as a split plot design with scarification forming the main plots. ANOVA was made using software programmes of the SAS statistical package. All percentages were transformed by arcsine transformation before statistical analysis. Duncan's new multiple range test was used to separate differences among treatment means.

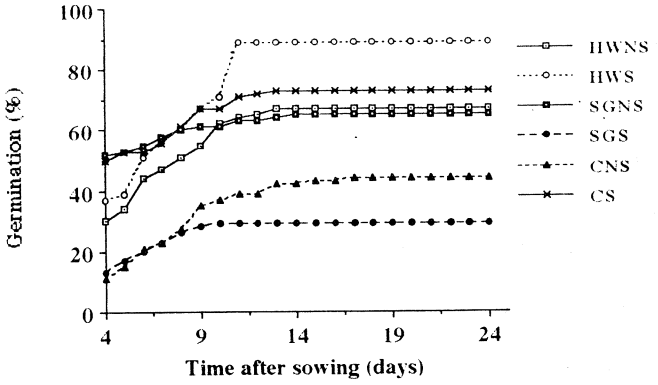


Figure 1. Effect of treatments on total germination

HW	Hot water	NS	Not soaked
SG	Seedgun	S	Soaked
C	Control		

3. RESULTS

Total germination and germination energy

Total germination percentages for all treatments are presented in Figure 1. Seed scarification showed highly significant differences in total germination. In the final analysis total germination percentage was highest in treatments hot wire and soaking in hot water.

Seeds treated by seedgun and then soaked in hot water produced very poor results (Table 1). Good germination percent was attained by the non-scarified but soaked seeds (Table 1), showing that soaking in hot water alone can produce good results.

Table 1: Effect of seedcoat scarification and hot water treatment on germination of *Acacia polyacantha* seed 18 days after sowing.

Treatments		Cumulative germination %	Germination value	Seedling height (cm)
Scarification	Water Soaking			
Hot wire	No Soaking	67 ± 0.7*	40 ± 4.9	16 ± 0.7
	Soaking (100°C)	89 ± 2.6	68 ± 2.9	21 ± 1.2
Seedgun	No Soaking	65 ± 2.9	43 ± 3.7	18 ± 0.9
	Soaking (100°C)	29 ± 3.3	8 ± 2.0	20 ± 1.7
Control	No soaking	44 ± 3.0	17 ± 2.6	14 ± 2.5
	Soaking (100°C)	73 ± 0.7	54 ± 1.2	17 ± 1.2

Data represents a mean of 3 replicates ± standard error

Germination value

Data for germination value (GV) is presented in table 1. Statistical analysis showed that there was significant interaction between scarification and soaking on germination value of *Acacia polyacantha* seed.

Height of the seedlings

Scarification by hotwire and seedgun had no significant effect on the height attained. However, soaking has a significant effect (Table 1).

Commencement of germination

None of the treatments had significant effect on commencement of germination.

Completion of germination and germination period

Both scarification treatments were found to have significant effect on completion of germination. Seeds which were not scarified took more time to complete germination (Table 2).

Table 2. Effect of physical seedcoat scarification on germination phases (dormancy periods) of *Acacia polyacantha* seed.

Treatments		Germination phases (days)		
Physical scarification	Water Soaking	Commencement of germination	Completion of germination	Germination period
Hot wire	No Soaking	4 ± 0.0	12 ± 0.7	8 ± 0.7
	Soaking (100°C)	4 ± 0.0	11 ± 0.0	7 ± 2.0
Seedgun	No Soaking	4 ± 0.0	11 ± 0.0	7 ± 2.0
	100°C	4 ± 0.0	11 ± 2.0	6 ± 0.6
Control	No Soaking	4 ± 0.0	15 ± 1.2	11 ± 0.7
	100°C	4 ± 0.0	13 ± 0.6	9 ± 0.6

Data represents a mean ± standard error of 3 replicates.

4. DISCUSSION

The hardness of *Acacia polyacantha* seeds poses a question on how seeds are rendered permeable to water and gases in nature. Pretreating the seeds prior to sowing improves the germination of these seeds although embryo damage while treating could lead to poor results as shown by the seed treated by seedgun and soaked in hot water. Possible explanation could be that the seedgun had cracked the seeds and killed the embryo or the hot water rapidly after the treatment caused some enzymes and hormones important for germination to flow out of the seeds, or both could be the case. Existence of large fractures on the seedcoat might have led to rapid water uptake which also causes death of cells of cotyledons. This may result in high levels of solutes leakage causing poor field emergence. This imbibition damage could lead to reduced mobilization of the food reserves from the cotyledons when cotyledonary cells have been damaged by rapid imbibition (Msanga and Kalaghe, 1993).

For non-treated seeds, germination was also poor due to poor uptake of water and oxygen. Germination studies have shown that the seedcoat of *A. polyacantha* is impermeable to water and gases. An adequate supply of oxygen plays a primary role as the electron acceptor in catabolism; in some species it may also be involved in activation of an inhibitor (Black and Wareing, 1959).

For non-scarified, but soaked *A. polyacantha* seeds, germination was close to those treated by hot wire and soaked (Table 1). This generally justifies that soaking of *Acacia polyacantha* seed prior to sowing alone, to some extent, can overcome seedcoat dormancy.

5. CONCLUSION

In this experiment scarification of *A. polyacantha* seed was shown to improve germination. It can therefore be concluded that before sowing *A. polyacantha* the seed must be pre-treated by hot wire and soaked in hot water for 24 hours. Seedgun at a speed index of 6 and crack percent of 15 followed by soaking in hot water should not be used in treating the seeds of this tree species. If soaking alone is used, prolonged soaking is recommended, but there should be frequent changes of water used for soaking to prevent microbial activities leading to substantial increase in rotting of the seeds (ISTA, 1993).

6. REFERENCES

Black, M. and Wareing, P.F. 1959. The role of germination inhibitors and oxygen in the dormancy of the light sensitive seed of Betula spp. Exp. Bot.10:134-145.

Djavanshir, K and Pourbeik, H. 1976. Germination value. A new formula, Silvae Genetica, 25:79-93.

ISTA. 1993. International Rules for Seed Testing. Seed Science and Technology 21: Supplement.

Msanga, H.P. Shirima, D.K. and Nyegeji, N. 1993. Pretreatment by seedgun to improve germination of hardcoated seeds of twenty tropical tree species. NTSP Technical Note No. 2. Morogoro 9pp.

Msanga, H.P. and Kalaghe, A.G. 1993. Germination of Wild Medlar (*Vangueria infausta* Burch) following manual seedcoat scarification and indole acetic acid treatments. *In*: Somé, L.M. and M. de Kam (Eds). Tree Seed Problems, with special reference to Africa. 23-28 November 1992. Ouagadougou, Burkina Faso. 170-179.

Stubsgaard, F. 1986. Pretreatment of *Acacia* and *Prosopis* seed. Two mechanical methods. Technical Note no. 27. Danida Forest Seed Centre. 8pp.

Watkins, G. 1960. Trees and shrubs for planting in Tanganyika. Government Printer, Dar-Es-Salaam. 158pp.

THE EFFECT OF STORAGE ON GENETIC DIVERSITY IN NEEM (AZADIRACHTA INDICA; A. JUSS) SEED

William Omondi Oloo, G.K. Campbell,
P. Berjak and N.W. Pammenter

Biology Dept. University of Natal
Private Bag X10, Dalbridge
4014, South Africa

ABSTRACT

In order to establish the effect of deterioration of a seedlot, an investigation was conducted on the rate of loss of viability of seeds from individual neem mother trees. Seeds were collected during peak maturity period and processed using conventional methods. Preliminary results after 4 months' storage showed progressive loss of germinability in all seed categories with differences in rates among individual trees. The findings provide strong evidence of reduction in genetic variability of the seedlot following loss of certain components (individual trees) during the storage period.

The study points to the risk of using seed of unknown deterioration level following a storage period and the necessity to minimise this risk by observing seed production rules which demand the use of seedlots that consist of carefully selected seed sources from as many individuals as possible. It also emphasizes the need to incorporate periodic re-testing of seedlots in all quality control programmes especially where medium and long term storage are anticipated.

1. INTRODUCTION

One of the most important attributes of high quality seed is a wide genetic variation. A seedlot intended for a large planting programme should therefore comprise seed collected from a large number of individuals in order to be of an acceptable high genetic variation. The long term objective of genetic diversification is to maintain the evolutionary viability of a species, by maximising its chances of persistence under changing environments (Wolf, 1992). Seed collection rules (Kenya Forestry Seed Centre, 1991) clearly stipulate the need and importance of collecting seeds from a large number of trees; understanding the risks of lowering the genetic variation during storage is equally important.

In most cases seeds of indigenous tree species are collected from as many individuals as necessary to meet a target, bulked and distributed for various planting activities. Many seed centres and dealers holding large stocks of seed face the challenge of storage, prior to which quality tests are conducted. However, the lack of a policy for re-testing stored seed and standards in many tree seed regulations (Oloo, 1992) raises one pertinent question: to which level does the germination capacity have to fall before a seedlot is declared unfit for use?

The effect of low genetic variation on the survival of a tree population is clearly illustrated by recent infestation of cypress trees by *Cinara cupressii*, Buckton, an aphid which found its way into Eastern Africa from Europe (Odera, 1990). The pest is believed to have been introduced into Kenya from a handful of seeds of unknown genetic base, which has since been the basis for extensive plantings, and one of the main sources of industrial timber. Other classic examples of this nature can be cited from many parts of the world. In all cases, the fact is that only tree populations with a high genetic diversity have a good chance of coping with both biotic and abiotic changes (Wolf, 1992). The aim of this study was therefore to determine loss of quality based on constitution of a seedlot resulting from deterioration during storage. The use of neem seed in this study was based on a short storage period under normal conditions; hence no artificial ageing was necessary while at the same time it provided an opportunity to investigate factors which could be used to determine storability of seed of the species.

2. MATERIALS AND METHODS

2.1 Seed source and processing method

In April 1994 mature seeds (greenish/yellow) were collected from 10 trees along the Kenyan coastal region; altitude 30 m, rainfall 1000-1400 mm. Seeds from the 10 mother trees were kept separate at all times. After collection the seeds were soaked in water for six hours then depulped by rubbing them over a soft wire mesh. Pure seeds were then separated from pulp by continuous washing and hand sorting. The seeds were then dried indoors (at 20-25°C) spread over wire mesh shelves to allow loss of excess water.

2.2 Storage method

Seeds from individual trees were spread over plastic trays and kept in a cabinet maintained at 25°C with continuous air circulation. These conditions had earlier been recommended for mid-term storage by Wolf (1993) and had been reported by Moore and Roos (1982) to facilitate an ageing process only to a point where abnormal stress is avoided in order for all the seeds to complete the deterioration cycle.

2.3 Test methodology

(a) Seed weight: 20 seeds were taken at random from the working sample and their weight determined. This was repeated ten times and an average calculated for 100 seeds. These values were further converted into the number of seeds per kilogram and number of germinable seeds using the following formulae:

$$\text{Seeds/kg} = \frac{100}{\text{100 seed wt.(gm)}} \times 1000$$

$$\text{Germinable seeds/kg} = \frac{\text{Germination capacity (\%)}}{100} \times \text{seeds/kg}$$

(b) Moisture content: 10 seeds, randomly picked from the working samples, were ground to pulp using a pestle and mortar. The pulp was then placed in a weighed glass petri dish, re-weighed and heated in an incubator for 17 hours at 103°C. The dried seeds were re-weighed and moisture content determined.

(c) Germination test: 200 seeds from each single tree were sown in sand in plastic containers in four replicates (50 x 4) and incubated in a glass house with a daily temperature range of 23-30°C. This process was repeated monthly for a period of four months. 20 days after sowing seedling evaluation was done daily for 20 days. All data recorded was analyzed using Quatro pro statistical program and differences between trees, storage period and rate of germination compared using the Duncan Multiple Range Method.

2.4 Seed leakage studies

This was done to assess and determine plasmalemma integrity at the beginning of the storage period. Ten seeds were drawn from each sample of individual trees, their endocarp removed and soaked individually in 5ml distilled water for 24 hours. Specific conductivity (electrical resistance) of the leachate solution was determined using a CRISON conductivity meter model micro CM 2201 and recorded in Siemens(S) and expressed per unit length i.e. S/cm.

In order to relate conductivity measurements to seedling vigour, seeds which were used in the leakage study were sown in vermiculite in plastic containers at ambient temperatures (23-25°C) for 14 days. They were then transferred into a growth chamber with higher temperature 28-30°C with the identity of each seed being retained until the close of the test. After 20 days the seedlings were classified into three main categories: normal, abnormal and dead following the standard ISTA system. Normal seedlings had well developed shoot and root systems and they were further rated according to their length (Table 1).

Table 1. Seedling vigour rating

Seedling category	Description	Vigour rating
Normal seedling	Seedling length > 80 cm	15
	< 80 cm> 60 cm	13
	< 60 cm> 40 cm	11
	< 40 cm	9
Abnormal seedling	Malformed plumule or radicle but either one of them well developed	7
	Malformed plumule and radicle	5
	Non emergence of both radicle and plumule but limited growth of embryo	3
Dead seed	Total cellular disorganisation and no visible development of embryo	1

3. RESULTS

Table 2 shows the relationships between various quality factors before storage and their variability among seed batches collected from single trees. It also shows germination capacity of seeds from individual trees and the decrease after four months' storage. There appears to be a general reduction in germinability in all seed categories; the differences between the trees were significant and increased with progressive storage periods.

Trees number 1, 5 and 8 showed greater reduction in germinability in comparison to other trees at rates which significantly reduced their proportional representation of viable seeds in the seedlot; this is shown graphically in figures 1 and 2.

Table 2. Quality factors* (means) of seeds from single trees before storage and mean germination percent before (Gb/s) and after (Ga/s) four months' storage in ambient conditions (20-25°C)

Tree no.	wt(gm)	% mc	cond (uA)	vigour (i)	Gb/s	Ga/s
1	2403	43.6	88.2	58.7	40	1
2	3353	37.3	68.1	78.7	48	21
3	3178	39.4	57.3	69.3	53	61
4	3178	37.9	62.4	49.3	55	12
5	2708	38.5	84.5	42.7	59	6
6	2248	36.6	80.0	56.0	75	52
7	2981	37.4	94.3	49.3	78	60
8	2738	41.6	84.4	54.7	79	4
9	3456	36.3	67.2	85.3	81	46
10	2971	37.4	73.6	56.0	87	21
s.d.	395.9	2.3	12.1	13.6	16.6	28.4
lsd 0.05	*	*	*	*	23.6	9.16

* Quality factors: weight of 100 seeds; moisture content; conductivity and vigour

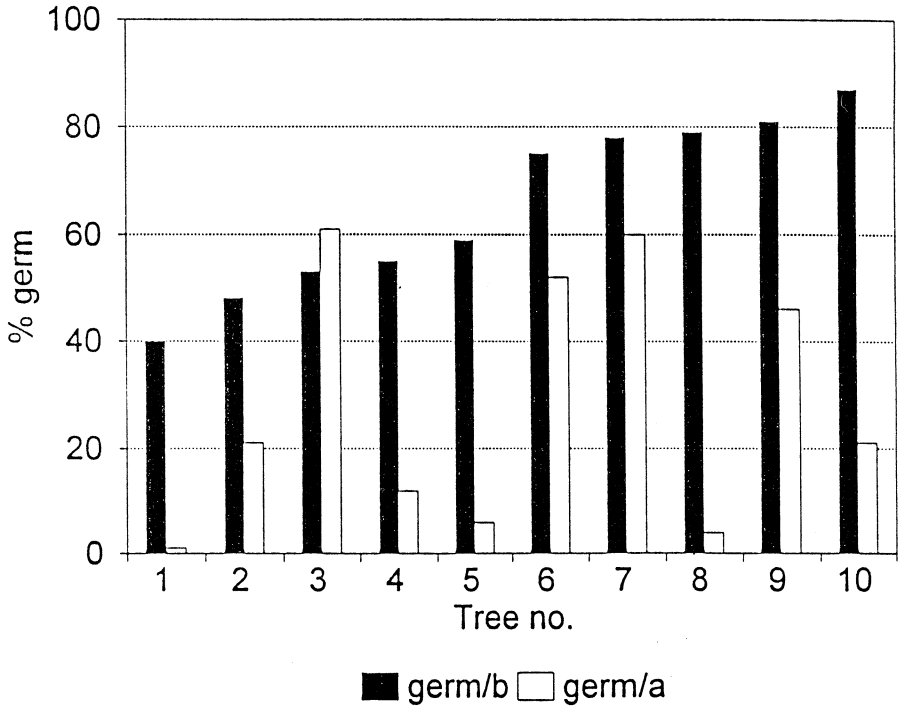


Figure 1. Comparison between germination capacities of seed batches from individual mother trees before and after four months' storage at ambient conditions (20-25°C.

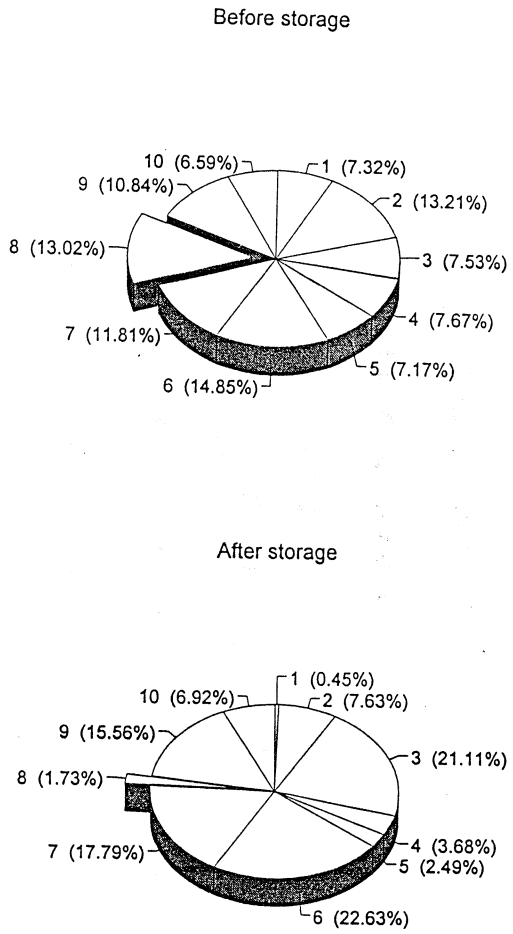


Figure 2. Proportional representation (%) of viable seeds of each of ten mother trees in a seedlot before and after four months' storage.

Table 3 and figure 4 show significant increases in viable seeds in one kilogram of seedlots from tree numbers 3, 6, 7 and 9 with decreases in seedlots from tree numbers 1, 2, 4, 5 and 8 after the same storage period. The results clearly indicate that tree number 8 contributed 13 and 1.7% of viable seeds proportionately before and after four months' storage respectively.

Figure 3 also provides a clear indication of increase in number of seeds in unit weight (kg) while figure 4 shows differences in amount of pure germinable seeds (Pgs) of each individual tree before and after storage. These correspond with the significant decrease in seed weight as shown in table 3.

Table 3. Changes in seed number in unit weight (kg) and available viable seeds for each mother tree before and after four months' storage at ambient conditions.

Tree no.	No. seeds/kg		Germinable seeds/kg	
	before	after	before	after
1	4,161	11,416	1,623	114
2	3,366	9,294	2,928	1,952
3	3,147	8,857	1,668	5,403
4	3,147	7,861	1,699	946
5	2,693	10,638	1,589	638
6	4,448	11,136	3,292	5,791
7	3,355	7,587	2,617	4,552
8	3,652	11,098	2,885	444
9	2,894	8,658	2,402	3,983
10	2,982	8,431	1,461	1,771
Mean	3,385	9,498	2,216	2,559
sd	558	1,447	682	2,167
Range	1,755	3,829	1,831	5,677
lsd	346*	897*	423*	1,343*

* Shows significant differences at 95 % confidence level

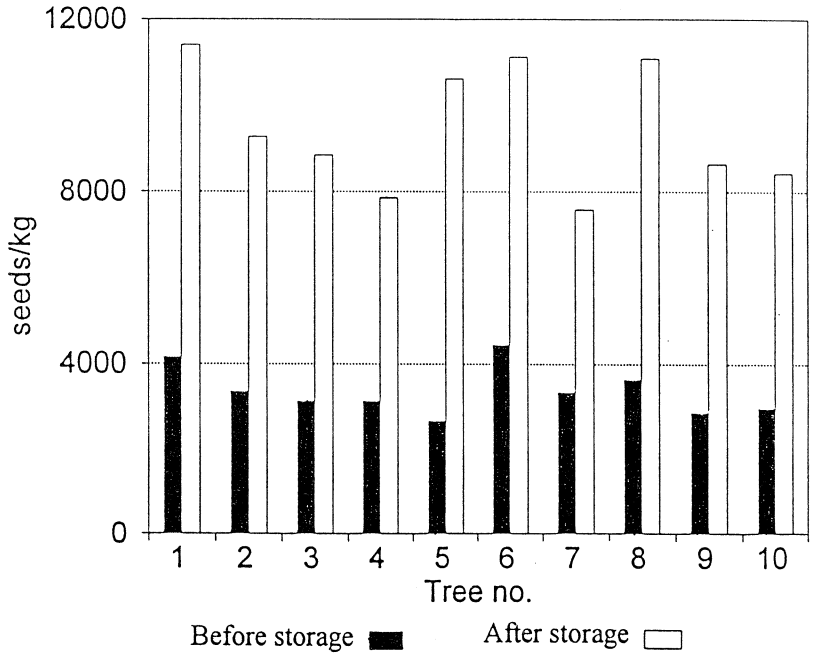


Figure 3. Increase in number of seeds in unit weight (kg) for ten seed batches before and after storage period (4 months).

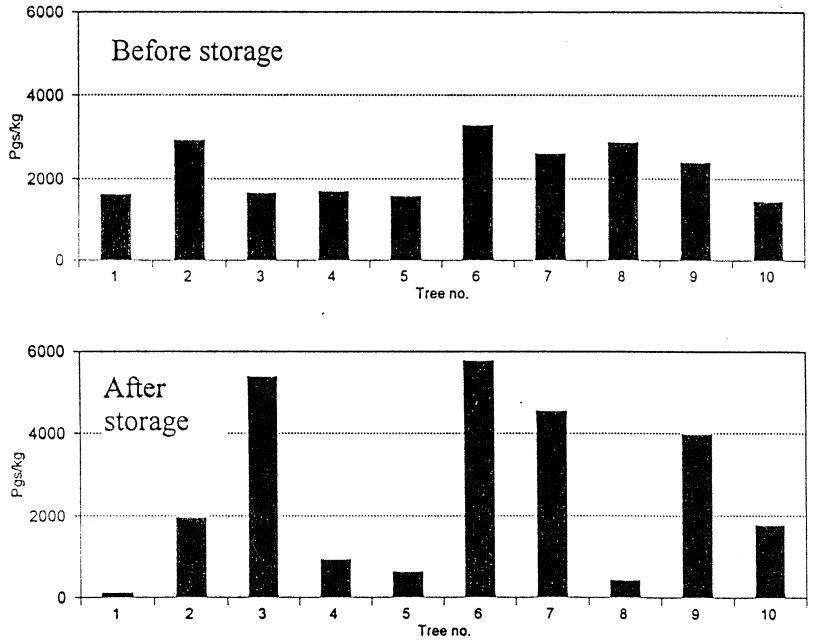


Figure 4. Number of pure germinable seeds (Pgs) in one kilogram expected from each mother tree before and after storage (4 months) at ambient conditions (20-25°C).

4. DISCUSSION

It became evident during the course of this study that there are differences in quality of seeds among individual trees. Variability exists already during collection time, and can be verified at various stages during handling (e.g. mechanical damage causing invasion by micro organism, rapid loss in seed moisture content). When such heterogeneity occurs in a seedlot, there are bound to be differences in deterioration rates among different seed categories. In an ideal situation, it would be expected that each tree would have a 10 % representation in a seedlot constituted from 10 individual mother trees and that during deterioration in store, seed deaths would follow a normal distribution until all seeds die. Whereas this might be true when considering a seed batch from one individual tree, results obtained herein show highly significant differences in the reduction of germinability after storage, e.g. trees No. 1 and 8. This observation is in agreement with that of Oriel et al. (1978), whose study on several cereal species found that not all individual seeds within a genetic group are destined to survive for the same period of time under a specified set of conditions. A sample of seed does not die at one time, but the individual seeds making up the sample lot die over a period of time. Within this period, individual groups of seeds, which are genetically related (siblings), each show characteristic mean times of death.

This study also provides sufficient evidence to confirm earlier findings by Moore (1955) that even before death, seeds become questionable or worthless for planting purposes especially under field conditions that are not highly favourable for germination and seedling development.

The large variation of seed weight and consequent loss of weight following storage among the trees further indicate differences in seed physiological state during collection and their storage potential. This to a large extent is determined by the micro environmental factors during seed maturation. The small variability of seed moisture contents (standard deviation 2.3) of seeds used in this study indicates uniformity in handling methods, i.e. depulping and drying.

The number of different individuals (genotypes) in a seedlot determining the degree of genetic variation is important for the flexibility of a population to withstand changing environmental conditions, Albrecht and Kioko (1993). Results obtained in this study strongly suggest periodic tests to monitor rate of reduction in genetic variation of a seedlot during storage. This is clearly illustrated by the rate of loss of germinability of seeds from tree Nos. 1, 4, 5 and 8. It consequently follows that longer periods of storage would result in complete loss of these individuals hence elimination of a large component of genetic variability from the lot.

5. CONCLUSION

The loss of seeds through death significantly reduces the number of individual trees represented in a seedlot. The differing rates of deterioration of certain categories of seeds would significantly contribute to the reduction of variability in terms of genetic base of the lot. Results obtained in this study clearly shows that a seedlot consists basically of seed categories of different quality.

Seed testing is arguably considered to be the final stage of a quality control operation; however this can only suffice if no changes which could drastically cause imbalance in the seedlot constitution occur after the test period. Besides, most test methodologies as recommended by International Seed Testing Association (1993), and other national institutions have yet to address the genetic quality of tree seeds. The responsibility of ensuring a wide genetic base therefore still remains with the seed collector; thus, Albrecht's (1991) assertion that seed collection is the most important activity in any tree planting programme. It follows that once seed is collected other processes which follow cannot improve on the aspect of quality, but can have a considerable negative effect.

In order to minimize reduction in genetic variability during all bulk seed collections, it is recommended that a seedlot should have equal representation from as many individual trees as possible. Furthermore, where seed is meant for large plantation programmes, individual tree seedlots should be processed, tested and stored separately, and only bulked in equal proportions during the distribution stage. Hence only sub-lots with acceptable standards should be included in the lot which means that periodic testing to monitor viability of each sub-lot before bulking must be done. Although setting standards could be an unrealistic approach in some situations, the suitable option would be to document the seed stock in terms of seedlings. This means that the bulking would be done considering the number of pure germinating seeds per tree rather than of seed weight. To avoid lengthy test periods, germination tests should be done using the optimum condition which for neem includes incubation at 25-28°C after the removal of the endocarps. At the same time all seedlots for which medium to long term storage is anticipated must be of a higher physiological quality and vigour.

More studies should be undertaken on the effect of aged seed on the phenotypic characteristics of individual trees, their adaptability under changing environmental conditions and their productivity under plantation forestry situations.

6. REFERENCES

Albrecht, J. 1991. Tree Selection and Seed Collection vs Genetic Diversity in Kenya Forestry Seed Centre: Proc. 1st National Tree Seed Workshop, Nairobi.

Albrecht, J. and Kioko, J. 1993. General Considerations; *In* Albrecht (ed) Seed Handbook of Kenya pp. 5-19. GTZ Forestry Seed Centre, Muguga, Kenya.

International Seed Testing Association. 1993. International Rules for Seed Testing, Seed Science and Technology; Vol. 21 Supplement, Rules 1993, ISTA, Zurich, Switzerland.

Kenya Forestry Seed Centre. 1991. General Rules of Seed Collection, Handling and Storage. Tree Seed Information Series.

Moore, F.D., and Roos, E.E. 1982. Determining differences in viability loss rates during seed storage. Seed Science and Technology, 10, 283-300.

Moore, R.P. 1955. Life alone is not enough - How alive are seeds? Seedmans Digest 6 (9): 12-13, 37.

Odera, J.A. 1990. Know and Prevent Entry of the Cypress Aphid *Cinara cupressii* in Kenya. Technical Note No. 7, KEFRI, Muguga, Kenya.

Oloo, W.O. 1992. Kenya Tree Seed Regulations; *In* Proceedings of the 1st International Symposium on Seed Procurement and Legal Regulations for Forest Reproductive Materials in Tropical and Sub-tropical Countries, Nairobi, Kenya.

Oriel, L., Justice, C. and Louis, N. Bass. 1978. Principles and Practice of Seed Storage: US Department of Agriculture. Agriculture Handbook No.506. Washington D.C.

Roberts, E.H. 1973. Predicting the Storage Life of Seeds. Seed Science and Technology 1, 499-514.

Wolf, H. 1992. The Importance of Genetic Variation for Tree Improvement. In Proceedings of the 1st International Symposium on Seed Procurement and Legal Regulations for Forest Reproductive Materials in Tropical and Sub-tropical Countries, Nairobi, Kenya.

Wolf, H. 1993. Neem - Collection, Drying and Storage - Preliminary Results: Kenya Forestry Seed Centre, Muguga.

WAYS AND RECOMMENDATIONS ON HOW TO TEST SEED QUALITY OF TROPICAL TREE SPECIES

(Status, progress and future aspects of alternative and quicker testing methods)

Karen Poulsen

Danida Forest Seed Centre
Krogerupvej 3a
3050 Humlebaek, Denmark

ABSTRACT

Today's use of quality tests for tree seeds is discussed and a short description of the methods is given. The importance of making quality tests through all steps of processing and an active use of the results in order to optimize processing and handling methods, is emphasized. The need for developing quality tests for tropical tree seed in addition to the standard germination tests is discussed. Methods in use for temperate tree species can be adapted to tropical species, especially the need of adapting the rapid tests is pressing. Future use of mechanized nursery production systems, expensive highly bred seed, and reduction of pesticidal application will all lead to an increasing need of seed quality tests measuring field performance.

Keywords: Seed centre, seed quality, seed testing, seed vigour, tree seed

1. INTRODUCTION

The basic quality test of seed is the routine germination test as defined, for example, in the ISTA-rules (1993) or as adopted at any seed centre. The principle of this test is to determine the germination percentage under optimal environmental conditions, i.e. the maximum potential of the seedlot is determined. This test is likely to remain the basis of seed quality testing, and it can probably not be replaced by any other test. However, it can be supplemented by additional tests.

The routine germination test measures the *final event*, i.e. whether a seed can germinate or not, whereas other quality tests may reflect deteriorative events preceeding the loss of germinative capacity, e.g. membrane damage, slow germination, susceptibility to environmental stress or morphological aberrations (Heydecker, 1972, p. 238; Black & Roberts, 1989; Venter, 1995). Seed quality testing leads to finer meshes in the safety net, in the sense that minor deteriorative events are disclosed leading to:

- Better estimates of field performance of seed (field performance may be very different from the performance estimated in the laboratory under optimal conditions),

- A potential use in optimizing seed processing and handling methods,

- Better estimate of storability; this facilitates selection of seed lots for medium or long term storage.

2. DEFINITION

In this text "seed quality" is used in a broad sense comprising genetic quality, technical quality (e.g. purity and moisture content) as well as the seed vigour concept. Seed vigour is defined according to Perry (1978):

> "Seed vigour is the sum total of those properties of the seed which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence. Seeds which perform well are termed high vigour seeds and those which perform poorly are called low vigour seeds."

Differences in vigour are manifested as:

> " 1. Biochemical processes and reactions during germination such as enzymatic reactions and respiratory activity,
>
> 2. Rate and uniformity of seed germination and seedling growth,
>
> 3. Rate and uniformity of seedling emergence and growth in the field,
>
> 4. Emergence ability of seeds under unfavourable environmental conditions.
>
> The effects of vigour level may persist to influence mature plant growth, crop uniformity and yield."

It is noticed that this definition is concerned with the seed as well as the initial seedling establishment, i.e. the initial phase in the nursery.

3. A STATUS OF QUALITY TESTS IN USE FOR TREE SEEDS

A number of quality tests are made as a routine at most tree seed testing stations. Apart from the standard germination test most laboratories make cutting tests during processing, which may give a good first impression of the seed lot. In addition to this, seed weight is determined as a routine; since a close relationship between seed weight and performance is common (Bonner, 1987, Msanga, 1992), seed weight may be a good indicator of seed quality. Finally, the speed of germination may be deducted from the standard germination test. Altogether, the germination percentage, speed of germination, seed weight and cutting test give a good picture of the seed quality, therefore these data should be regularly collected and compared. However, in some situations additional testing may be relevant.

The list of different seed quality test methods or vigour tests is long (Poulsen, 1993), but the list of *methods in use* is comparatively short. The most commonly used tests are:

- Tetrazolium test
- Indigo carmine test
- Hydrogen peroxide test
- X-ray test
- Conductivity test
- Embryo excision test
- Ageing

The topographical tetrazolium test is much used. The tetrazolium salt will stain live cells, and from a thorough evaluation of the staining pattern the site and extent of damage in the seed may be indicated (Perry, 1987; Moore, 1985). The result of the test is given in 1-2 days, and it is therefore practical in many situations.

The indigo carmine test is used much in the eastern European countries. It is also a staining test, the colour will penetrate only dead cells (Suszka, 1991).

The hydrogen peroxide test consists in soaking seed with exposed radicle tips in a hydrogen peroxide solution and germination is evaluated after 3 and 7 days. The biochemical basis of the test is probably a stimulation of respiration. The test has proved useful for temperate conifers (Leadem, 1984).

The X-ray test is particularly valuable in evaluating embryo development and in disclosing insect attack (Simak, 1991, Kamra, 1993). It is used as a routine for conifer seeds in Scandinavia.

The conductivity test is used for evaluating pine seed quality in the USA; it shows good correlation with nursery emergence (Bonner & Vozzo, 1986). The conductivity test is a leakage test measuring the conductivity of substances from the seed leached into the soak water. High leakage is thought to be a result of membrane deterioration and is correlated to poor performance. Instead of measuring conductivity, leakage tests may measure specific components of the soak water, e.g. sugars or potassium.

The embryo excision test is particularly suited for slowly germinating or dormant seed. Procedures are specified for a number of temperate species (Chirco & Waters, 1991).

It is probably presumptuous to say that ageing is in use as a quality test for tree seeds, however for a few tropical species the initial steps have been taken (see section 5 below).

Each of the tests have their scope and limitations. These aspects will, however, not be discussed in this paper. The tetrazolium test, embryo excision test and X-ray test are all adopted in the ISTA rules (ISTA, 1993). This means that standardized procedures are prescribed and that the amount of experience regarding these methods is considered sufficient to include them in the rules.

4. NEED OF QUALITY TESTS FOR TROPICAL TREE SEED AND RECOMMENDATIONS FOR THEIR APPLICATION

For the time being, most tree seed centres obtain the seed quality data necessary when performing the routine tests of germination capacity and speed, seed weight and cutting test. It is important to obtain these results, but it is equally important that results are used in an active manner. It is important for proper decision-making that tests are performed through all steps of seed procurement and that the results are integrated in the subsequent activities.

Collection: Sampling should be made for cutting test of the developing crop to decide on collection and estimate amounts to collect. Testing during ripening (e.g. moisture content, colour) helps to determine optimal maturity stage and time for collection.

After collection before transport: Moisture content testing in the field is important to determine need of desiccation and suitable storage container for transport.

Processing: During drying, continuous monitoring of moisture content is necessary to determine when desiccation is finished. During cleaning, the purity percentage should be tested to determine when the cleaning process should stop. During cleaning and possibly grading of seed lots, the different fractions should be cutting tested, among other things to avoid loss of too much good seed in the discarded fraction. Seed weight testing, comparing the different fractions, may also be relevant.

Processed seed lot: Routine testing should take place and results should be evaluated and used, i.e. causes of low or high quality should be deducted as far as possible and discussed in relation to the collection and processing procedures.

Storage: In the store, registration of germination capacity and moisture content should be made at regular intervals.

Later steps: Where seed is pretreated before it is sold, the seed should be tested in order to confirm the suitability of the pretreatment method.

Altogether, the conventional routine testing gives very good information when used actively. But operations of tropical tree seed centres could still be improved by taking testing some steps further and adapt additional tests. The seed quality tests dealt with in section 3 were developed and implemented mainly for temperate tree species. But all the methods can be modified and adapted to tropical tree seeds. This has probably already taken place to some extent in a number of countries. The intensity of this work will probably increase during the next decade, driven mainly by two forces:

- customers become more aware of the importance of seed quality and start demanding additional information,

- the rather young tree seed centres in many developing countries have become better established and have consolidated themselves technically and may therefore undertake development of quality test methods in order to optimize their operations.

In developing countries the second force will probably be the strongest.

When dealing with tree seed centre operations and seed supply for nurseries, the applied view on quality testing should be taken. In general the relevance of developing a quality test is dependent on the particular problems encountered for the species. Some tests are of a general nature, e.g. the conductivity test, but if insect attack is the problem, it is probably more relevant to develop the X-ray test, or if the seed has endogenous dormancy, efforts should probably go into adapting the tetrazolium test. The time consumption in modifying and implementing the method, the reliability of it and the cost of equipment should also be considered. Examples of situations where the adaptation of additional quality tests may be justified are discussed below.

Quick tests: The deeply dormant seed constitutes a major testing problem. Results of routine germination tests may not be available until months after initiation of the test. Slowly germinating seeds pose a similar problem. Quick tests are needed. For rapidly deteriorating recalcitrant seed a quick estimate of quality is particularly important, since the quality may have declined during the period of the germination test and the germination test result is outdated when it is obtained. Rapid tests may also be useful for various operational reasons even for non-dormant, orthodox seed, e.g. when seed is ordered before the germination test is completed, and a preliminary quality estimate therefore is needed, or when a quick decision regarding further collection must be taken, and an estimate of the quality of the already collected crop is required. In these cases development of the embryo excision test, hydrogen peroxide test, and the tetrazolium or indigo carmine tests is relevant.

The development of these rapid tests for tropical tree seed should therefore have high priority.

X-ray test: Insect damage is very common in many tropical arid areas, especially legume seed have many predators and considerable losses are experienced (Sary & Some, 1989). In such cases it may be relevant to develop the X-ray test in order to check seed lots for insect damage as a routine (Kuruni 1993). The test result can be used to decide on insecticidal treatment, and possibly to determine the cause of poor performance.

Test for field performance: Another important aspect is the prediction of field performance, e.g. by exposing seed to the stress factors it is likely to meet in the field, e.g. water stress, variable/low temperatures, stony cover. These stress factors may be prevalent when seed is directly sown, whereas in the nursery the stresses may be relieved. The response in terms of germination capacity and speed after exposure to stress is compared to the performance in the routine germination test. In temperate areas and possibly at high altitudes in the tropics, the limiting factor will often be the low temperature. Therefore the response to low temperatures is interesting. For many years the socalled cold test has been used for maize seed (Fiala, 1987). It consists basically in subjecting imbibed seeds to 10°C for 7 days and then transferring them for germination at 25°C and evaluating seedlings after 13 days. Water stress can be created in a simple way by germinating seed on filter paper continuously moistened by a solution of an inactive polymer, e.g. polyethyleneglycol at a specified water potential. Development of similar tests for tree seeds is not demanding in terms of equipment.

Test of pretreatment quality: An example of using a seed quality test to determine optimal pretreatment method is found in Jones & Gosling (1994). They determined the quality of pretreatment by exposing variously pretreated temperate conifer seeds to a range of temperatures and comparing germination results. The best pretreatment was

chosen as the one which resulted in a high germination capacity at all temperatures. For comparison of scarification methods for tropical physically dormant seed, germina-tion speed, in addition to germination capacity, is likely to be a good measure of pretreatment quality.

Ageing test: When medium term storage of seed, e.g. 10-15 years, is necessary, selection of the best quality seed lots for storage is important. It is relevant to subject seed to an ageing test, since this test imitates prolonged storage. Another example is the introduction of an alternative processing method, e.g. drying at a higher temperature. Any negative effect of the new drying method may be revealed by an ageing test. Finally, the ageing tests may be efficient in determining optimal stage of maturity for collection of seed; it has been used for this purpose in research.

5. SOME RECENT EXPERIENCES IN QUALITY TESTING OF TROPICAL TREE SEED

The work referred to below exemplifies ongoing work on development of quality tests for tropical tree seed.

Thomsen (1992) developed an ageing method for Caribbean pine (*Pinus caribaea*). Seed was hydrated to a moisture content of 32% and immersed in 60°C hot water for 1-10 minutes. In a later study she showed that temperature and moisture content were very critical, a 2°C deviation in temperature and a 4% deviation in moisture content caused dramatical changes (Thomsen, 1994). Furthermore the test was probably not effective in estimating seed quality since the three seed lots tested reacted similarly to the stress, even if they had different initial germination capacities. This makes the scope for further development of the method questionable.

Two ageing methods, i.e. controlled deterioration and hot water ageing, were tested on 21 seed lots of 15 hardcoated species of tropical arid zones at Danida Forest Seed Centre. For controlled deterioration, seed was hydrated to 15% moisture content, packed in sealed aluminium bags and exposed to 45°C for 24, 48, 72 and, in some cases, 120 hours. For accelerated hot water ageing, seed was imbibed for 18 hours at 30°C and soaked in 60°C hot water for 3, 5, 10, 20 and 30 minutes. Preliminary evaluation of germination test results shows a tendency of large seeded species being more tolerant to ageing. The controlled deterioration method held more promise than the hot water ageing method. It is also preferred because the ageing conditions in the hot water method are extreme, whereas exposure to 15°C at 15% moisture content during controlled deterioration may in fact be experienced in nature itself.

The tetrazolium test showed promise for dormant *Juniperus procera* seed from East Africa (Maina Were, 1993).

Kamra (1990, 1973) studied the X-ray method for tropical pines and teak seed.

Initial experience of ageing and tetrazolium testing of *Pinus elliottii* seed were gained in a study by Alvarez et al. (1990). Elam & Blanche (1990) also worked with ageing of, amongst other species, tropical pines.

Chen & Chen (1990) attempted to develop a seedling vigour test for prediction of field emergence of Chinese fir (*Cunninghamia lanceolata* (Lamb.)).

X-radiography gave a reliable estimate of the quality of *Peltophorum pterocarpum* seeds from Thailand (Chaichanasuwat et al., 1990).

Experience on tetrazolium testing (Prasad & Kandya, 1992, p. 237) and other quality tests was reported for a number of tree species used in India (Prasad & Kandya, 1992).

6. FUTURE DEVELOPMENTS

The need of quality tests increases as the nursery increases its demand of high quality seed; the latter is often correlated to the degree of mechanization in the nursery production system. The more mechanized the system, the higher is the seed quality demanded. Single-seed sowing into containers is common practice for many temperate conifers; this requires a germination capacity near 100%. Consequently, methods to sort away poor seed were implemented, and a series of quality tests using X-ray was developed and integrated in the cleaning process in order to determine the potential of submitting the seed to such quality improving methods (Sahlén & Henriksson, 1985).

For highly bred and therefore very expensive seed (typically horticultural and vegetable seed), the need of getting as many plants as possible out of the seed lot has led to mechanized single seed sowing in the field. In this case, it is important for the yield that every seed germinates. In order to achieve this seed is primed. The effect of priming is typically monitored by a quality test, which evaluates germination capacity at a range of temperatures, i.e. seed is exposed to a stress tolerance test. A similar situation could be expected for future highly bred tree seed.

In many countries there is a pressure to reduce the use of pesticides. One way of reducing pesticide application in the nursery is to sow high quality seed, which will not need pesticidal treatment before sowing and during plant establishment. In order to ensure good performance of seed, stress tolerance testing may be necessary.

Mechanized production systems, high-value seed, pretreatment methods, and reduction of pesticide application exemplify future trends which may lead to the need for further development of seed quality testing for tree seed.

7. REFERENCES

Alvarez, M., Kuhfuss, V., Romero, G. 1990. Methods for seed quality control for *Pinus elliottii var. elliottii*. In: Turnbull, J.W., Tropical Tree Seed Research. Proceedings of an international workshop held at the Forestry Training Centre, Gympie, Qld, Australia, 21-24 August 1989.

Black, M., Roberts, E. H. 1989. Seed quality. Seed Science and Technology, 17:175-185.

Bonner, F. T. 1987. Importance of seed size in germination and seedling growth. In: Kamra, S.K. & Ayling, R.D. (eds.), Proceedings of the international symposium of forest seed problems in Africa, Harare, Zimbabwe. 23/8-2/9 1987, p. 53-61.

Bonner, F.T., Vozzo, J. A. 1986. Evaluation of tree seed by electrical conductivity of theirleachate. Journal of Seed Technology, 10:142-171.

Chaichanasuwat, O., Wang, B.S.P., Wasuwanich, P. 1990. Evaluating seed quality of *Peltophorum pterocarpum* by X-radiography and germination. In: Turnbull, J.W., Tropical Tree Seed Research. Proceedings of an international workshop held at the Forestry Training Centre, Gympie, Qld, Australia, 21-24 August 1989.

Chen Yousheng, Chen Zhijian. 1990. Testing Chinese fir seeds by seedling vigour classification on vertical plates. In: Turnbull, J.W., Tropical Tree Seed Research. Proceedings of an international workshop held at the Forestry Training Centre, Gympie, Qld, Australia, 21-24 August 1989.

Chirco, E. M., Waters, E.C. 1991. The embryo excision test. In: Gordon, A.G., Gosling, P., Wang, B.S.P. (eds.), Tree and shrub seed handbook. International Seed Testing Association, Zürich, Switzerland.

Elam, W.W., Blanche, C.A. 1990. Accelerated ageing: Potential vigour test for multipurpose tree seeds. In: Turnbull, J.W., Tropical Tree Seed Research. Proceedings of an international workshop held at the Forestry Training Centre, Gympie, Qld, Australia, 21-24 August 1989.

Fiala, F. 1987. Cold test. In: International Seed Testing Association. Handbook of Vigour Test Methods. 2nd edition. Zürich, Switzerland.

Gordon, A.G., Gosling, P., Wang, B.S.P. 1991. Tree and shrub seed handbook. ISTA, Zürich, Switzerland.

Heydecker, W. 1972. Vigour. In: Roberts, E. H. (ed.) Viability of seeds. p. 209-252, Syracuse N.Y., Syracuse University Press.

ISTA. 1993. International Rules for Seed Testing, Rules 1993. Seed Science and Technology,21, supplement.

Jones, S.K., Gosling, P.G., 1994. "Target moisture content" prechill overcomes the dormancy of temperate conifer seeds. New Forests, 8:309-321.

Kamra, S.K. 1973. X-ray radiography of teak seed (*Tectona grandis* L.). Proc. IUFRO International Seed Symposium, Bergen, Norway. Vol. 1, Paper No. 9:1-13.

Kamra, S.K 1990. Studies on seed of some tropical pines by X-ray contrast method. International seminar on investigation of tropical forest seeds, Bogota, Colombia, 1988. Serie Documentation No. 18:101-108.

Kamra, S.K. 1993. Determination of quality of forest seeds by rapid tests. In: Les problèmes de semences forestières, notamment en Afrique. Proceedings of the IUFRO Symposium of the project group P.2.04.00 'seed problems'. Ouagadougou, Burkina Faso, 23-28 Nov, 1992.

Kuruni, D. 1993. Insect damage and its effect on germination of *Faidherbia albida*. In: Les problèmes de semences forestières, notamment en Afrique. Proceedings of the IUFRO Symposium of the project group P.2.04.00 'seed problems'. Ouagadougou, Burkina Faso, 23-28 Nov, 1992.

Leadem, C.L. 1984. Quick Tests for Tree Seed Viability. B.C., Ministry of Forests, Research Branch. Issued as Land Management Report No. 18, Canada.

Mayna Were, J. 1993. A comparative analysis of the methods used in assessment of viability in cold-stored *Juniperus procera* (Hoechst. ex Endl.) seeds. In: Proceedings of an international symposium 4-10th Oct., 1992, Nairobi, Kenya.

Moore, R.P. (ed.) 1985. Handbook on tetrazolium testing. ISTA, Zürich, Switzerland.

Msanga, H.P. 1992. Influence of seed size on germination and early development of Teak (*Tectona grandis* L.) seedlings. National Tree Seed Project, Tanzania, Research Note No.1.

Perry, D.A. 1978. Report of the vigour test committee 1974-77. Seed Science and Technology, 5:709-719.

Perry, D.A. 1987. Topographical tetrazolium test. In: International Seed Testing Association. Handbook of Vigour Test Methods. 2nd edition. Zürich, Switzerland.

Poulsen, Karen 1993., Seed Quality. Lecture Note C-14, Danida Forest Seed Centre, Denmark.

Prasad, R., Kandya, A.K. 1992. Handling of forestry seeds in India. Associated Publishing Company, New Delhi.

Sahlén, K., Henriksson, G. 1985. Frötestning i samband med konditionering. (Testing of seeds to be conditioned). Sveriges Skogsvårdsförbunds Tidsskrift 1.

Sary, H., Some, L.M. 1989. Attacks by spermatophageous insects on the seed of three Acacias - *A. albida, A. nilotica var. adansonii* and *A. senegal.* In: Turnbull, J.W., Tropical Tree Seed Research. Proceedings of an international workshop held at the Forestry Training Centre, Gympie, Qld, Australia, 21-24 August 1989.

Simak, M. 1991. Testing of forest tree and shrub seeds by X-radiography. In: Gordon, A.G., Gosling, P., Wang, B.S.P. (eds.), Tree and shrub seed handbook. International Seed Testing Association, Zürich, Switzerland.

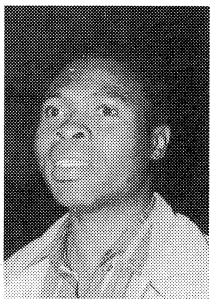
Suszka, B. 1991. The indigo carmine test. In: Gordon, A.G., Gosling, P., Wang, B.S.P. (eds.), Tree and shrub seed handbook. International Seed Testing Association, Zürich, Switzerland.

Thomsen, K. 1992. Hot water ageing as a vigour test method of pine seeds. MSc thesis, Royal Veterinary and Agricultural University, Copenhagen.

Thomsen, K. 1994. Hot water stress as a vigour test in *Pinus caribaea* seeds. Poster no. 126. ISTA/ISHS Symposium. Technological advances in variety and seed research. Wageningen, Holland, 31/5-3/6 1994.

Venter, H.A. van de 1995. Seed Vigour Testing Seminar. 7/6 1995, Copenhagen. International Seed Testing Association, Zürich, Switzerland.

PRETREATMENT WITH WATER AND SULPHURIC ACID OF DIFFERENT SEED SOURCES OF ACACIA NILOTICA



Cremildo Rungo

Ministerio de Agricultura e Pescas
Centro de Experimentaçao Florestal (CEF)
P.O. Box 1406 - Maputo - Mozambique

ABSTRACT

This paper presents results of an evaluation of the influence of seed source of *Acacia nilotica* on germination in the laboratory.

The germination trial was established in the laboratory of Serviço Nacional de Sementes using seed from Boane, Matutuine and Maniquinique. Seeds were submitted to the following treatments; soaking for 24 hours in water at ambient temperatures; 3, 5, 7, 9 and 15 minutes in boiling water; and for 3, 5, 7, 9 and 15 minutes in concentrated 98% H_2SO_4. Untreated seeds were used as a control.

Analysis of variance showed a significant interaction between seed source and treatment. The best treatment using water only was soaking for 24 hours for seed from Maniquinique with 42.5 % germination, where seeds from Boane and Matutuine were best treated with boiling water for 5 minutes, with 26.25% and 32.75% germination respectively. Among H_2SO_4 treatments, soaking for 15 minutes was the best one for all three seed sources with 49.24%, 68.75% and 75.50% germination for Boane, Maniquinique and Matutuine, respectively. As germination increased with increasing time of soaking in H_2SO_4, it is recommended to test even longer soaking time than 15 minutes in order to find optimal duration of treatment.

1. INTRODUCTION

In Mozambique the majority of people use the forest resources to obtain food, fuelwood and construction material. Among several forest species used as fuelwood in rural areas *Acacia nilotica* is mostly preferred because of the high calorific value of its wood.

In studies led by Bjerke (1991), it was found that among 13 species used as fuelwood in Maputo province (South Mozambique) *Acacia nilotica* is the most used fuelwood in the region with 17% of total fuelwood utilization.

In the last two years many government institutions and NGOs have been contacting Centro de Experimentaçao Florestal (CEF) to get the seeds from this species for propagation in areas were this species is largely used.

CEF is investigating the germination process of the seed from different provenances to be able to find out the best treatment for each seed source.

2. OBJECTIVE OF THE STUDY

Specifically, the study is aimed at establishing the best pre-treatment method of seed of *Acacia nilotica* to break its dormancy.

3. MATERIAL AND METHOD

The seed was collected by CEF in Matutuine, Boane and Maniquinique in 1993.

The germination test was established in the laboratory of Servico Nacional de Sementes.

The samples for the test were randomly prepared from six primary samples collected on six different places of the same seedlot. Then the seed was mixed to make a composed sample (ISTA, 1985). From the composed sample 400 seeds were taken per provenance for the test.

The seed was submitted to the following treatments: soaking for 24 hours in water at room temperature; in boiling water for 3, 5, 7, 9 and 15 minutes and in 98% sulphuric acid for the same periods. Untreated seed was used as control.

After immersion in water and sulphuric acid, seed was washed in running water for five minutes to remove all traces of acid (Willan, 1985).

The test was installed in a germination cabinet at 25°C, 98% humidity and 12 hours of light. The counting time started from day 7 up to day 23.

The results of germination were analyzed using factorial design with 3 provenances, 6 treatments and 4 replications.

For the two cases (water and sulphuric acid) the analysis was done according to Cochran and Cox, 1957.

4. RESULTS AND DISCUSSION

4.1 Seed treated in water

The results of the seed treated in water are shown in table 1.

Table 1. Mean germination percentages of three provenances for different pretreatment periods in water

Immersion period in boiling water (minutes)	Provenances		
	Boane %	Matutuine %	Maniquinique %
0 (control)	3.00 g	3.75 g	2.75 g
3	19.50 cdef	23.25 cd	19.75 cdef
5	26.25 bcd	32.75 b	27.75 bc
7	18.25 def	19.75 cdef	20.75 cdef
9	13.50 f	14.00 f	14.25 ef
15	0.00 g	0.00 g	0.00 g
24 hours *	20.75 cdef	23.00 cde	42.50 a
General mean			16.45
F-value			28.42**
Cv (%)			8.00
Tukey			8.75

Notes:
* in water at room temperature
** Significant at 1% probability
F- is the value of F obtained from analysis of variance
Cv (%) is the experimental coefficient of variation
Tukey is the value obtained by Tukey test

The average followed by the same letter in the same column and line does not show significant differences by Tukey test at 1% probability.

The analysis of variance showed significant statistical differences in interaction between the seed provenance and treatments. The coefficient of variation observed is low, which means that the experiment was conducted properly (Gomes 1978).

The statistic differences observed showed that there are differences in seed coat hardiness of the different provenances.

It seems that pretreatment improves seed germination (refer table 1 and figure 1), this might be due to an improved water permeability through the seed coat.

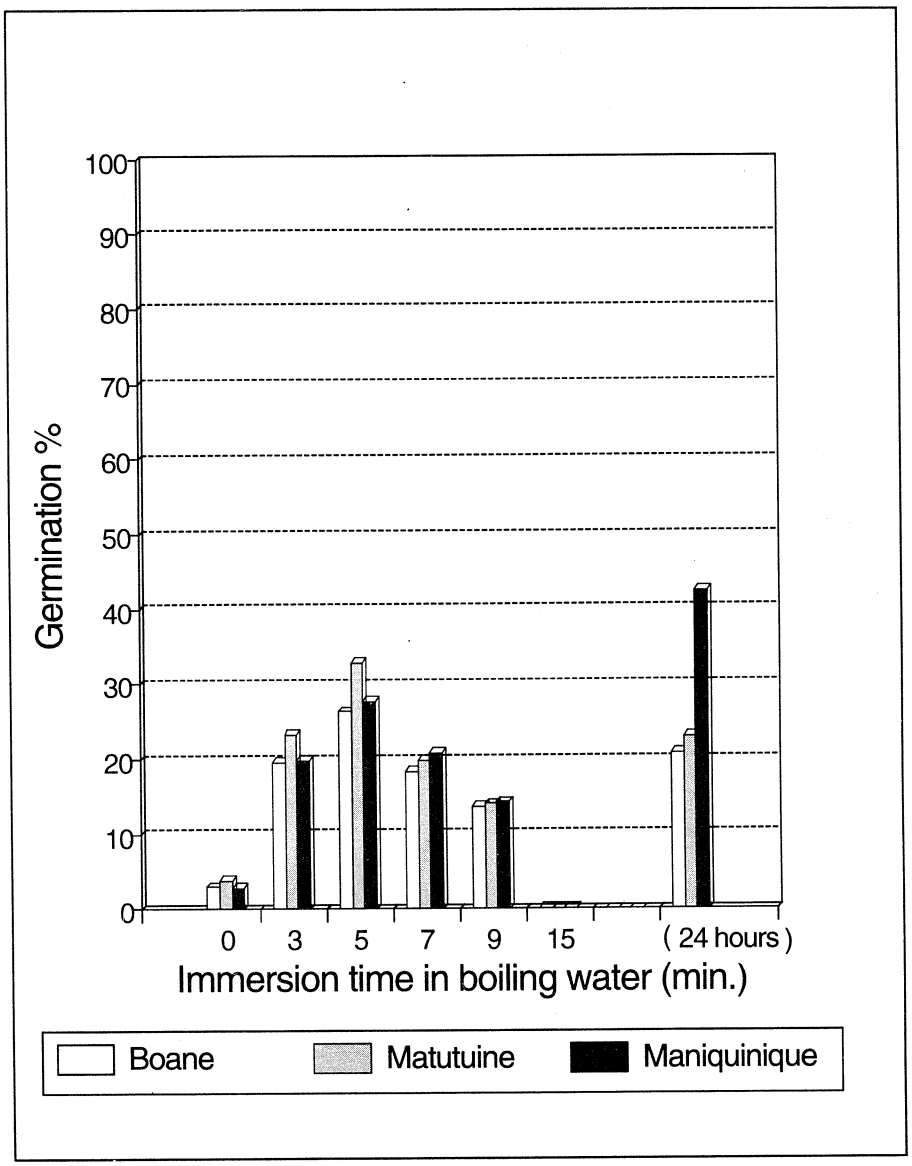


Figure 1. Total germination percentage after 23 days for different periods of water treatment.

In the 15-minute immersion treatment in boiling water no germination was observed; it was also observed that there was a decrease in germination of seed treated with boiling water for 7 and 9 minutes. This might be due to the long time the seed was exposed to high temperature causing its death.

The highest germination was obtained by seed collected in Maniquinique, 42.50% for seed treated for 24 hours. For seed obtained in Matutuine and Boane the best treatment was the 5 minutes immersion in boiling water which gave 32.75% and 26.25% germination, respectively.

These differences may be due to geographical variation since environmental conditions during plant growth can define crop period and maturation grade (Willan, 1985).

The Matutuine provenance seed showed higher percentage germination except when soaked in water at room temperature for 24 hours.

It is quite evident that germination capability increases for all provenances with increasing immersion periods until 5 minutes (see figure 1).

The results obtained for seed treated with boiling water during 3 and 5 minutes are quite superior (for all provenances) from those found by Tietema et al. (1992), where the maximum germination percentage obtained was 9% for seed treated with boiling water for 3 minutes and 4% for seed treated for 5 minutes.

The differences in results between this study and the one reported by Tietema et al. (1992) might be due to differences in seed source, crop period, and storage time (Kemp cited by Willan, 1985).

4.2 Seed treated by 98% concentrated sulphuric acid

The values observed in seed germination of the seed treated with 98% concentrated sulphuric acid are shown in table 2.

The analysis of variance found significant statistical differences in the interaction between treatment and provenance. The observed variation coefficient is low, showing good precision in the experience (Gomes, 1978).

According to table 2 and figure 2 it is evident that the sulphuric acid treatment was also effective in increasing germination of seed of *Acacia nilotica* in all provenances. Germination also rose with the immersion period.

This can be explained by the fact the the seed coat of *Acacia nilotica* is quite hard and requires more immersion time in acid in order to destroy the seed tegument (Willan, 1985).

Table 2. Mean germination percentages of three provenances for different pretreatment periods with sulphuric acid.

Immersion period in 98% H_2SO_4 (minutes)	Provenances		
	Boane %	Matutuine %	Maniquinique %
0 (control)	3.00 f	3.75 f	2.75 f
3	20.00 e	23.25 e	21.00 e
5	21.25 e	42.50 cd	26.00 e
7	24.25 e	48.75 bc	31.50 de
9	29.50 de	62.25 ab	34.00 cde
15	49.25 bc	75.50 a	68.75 a
General mean			32.63
F-value			24.36**
Cv (%)			5.24
Tukey			15.78

Notes: ** Significant at the 1% level
F- is the value of F obtained from analysis of variance
Cv (%) is the experimental coefficient of variation
Tukey is the value obtained by Tukey test

The average followed by the same letter in the same column and line does not show significant differences by Tukey test at 1% probability.

The best sulphuric acid treatment was the 15 minutes' seed immersion where the germination percentage was as high as the germination capacity (Picture IIIb, IIId, and IIIf in appendix?), which was 75.50%, 68.75% and 49.25%, respectively, for seed from Matutuine, Maniquinique and Boane. The lowest germination was observed in the seed not treated (control). These results reveal that the existing variation in hardness of seed coat can be due to geographic differences (Gunn, 1989).

The results obtained are superior to those found by Tietema et al. (1992), in which he studied *Acacia nilotica* seed germination treated with concentrated sulphuric acid during 30 minutes obtaining 2% of germination and 66% for the seed immersed in sulphuric acid for 120 minutes.

When the water and sulphuric acid treatment are compared, it seems that the latter is more effective in increasing germination. For instance for the best water treatment (5 minutes) 26.25%, 21.75% and 32.75% germination were obtained for seed from Boane, Maniquinique and Matutuine respectively, while the best sulphuric acid treatment (15 minutes) produced the following values: 49.25%, 68.75% and 75.50% for Boane, Maniquinique and Matutuine seed respectively.

Therefore, the results obtained in this study agree with those found by Goda (1987), in which the seed treated with concentrated sulphuric acid showed better results than the seed treated in boiling water.

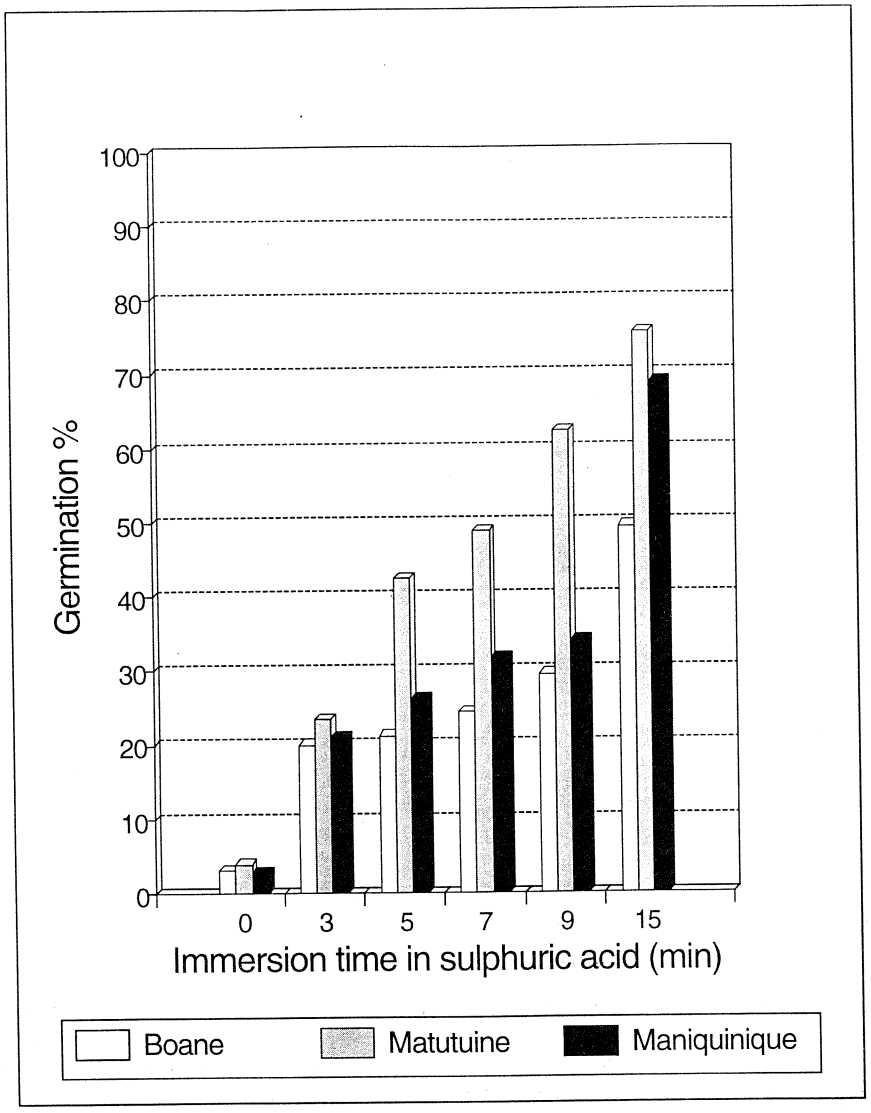


Figure 2. Total germination percentage after 23 days. The seed was treated with sulphuric acid.

5. CONCLUSIONS

The best treatment for the seed of *Acacia nilotica* is immersion in water for 24 hours at ambient temperature for seed from Maniquinique (42.50%) and immersion in boiling water for 5 minutes for Boane and Matutuine with 26.25% and 32.75% germination, respectively.

As germination increased with increasing time of soaking in H_2SO_4, it is recommended to test even longer soaking time than 15 minutes in order to find optimal duration of treatment.

6. REFERENCES

Bjerke, J.O. 1991. Fuelwood consumption and transport in Maputo, Mozambique, 76 pp.

Cochran, William G. and Cox, Gertrude M. 1957. Experimental Designs. John Wiley & Sons. New York and London.

Goda, S.E. 1987. Germination of *Acacia nilotica* seeds. University of Khartoum. 7 pp.

Gomes, F.P. 1978. Curso de Estatistica experimental 8. ediçao. Escola Superior de Agricultura "Luis de Queiros". Piracicaba, Brasil 430 pp.

Gunn, B.V. 1989. Germination pretreatment for selected Acacia species from the Pilbara region of Western Australia. In: Tropical tree seed research. IUFRO- ACIAR 46-50 pp.

ISTA, 1985. International Rules for Seed Testing 1985. Seed Science and Technology volume 13, 2. Zurich, 430 pp.

Tietema, T., Merikesda, E. & Schorton, J. 1992. Seed Germination of Indigenous Trees inBotswana. Forest Association of Botswana, Gaberone. 106 pp.

Willan, R.L. 1985. Guide to Forest Seed Handling. FAO Forestry paper no. 20/2 Rome Italy. 379 pp.