FORESTRY RESEARCH IN ARID AND SEMI – ARID LANDS OF KENYA

SEMINAR PROCEEDINGS

Embu, February 1988,

Kenya Forestry Research Institute in Co-operation with EMI ASAL Programme.

FORESTRY RESEARCH IN THE ARID AND SEMI-ARID LANDS OF KENYA

The seminar held in Embu from 23rd-25th February, 1988

was organised by

KENYA FOREST RESEARCH INSTITUTE, DRYLAND SILVICULTURE DIVISION

AND

EMBU, MERU, ISIOLO ASAL PROGRAMME, FORESTRY RESEARCH

and sponsored by the

OVERSEAS DEVELOPMENT ADMINISTRATION, U.K. (ODA)

Compiled and edited by

P.B. MILIMO and M. STEWART

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FOREWORD

The Dryland Silviculture Division of Kenya Forestry Research Institute (KEFRI) was constituted to help identify priority problems requiring forestry research and to co-ordinate collaboration with NGOs and donor agencies working in similar areas. Seminars are one of the primary avenues through which KEFRI can effectively realize this mandate.

The state of the art on how to grow trees in high potential areas is generally well understood. In the Arid and Semi-Arid Lands (ASAL) the situation is different because the technologies for growing trees are much less understood. This situation has made it difficult to provide practical afforestation protocols for given areas. In addition, there are other considerations to be made when planting trees in the ASAL of Kenya.

These include: social issues (land use and tenure, and community organisation) and economic constraints (lack of monetiz
ed economy, poor transport and marketing systems and poor understanding of long-term cost benefit appraisal).

In order for the Dryland Silviculture Division specifically and KEFRI in general to play a leading role in co-ordinating the many organisations involved in dryland forestry initiatives, a seminar was organised at Embu from 23rd to 25th February 1988. This seminar was able to define (in preparation for the workshop on setting national forestry research priorities) medium and long-term research priorities, objectives and strategies for research and development in the ASAL. This was a necessary step that has conveniently complimented the activities of the bigger workshop.

The seminar was sponsored by EMI as part of its Forestry Research Programme. KEFRI wishes to thank the Forest Department, EMI (ODA), NORAD, RTDS, GTZ, FINNIDA, DANIDA, JICA, FAO and other institutions for their assistance in organising the seminar.

The 28 participants came from GOK and the project named above. Our thanks to those who presented a total of 14 papers, which when published will form a valuable new reference source for work in the ASAL of Kenya. We would also like to thank Mr. Tom Barrett for being instrumental in procuring funds to support the seminar.

J.A. ODERA
DIRECTOR, KEFRI

ASAL FORESTRY RESEARCH SEMINAR

OPENING ADDRESS BY B.G. WAMUGUNDA
CONSERVATOR OF FORESTS R.A.E.S.NAIROBI

Ladies and Gentlemen,

In many areas of the world including both developing and developed nations, arid and semi-arid lands are being effectively destroyed at a rate that appears to be accelerating. The process of conversion of productive land into desert-like wasteland is observable in most continents. There is widespread mismanagement of domestic and wild animals resulting in over-stocking, overgrazing, destruction of vegetation, loss of soil and interference with the hydrological cycle. The damage done may be virtually permanent in its effects in some parts. Other parts are redeemable.

The developing world suffers more because of the relatively greater dependence on the land for human existence besides grazing, cultivation, provision of wood products such as charcoal, fuelwood and poles. A few owners of domestic animals, charcoal burners and fuelwood cutters may receive high short-term profits by the mining of plant and soil resources that could otherwise yield long-term benefits to the many. This poses the greatest conservation dilemma to many governments and therefore knowledge of how to manage such lands is constantly being sought by government agencies in the countries involved. The research for this knowledge, its effective application and effective control over land-use is of extreme importance particularly to developing economies.

Kenya faces serious land-use associated problems, namely:

1. Lack of agricultural self-sufficiency.
2. Lack of enough productive farm-lands to encourage resettlement and expansion of the agricultural productive base.
3. Over population of the urban centres with the attendant over subscription on infrastructure facilities.
4. Increased unemployment.
5. Lack of adequate income for farmers on marginal lands.
6. Loss of tax revenue because of the above.
7. Increased outflow of land currency for food importation and generally negative pressures on Kenya's international balance of payments position.

The country must not only restore productivity on the arid

and semi-arid lands lost through centuries of mis-use but must also seek ways for increasing productivity on these approximately 173,000 square kilometres or 82% of the nation's land area through:-

1. Establishing criteria for determining agricultural production and development potential.
2. Identifying possible constraints on agricultural intensification.
3. Recommending the most appropriate types of agricultural intensification for individual areas in a manner consistent with social and ecological needs of the areas.

Work along these lines has started in the districts-Machakos, Siaya, South Nyanza, Taita Taveta, Baringo, Turkana, Kitui, Isiolo, Meru and here in Embu. Hitherto considered god-forsaken lands are seeing rays of hope with restoration and enhancement of productivity of previously depleted areas.

However, it is not yet time to be complacent. The task ahead is heavy and formidable, particularly in planting and reseeding water catchments, denuded lands and other areas gripped with chronic incidences of wood shortages.

The Kenya Forestry Research Institute (KEFRI) is to be congratulated for casting eyes on the Arid and semi-Arid lands of Kenya. This is an extremely bold step which even eagles and angels like ICRAF, BEIJER Institute, KARI and Kenyan Forestry Department feared to tread. What of the hurdles of climatic, edaphic, vegetation, fires, drought, and myriads of grazing animals that characterise these lands?

The nation is looking up to you for solutions to the problems of the A.S.A.L. However the past mistakes of attempting to impose new patterns of behaviour upon tradition-bound people (the majority of whom occupy these lands), must be avoided by all of us. Ecologists have in particular been guilty of throwing such problems under the carpet as belonging to anthropology, sociology and politics and not of their (ecologists) concern.

Research without concern for practical application is like a half-baked loaf of bread. We must be concerned with all the economic, sociological, cultural, anthropological and ecological aspects.

With these few words I have pleasure to declare this A.S.A.L. Forestry Research Seminar, open.

B.G. WAMUGUNDA

SEMINAR OBJECTIVES

ASAL FORESTRY RESEARCH

(FEBRUARY 23 - 25TH 1988, AT EMBU)

Objectives

1. To familiarize and introduce participants to the various ASAL forestry research projects and personnel in Kenya.

2. To develop systematic communications between ASAL forestry projects and KEFRI.

3. To define medium and long term research priorities, objectives and strategies for ASAL forestry research and development.

1. To produce a summary report of ASAL research findings to date for practicing foresters, researchers and other interested parties.

PROGRANMME

Day 1 - Tuesday February 23 1988

Session Chairman: Mr. P. Milimo

Rapporteur : Mr. G. Rode

8.00 - Introduction of Participants and seminar objectives (Milimo)

8.30 - Opening CCF (Wamugunda)

9.15 - Director KEFRI (Dr. Odera)

10.00 - COFFEE BREAK

Session Chairman: Mr. G. Rode

Rapporteur : Mr. P. Milimo

10.30 - ACIAR Project 8320

11.00 - Forestry Research in Turkana (NORAD)

11.30 - Embu, Meru, Isiolo Forestry Project, Forestry Research

12.00 - Forestry Seed Centre Muguga

12.30 - Discussion / Questions

13.00 - LUNCH

Session Chairman: Dr. R. Zimmerman

Rapporteur : Mr. G. Muturi

14.00 - Seeds and Research

14.30 - FINNIDA (Bora)

15.00 - JICA (Kitui)

15.30 - COFFEE BEEAK

Session Chairman: Mr. M. Stewart

Rapporteur : Mr. L. Murugi

16.00 - Baringo ASAL Forestry Project

16.30 - Fuelwood - Agroforestry FAO

17.00 - End of formal sessions

N.B. Rapporteurs and Chairmen are to hand edited reports to P.D. Milimo no later than 14.00 for morning sessions and 19:00 for evening sessions. These will then be typed immediately.

Day 2 Wednesday February 24th 1988

Session Chairman: Mr. G. Muturi
Rapporteur : Mr. J.E. Lugadiru

8.30 - Continue presentation of positional papers

8.30. - Danida (South Nyanza)

9.00 - Ramogi

9.30 - Taita-Taveta - DANIDA

10.00 - COFFEE BREAK

Session Chairman: Mr. P. Milimo
Rapporteur : Mr. M. Stewart

10.30 - Introduction of discussion groups

11.00 - Coordination of research and dissemination of findings

11.30 - Formulation of short term and long term ASAL forestry research objective.

12.00 - Formulation of short term and long term ASAL forestry research objective.

12.30 - Formulation of short term and long term ASAL forestry research objective.

13.00 LUNCH

14.00 - Group discussions

14.30 - " "

15.00 - Group discussions

15.30 - COFFEE BREAK

Session Chairman: Mr. C.K. Kiriinya
Rapporteur : Mr. Kees Vogt (NORAD)

16.00 - Representation of recommendation

16:30 - " " "

17.00 - " " "

17.30 - " " "

18.00 - End of formal sessions.

20.00 Dinner hosted by EMI Forestry (Tom Barrett)

Day 3 Thursday February 25, 1988

Session Chairman: Hugh Evans (EMI)
Rapporteur : Klaus Wetterberg

9.00 - Seminar reporting

9.30 - Draft of recommendations

10.00 - COFFEE BREAK

10.30 - Draft teams recommendations

11.00 - " " "

11.30 - " " "

12.00 - Presentation by draft team leaders

12.30 - LUNCH

11.00 - Departure or field trip to EMI trial site (optional)

WAYS TO IMPROVE SEED SUPPLY IN KENYA

by

Gert Rode
Kenya Forestry Seed Centre, Muguga

ABSTRACT

There is an increasing demand in Kenya for trees and tree products and, consequently, for high quality seed of defined origin. The Kenya Forestry Seed Centre, Muguga co-ordinates procurement, storage and distribution of seed from most Kenyan ecological zones. The organisation and methods used in these processes are described and users of the seed stores facilities are requested to make use of available information to assist optimal operation of the Seed centre.

1. INTRODUCTION

The growth rate of Kenya's population results in an expansion of agricultural acreage and an exponentially increasing need for timber, fuel, fodder and tree planting for erosion control, water catchment protection and other environmental benefits. A basic requirement to meet these demands for the foreseeable future is large scale production of vigorous, locally adapted plants derived from seeds of high quality and defined provenance.

It is the objective of the Kenya Seed Centre to procure forest seeds in sufficient quantity and quality from seed orchards, certified seed stands and selected trees.

Seeds are expensive and delicate goods which have to be treated carefully. Every person involved in seed handling is, therefore, requested to make the best use of a seedlot. In turn, the Seed Centre must optimise organisation of seed collection and extraction, develop and recommend suitable pretreatment and storage methods and minimise the period of delivery to the consignee.

2. ORGANISATION

The Kenya Forestry Seed Centre at Muguga is a sub-programme within the Silviculture and Tree Improvement Programme of the Kenya Forestry Research Institute (KEFRI). The Seed Centre handles seed collection, extraction, cleaning, testing, storage and distribution. Seed collection is largely decentralised to six seed collection centres at:

- Gede
- Kakamega
- Kibwezi
- Londiani
- Nyeri
- Kitale

Thus, most ecological zones of the country are covered. Special emphasis has been put on semi-arid areas and on indigenous species. The collection centres forward the seeds after extraction to headquarters at Muguga for further processing. In addition to the work in the collection centres, the headquarters also conducts seed collection within the vicinity of Muguga.

3. SEED COLLECTION

3.1. Seed sources

Seeds of the two most important plantations species Cupressus lusitanica and Pinus patula are collected mainly in clonal seed orchards, where we have a broader genetic base than in plantations or - as is also the case with Eucalyptus species- from certified seed stands with a size of at least 5 Ha and with superior phenotypical performance. Indigenous plantation species from high potential areas like Juniperus procera, Maesopsis eminii, Prunus africanum, and Vitex keniensis are obtained from selected seed stands in various districts. Seeds of tree species in natural stands both from the Highlands and semi-arid areas are increasingly collected from selected, non-related individual trees within a defined area. This is also applicable for some important agroforestry species. Seeds, which are not locally available but are in high demand, are imported and used for the establishment of seed stands in order to ensure future local supply. In some cases "general collection" of a particular species is accepted due to a very high demand, but the Seed Centre does not accept any seedlots without clear documentation on origin (see seed collection data form).

3.2. Method of seed collection

After checking maturity by colour change of fruits or cones and the examination of seed contents by cutting test on the spot, seeds are collected using different methods.

- collection from the standing trees by climbers
- collection from the ground by cutting of seed branches
- collection from the felled tree
- collection from the ground

3.3. Seed handling after collection

The period after collection can be very important for seeds since rapid transportation to a seed processing place may not be practical. Seeds may lose viability and identity, especially when transport problems occur. All collected seedlots have to be provided immediately with a label indicating the details of collection. It is intended to transport all seeds or fruits in gunny bags (hessian sacks) to the processing place to avoid deterioration through moulds and overheating (except smallest seeds like Eucalyptus) and to stop the use of polythene bags for transportation.

4. SEED EXTRACTION

Seeds are dried and extracted by using covered sun-drying beds or in the case of hot weather under a shelter. The purpose is to ensure a slow and gradual decrease in moisture content of fruits and seeds. The cones, fruits or pods are placed on top of a wire mesh to promote free air circulation which is of great importance.

Fleshy fruits are usually depulped by soaking in water with gentle abrasion, if necessary. Fruits of Vitex keniensis are dried first and then pulp is removed by a concrete mixer; others by hand maceration. Another method of depulping or extracting seeds is by mortar and pestle or in future by a coffee depulper. A new drying unit will dry the fruits with a combination of air and artificial heat which will be especially suited to indigenous species from highland forests.

At the moment, separation, threshing, dewinging and cleaning of seeds is done manually using various types of sieves.

5. OUTLOOK AND PROBLEMS

Although the Seed Centre embarked on collection of indigenous tree species early, demand is still increasing. The Seed Centre has in stock almost all the species demanded. However, supply of sufficient quantities of these species is still a problem. There is need to include another 20 - 30 species in the programme of work which will raise the number of species handled to 220. For some species, information on phenology, germination and storage methods is unavailable. To ease the situation, the Seed Centre requests practicing foresters to make use of published test results when compiling their seed indents, in order to indent for correct quantities.

SEED STORAGE AND TESTING AT THE KENYA FORESTRY SEED CENTRE

by

E. MURUGI KARIUKI
KENYA FORESTRY SEED CENTRE,
KENYA FOREST RESEARCH INSTITUTE,
KIKUYU.

ABSTRACT

The Kenya Forestry Seed Centre (KFSC) is a sub-programme within the Kenya Forestry Research Institute (KEFRI). KEFRI is responsible for collection, storage, testing and distribution of forest seeds in Kenya.

Factors affecting seed viability and storage are discussed in the light of increasing demand for seeds of diverse species for use in both conventional and unconventional planting programmes.

The need for testing and the methods used in purity analysis, weight determination, germination percentages and viability testing are described.

INTRODUCTION

The Kenya Forestry Seed Centre (KFSC) is a sub-programme within the Kenya Forestry Research Institute (KEFRI). It is responsible for research work on all aspects related to seeds, from their collection to storage and dispatch.

The facilities at the KFSC are being enlarged and modernized with the aid of the German Government (GTZ). The main objective of the KFSC is to improve seed quality and supply. These improvements are aimed at satisfying the increasing demand for tree seeds in Kenya. The increased awareness and interest in conventional afforestation programmes in Kenya today requires that seed of many different species be available.

Greater interest and emphasis is now being placed on indigenous trees and shrubs, about which little information is available. The KFSC has the mandate to carry out investigations on conditions and facilities required for maintaining high seed quality in these species.

Seed storage is an integral part of the process of seed procurement. The need for storing seeds is to avail a viable supply whenever it is required Stein et al (1974). Storage period will vary (Willan 1985) depending on seed longevity in a particular species and on storage conditions.

In order to supply seeds of known quality to the users, monitoring and regulation of seed conditions from collection

through handling to storage is a prerequisite. This involves seed testing. To assess the value of a seedlot, both physical and biological characteristics must be measured (Bonner 1974). Tests carried out at KFSC include: purity analysis, weight determination, germination, occasional indirect testing of viability (Tetrazolium salt test) and moisture content determination.

STORAGE

Storage involves maintaining the viability of a seedlot from collection time to the time when the lot is required for sowing. longevity of seeds in storage is affected by their storage condition. Even under ideal conditions, seed will soon lose viability if it is defective from the start (Willan 1985). Therefore, factors to be considered before storage are:

(1) Seed maturity: Fully ripened seeds retain viability longer than immature seeds.

(2) Parental and annual effects: In seed harvest, quantity and quality often go together. When there is a bumper crop, the seed quality is also high and vis-a-vis.

(3) Freedom from mechanical damage: Seeds damaged mechanically during extraction, cleaning, dewinging etc, may rapidly, lose viability.

(4) Freedom from physiological deterioration: Poor handling in the forest, during transit or processing cause physiological deterioration of seeds even when mechanical damage and fungal attack is absent.

(5) Freedom from fungi and insects: Avoid collection of crops showing a high incidence of fungal or insect attack and carry out all operations of collection, transport, processing etc. as quickly as possible to ensure seed is not damaged before it goes into storage.

(6) Initial viability: Seedlots with high initial viability and germinative capacity have a higher longevity in storage than those with low initial viability.

It is generally agreed that storage conditions and longevity of seeds vary from species to species. (William 1985; Stein et al,1974); and Harrington 1972. Storage periods are generally:

(1) Up to one year. When both seed production and afforestation are regular annual events.

(2) 1-5 years or more. When a species bears an abundant seed crop at intervals of several years and enough seed must be collected in a good year to cover annual afforestation needs in intermediate years of poor seed production.

(3) Long-term storage. For purposes of conserving genetic resources and also for research work.

The KFSC is in a position to store seeds at room temperature (+24 C - +28 C), cool room (+3 C) and freezing (- 18 C), due to modern and improved storage conditions. This facilitates investigation of different storage methods appropriate for the increase in species diversity required. Most species apparently store well at +3 C and are in storage for approximately 0 to 5 years only. It has become clear from storage of these seeds, that different species require different storage conditions and durations irrespective of the processing.

Some species require to be sown when fresh due to rapid loss of viability. These include; Podocarpus milanjianus, Rendle, Vitex keniensis Turill., Azadirachta indica (A juss), Olea spp, etc. These species require further investigation. Other groups of species can be stored for 3 to 15 years; and for more than 15 years, for example, the Acacia spp.

Different methods of storage are suitable depending on the availability of equipment. Where equipment is available, the most important factors to be considered for seed storage are moisture content and temperature. Some seeds are killed by excessive drying.Moisture content of these species should be above 15% and temperatures above OC. Most of these seeds cannot be stored for long durations and require aeration.

Another group of seeds are those that can be dried between 5% to 10% moisture content and are stored for long durations in sealed containers under low temperature (freezing).

The KFSC is in the process of categorising species into their appropriate storage conditions.

SEED TESTING

Seed tests are important; firstly, after extraction and cleaning of seeds in order to store seeds of known high quality and viability. Secondly, before sowing it is necessary to know the viability of seeds in order that correct quantities are issued and sown in a manner suitable for production of the desired number of seedlings.

At KFSC, all incoming seeds are tested before storage or before dispatch. Tests include Purity percent, seed weight, moisture content and germination percentage.

Purity Analysis

Tree seed samples often contain impurities, for example, detached seed structures, leaf particles and other objects. Purity analysis is conducted in order to determine the composition by

weight of the sample being tested, William (1985). Two samples are divided into eight replicates each. The replicates are weighed separately. Seeds of some species cannot be separated from their impurities, for example, some Eucalyptus spp.

Weight Determination

Weight is determined by use of the pure seed component separated in the purity analysis. The weight of 10 replicates of 100 seeds each is determined from which the standard deviation, coefficient of variation and mean of the sample may be calculated.

Moisture content determination

Moisture content is determined by drying seeds in an oven for 17 hours (Slow method) at 103 C. The weight loss of the original material is used as a measure of moisture content. Moisture content can also be determined by use of the fast method. Whereby, the seeds are heated for 2.5 hours at 130C in an electric moisture meter, whose accuracy is similar to that of the slow method.

Germination Tests

Potential germination of seeds is the most important factor in the measure of quality (Bonner 1974). A germination test is used as an estimate of the number of seeds which are germinated at a given time. At the KFSC, seeds are germinated in the laboratory, nursery and glasshouse. In the laboratory the seeds are either germinated in petri-dishes, lunch packs or germination boxes on the benches (room temperature); or under controlled temperature in a rodewald apparatus, germination tank or germination cabinets. The germination media used in the nursery and glasshouse is sand. These different conditions give varying results, which aid in approximation of percentages achieved by seed sown in nurseries. Results from the laboratory are usually higher compared to these from the nursery and glasshouse because conditions are more controlled in the laboratory.

A sample of 4 replicates of 100 seeds each is used for germination tests. In the case of small seeds mixed with impurities 4 replicates of equal weight are used.

Some species have germination problems. Hence the KFSC conducts investigations on these species. Recommendations are listed whenever pretreatment is successful. Preliminary results have been published (Rode 1986; Kariuki 1987; M. Kariuki and G.Rode 1988)

CONCLUSION

High quality seeds are prerequisite for good afforestation. It is therefore, necessary to handle seeds carefully from collection to sowing time, in order to maintain quality and viability of a given seedlot.

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PRELIMINARY RECOMMENDATIONS FOR THE PRETREATMENT OF FOREST SEEDS IN KENYA
REPORT NO. 7

by

E. MURUGI KARIUKI and GERT RODE

ABSTRACT

A brief outline of seed testing and reasons for pretreatment is given. Seven pretreatment methods are described and a preliminary list of species for which they are suitable presented. In addition, some species requiring no pretreatment or which should be sown fresh are tested.

It is hoped this preliminary categorization will be of value to practical foresters.

1. INTRODUCTION

Generally seed testing covers the determination of viability, moisture content, weight of 1000 seeds or number of seeds per Kg and purity. This information is the basis for calculation of the number of seedlings which can be raised from a given seedlot and is important for the consignee.

The supply of forest seeds of good quality is expensive. To gain maximum benefit from seeds, it is necessary to conduct and develop appropriate handling methods from the time of seed collection until delivery and to transfer practical methods to nurseries and forest stations. This report gives some proposals on treatment methods which have given reasonable results (>50% germination) under nursery, glasshouse and laboratory conditions of the Kenya Forestry Seed Centre, Muguga. The list of recommendations is not final but should be of assistance to practical foresters.

2. PRETREATMENT METHODS

2.1. General remarks

Seeds have to be handled very carefully. They should not be kept too long after delivery but should be collected immediately after receiving the issue notes and sown as soon as possible. They can be damaged by overheating, fermentation, pests or imbibition of moisture.

In general, we can distinguish seeds which will germinate immediately after sowing, given ideal conditions of moisture, warmth, air and light. Others are dormant and will only germinate after they have been subjected to special treatments either to enable moisture imbibition or to leach out chemicals

preventing germination.

2.2. Pretreatment methods

2.2.1. Nipping the seedcoat

Nipping is the treatment by which the seedcoat is cut to enable imbibition of moisture and can be done with nail clippers, fine pliers, knives or pricking with a needle. A small scar at the end of the seed indicates the point where to nip. This is the end of the seed furthest from the point where the seed was attached to the pod or fruit where the embryo radicle is found. The radicle must not be damaged.

The same effect can be achieved with a broad file or sandpaper. Seeds can be mixed with an equal amount of sand and are then put in a tin lined with a sandpaper. The tin has to be shaken thoroughly until the seeds are dull.

2.2.2. Soaking the seeds in hot water till cool (24 hours)

Seeds are immersed in about 4 times their volume of hot water which has just boiled and been removed from the heat. Seeds are then left in the cooling water for 24 hours.

2.2.3. Soaking the seeds in cold water

Seeds are immersed in about 4 times their volume of cold water and left for the required time.

2.2.4. Combined nipping and soaking in hot water till cool (24 hours)

See 2.2.1. and 2.2.2.

2.2.5. Combined soaking in hot and cold water for 2 hours

Some seeds might be cooked and killed when left for too long in hot water. After dropping the seeds in about 4 times their volume of hot water, the seeds should then be removed after a certain time and soaked in cold water for 24 hours.

2.2.6. Prechilling

Seeds are stored in a cold and moist environment, e.g., damp sand. In the field this can be done by sowing the seeds during the cold season; usually the pretreatment requires a refrigerator or coldroom. However, there are few species which require this treatment in the tropics.

2.2.7. Soaking in concentrated sulphuric acid

This method is only suitable for laboratory use. Seeds which require this treatment are treated by the Forestry Seed Centre

prior to dispatch.

2.2.8. Fresh seeds only

Some species will not germinate after storage. These species should be sown soonest after collection. Forest stations are requested to collect for their own use but to send surplus to the seed centre for testing and distribution to other stations. An example of this is Boscia coriacea which only grows in arid and semi-arid areas.

3. LIST OF SPECIES TO BE PRETREATED

3.1. Nipping

Acacia albida
A. brevispica
A. mellifera
A. nilotica
A. polyacantha
A. senegal
A. tortilis
A. xanthophloea
Acrocarpus fraxinifolia
Albizia lebbeck
A. lophantha
Calliandra calothyrsus
Cassia spectabilis
Entada abyssinica
Leucaena leucocephala
Melia volkensii (radicle end of extracted seed slit)

3.2. Soaking in hot water till cool (24 hours)

Acacia gerrardii
A. mearnsii
A. melanoxylon
A. mellifera
A. xanthophloea
Albizia lophantha
Calliandra calothyrsus
Cassia siamea
Cassia spectabilis
Cordia abyssinica
Craibia laurentii
Delonix regia
Entada abyssinica
Leucaena leucocephala
Parkinsonia aculeata
Tamarindus indica
Diosphros scabra

3.3. Soaking in cold water

Tipuauna tipu
Newtonia hildebrandtii (12 hours)
Ziziphus mauritiana

3.4. Combined nipping and soaking in hot water till cool

Acacia mellifera
Manilkara sansibarensis

3.5. Combined soaking in hot and cold water for 24 hours

Acacia mangium (30 seconds - 3 minutes in hot water, 24 hours in cold water)
Albizia falcataria (3 minutes in hot water, 24 hours in cold water)

3.6. Prechilling

Cupressus lusitanica
Juniperus procera

3.7. Soaking in concentrated sulphuric acid

Acacia auriculiformis (30 minutes)
Acacia tortilis (45 minutes)
Adenanthera pavonina (15 minutes)
Albizia lophantha (10 minutes)
Caesalpinia spinosa (10 minutes)
Cassia spectabilis (45 minutes)
Cotoneaster pannosa (90 minutes)
Leucaena leucocephala (2 minutes)
Trachylobium verrucosum (32 minutes)

3.8. Fresh seeds only

Acokanthera friesiorum
Aningeria adolfi-friederici
Antiaris toxicaria
Azadirachta indica
Kigelia aethiopum
Podocarpus milanjianus
Salvadora persia (depulped)
Vitex keniensis
Warburgia ugandensis
Boscia coricea

4. LIST OF SPECIES REQUIRING NO PRETREATMENT

Afzelia cuanzensis
Araucaria angustiforia

A. cunninghamii
Callitris spp.
Casuarina equisetifolia
Casuarina junghuhniana
Casuarina stricta
Conocarpus lancifolius
Croton megalocarpus
Cupressus lusitanica
Dalbergia melanoxylon
Delonix regia
Dombeya geotzenii
Ehretia cymosa
Eucalyptus spp.
Grevillea robusta
Hakea saligna
Harungana madagascarensis
Jacaranda mimosifolia
Lawsonia inermis
Markhamia lutea
Melia azedarach
Pinus caribaea
P. patula
P. radiata
Prosopis juliflora
Sterculia acerifolia
Tecoma conferta

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Report No. 4, 1986: Evaluation of seed demand in Kenya by Michael Jestaedt.

Report No. 5: Preliminary results of pretreatment and germination tests of Cupressus lusitanica, Juniperus procera and Vitex keniensis by Gert Rode.

Report No. 6, 1987: Weight of 1000 seed and number of seeds per Kg by Milkah Gaitho and Gert Rode.

The different nutrient content for soils used in individual nurseries implies that the combination giving best growth will vary. Caution should be observed as undecomposed vegetable material could increase the incidence of damping-off diseases in the nursery. This can be minimised by proper sieving of the compost manure before using it in the nursery.

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AUSTRALIAN HARDWOODS FOR FUELWOOD AND AGROFORESTRY

by

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ABSTRACT

Kenya Forestry Research Institute is implementing a research programme on "Australian Hardwoods for Fuelwood and Agroforestry" funded by the Australian Centre for International Agricultural Research. The objective of the project is to determine the potential of a range of Australian species to supply useful products at three representative sites in Kenya. The sites are located at Gede, Loruk and Turbo.

Turbo is classified as 80% humid, Gede 45-50% semi-arid and Loruk as 25-10% semi-arid. Details of rainfall, potential evaporation and temperature range are given for each site.

Trials were established during the April-May rains in 1986 and 1987. Seedlings were pit planted and not watered after planting; beating up took place within three months of planting. Plots at Gede were clean weeded and at Turbo spot weeded.

A randomized complete block design with 4 pair replicates and 25 trees per treatment was used. Assessment of height and survival was made at three and six months; annually thereafter.

Best and worst performers of the 1986 and 1987 plantings are given for Gede and Turbo. No trials were successfully established at Loruk due to failures in the nursery and pest damage.

Of the 181 seedlots brought into Kenya on the project only 57 have been successfully established. The reasons for the high rate of failure are discussed.

INTRODUCTION

In many parts of Kenya, insufficient fuelwood has long been a pressing problem. The problem has become more serious with the high population growth rate (4.1% per annum). Development, in its thirst for energy and continuously growing standard of living (and in its widespread refusal to institute effective population control), has ignored a simple ecological tenet - that many natural resources are finite, and that excessive exploitation hastens their exhaustion (Janick et al. 1981). In semi-arid Kenya, once luxuriant forest land is now desert. The seemingly limitless virgin humid forests are suffering significant degradation. The consequences are staggering. Stands of virgin

plant communities are about to run out, and trees have started to be grown and managed like a crop. It is encouraging to learn that Kenya is beginning to adopt a more far sighted approach. After centuries of cutting and depletion, reforestation with selected species is being undertaken.

Recognising this, the Australian Centre for International Agricultural Research (ACIAR) is funding a research project in Kenya (ACIAR Project 8320), on "Australian Hardwoods for Fuelwood and Agroforestry". The Kenya Forestry Research Institute (KEFRI) is the implementing agency.

The objective of this project is to determine the potential of lesser-known Australian trees, shrubs and their provenances for provision of fuelwood, roundwood and other products. Three sites were selected for field trial establishment. These were: Gede, Turbo and Loruk.

The main purpose of this paper is to give a development account of ACIAR Project 8320 in Kenya, and also present early results from its field trials.

METHODS

Trial sites

Sites at Gede and Turbo are former plantations of exotic tree species. These classified as 15-30% semi-arid and 80% humid, respectively. Loruk, on the other hand is classified as 25-40%, semi-arid (Teel 1985).

Gede:

Gede is located on the coast at 3 19'S and 40 01'E. At 40 m above sea level, the site receives a mean annual rainfall of 988 mm. The mean maximum temperature is 32.3 C, mean minimum of 21.7 C and average annual potential evaporation 155-2200 mm. The vegetation is composed of a low-deciduous forest composed mainly of dry woodland and bushland.

Turbo:

Turbo is located at 0 37'N, and at an altitude of 1800 above sea level. Turbo receives a mean annual rainfall of 1315 mm and has four months of severe drought. Its mean annual temperature is 17.9 C, a mean maximum of 28.2 C and mean minimum of 14 C. The site originally carried an Acacia mearnsii De Wild, plantation for tannin. This was then replaced with Pinus patula in the early 1970s for pulpwood production. In 1985 the P. patula stand was clear felled.

Loruk:

Loruk is situated at 1 2'N and 36 3'E within a semi-arid Zone. At 1000 m above sea level, the site receives 760 mm of rainfall annually and an average annual potential evaporation of 1650-2300 mm. The vegetation is generally classified as bushland dominated by Salvadora persica L., Acacia tortilis (Forsk), etc.

TRIAL ESTABLISHMENT

Prior to field plot establishment, no ploughing was done. Plots at Turbo have been fenced but those at Gede and Loruk have not.

Seeds for establishment of plots on the project were received from CSIRO's seed centre, Australia. Before mailing they were fumigated with carbon disulphide and/or carbon dioxide. Some of the seed lots were given a cold moisture stratification or boiling water treatment. The rest did not require pre-sowing treatment.

In all cases, planting commenced after the start of the rainy season (April-May), and beating up done within three months of planting. Plants were not watered after they were planted in the field.

At Gede, plots were clean weeded whenever it was necessary. At Turbo, they were spot weeded.

DESIGN AND PLOT

Plants were established in a randomized complete block design with four replicates per site. Each treatment plot was comprised of 25 plants, at 2.5 x 2.5 m spacing. However, for seed lots with insufficient seedlings, unreplicated plots were established.

ASSESSMENT

Assessment of height and survival was done at three and six months after establishment and, thereafter, annually. Two way analysis of variance and a student t-test were used to compare means (Steel and Torrie 1980, Freese 1983).

Significant differences among treatment means at 5% confidence level were compared by Duncan's New Multiple-Range Test (Steel and Torrie 1980).

RESULTS

Turbo: 1986 planting

Mean height at six months and at 18 months differed significantly at 5% confidence level. Eucalyptus saligna Smith had the best height growth age 6 (0.96 m) and 18 months (7 m) after outplanting. At six months, the poorest height growth (0.53 m)

was observed in E. laevopinea R. Baker; and at 18 months,(4 m) in E.urophylla S.T. Blake.

Eucalyptus saligna and E. grandis Hill ex Maiden had the best survival at both 6 and 18 months. Eucalyptus laevopinea had the poorest survival.

Turbo: 1987 planting

Mean height growth at 3 months differed significantly at 1% confidence level.

The best height was 53 cm for E. panctata Smith and the poorest was 12 cm for Acacia flavescens Cunn. ex Benth.

Per cent survival at 3 months differed significantly at 5% confidence level. The best survival was 95% and was for A. auriculiformis Cunn. ex Benth and E. paniculata. The poorest survival was 50% and it was for A. flavescens.

Gede: 1987 planting

Two separate experiments were established. The first one was for Eucalyptus and the second for Acacias. Mean height growth among Eucalyptus significantly differed at 5% confidence level with E. tereticornis Smith attaining the best height growth (89 cm). Mean survival was found not to differ significantly among Eucalyptus.

Mean height growth and survival per cent among Acacias did not differ significantly. This could be due to the fact that competition at age 1.5 months had not set in. Significant differences are expected after some time.

Loruk: 1986 and 1987 planting

Seedlings for planting have been raised each year since 1986. In 1986, seedlings dried before outplanting due to lack of water in the nursery. In 1987, seedlings were successfully raised at Muguga and transported to a temporary nursery at the site prior to planting, but a combination of browse damage, termite attack and drought led to unsuccessful establishment.

DISCUSSION

There is an urgent need to identify multi-purpose woody perennials suitable for reforestation or integrated farming systems in semi-arid Kenya. Although this paper is based on preliminary results; with sufficient caution, practical decisions can be made about nursery treatments, site preparation, planting, and genetic selection.

Since February 2, 1985, more than 181 seed lots have been received from Australia for planting on ACIAR project 8320. These belong to the genera Eucalyptus (91), Acacia (76), Melaeuca (11), Casuarina (2), and Grevillea (1).

Only 57 of these have been successfully established in the field. These are: 38 Eucalyptus, 17 Acacias, and 2 Casuarina. Some of the factors responsible for the poor performance are:

(a) Very poor germination;

(b) High rates of seedling mortality in the nursery;

(c) Harsh environmental field conditions;

(d) High susceptibility of most species to termite attack, and,

(e) Browse damage.

About 50% of the seed lots received were characterised by low germination. Although, all species had poor germination, the problem was most severe in the genera Grevillea and Melaleuca. For the 1988 planting, Acacia seeds completely failed to germinate at Turbo. At Loruk and Kibwezi (Gede seedlings) Eucalyptus failed to germinate. Poor germination could be due to low seed viability, dormancy or both. Most Acacias have hard seeds which germinate more quickly following hot water scarification (Crocker 1916).

According to Zummer-Linder (1933) this treatment promotes faster germination of the smaller seeds. Studies with boiling water treatment in West Africa indicated that it is ineffective on some African Acacias. As for Australian Acacias, boiling water treatment is suspected to destroy 20% of the seed, or the treatment is simply not effective. Pure water is depressed by impurities and high elevation. It is possible that the boiling water treatment does not attain sufficient temperatures to be effective where impurities are present or at high elevation. This could partly explain better germination observed at Gede compared to Loruk, Muguga and Turbo (Milimo 1986). Investigations to establish the cause of poor germination are currently considered necessary.

Performance of field plots at Gede and Turbo, based on height growth were not unexpected as these already exist. Some data on Australian species and provenances (E. grandis and E. saligna) from Elburgon and Turbo. Stressful environmental conditions are contributing to poor field performance at Loruk. Knowing this, it is, therefore, not enough under arid and semi-arid conditions to screen species and their provenances for adaptability but also a clear understanding of how to condition nursery stock to resist outplanting stresses is urgently needed. Stress is defined

here as 'excess or deficiency of any factor needed for growth', e.g., light, heat, water, carbon dioxide, etc., as well as presence of such unneeded factors as browsing animals, disease causing organisms, or toxic chemicals. Depending on its intensity, rapidity of onset, total duration, and frequency of occurrence stress may be injurious or merely inhibitory. Stress may also led to secondary stresses (Timmis 1980).

Seedlings of high physiological quality are those that will flourish in spite of the relatively harsh environment into which they are transplanted (Duryea and Landis 1984). Producing such seedlings consistently and economically should be the nurseryman's prime objective. However, it is an objective made difficult by the absence of definition of the term, the complexity of plant-environment interactions embraced by lack of a national framework in which to view these relationships (Timmis 1980). Therefore, a starting point in solving the problem is for nursery personnel to thoroughly familiarise themselves with the physiology of the plant species they work with. They should become aware of interactions between various nursery cultural practices. For example, if a current practice is altered or discontinued or a new practice is added, careful considerations should be given to its effect on other cultural practices in the nursery.

Termite attack on outplanted seedlings is a serious problem in semi-arid areas. Among those that have shown high susceptibility are Eucalyptus, Casuarina and some Acacias. For the 1988 planting, investigations with slow release inert plastic granules of carbamate insecticide (Inciteo Itd, Australia), are planned.

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RESULTS OF FORESTRY RESEARCH AT KIBWEZI

by

R.K. CHIRCHIR

ABSTRACT

Several species and provenance trials have been established in Kibwezi, the following have shown satisfactory growth: Cassia siamea, Eucalyptus tereticornis, Leucaena leucocephala and Parkinsonia aculeata. Nursery and field establishment studies have been discouraged by game browsing and poor survival. Wild fires, termite attack and harsh weather are other constraints experienced in Kibwezi. Possible solutions are discussed.

1. INTRODUCTION

Kibwezi is a typical example of a semi-arid area. It is located at an altitude of about 910 m above sea level and receives a mean annual rainfall of about 640 mm which falls in two seasons. The mean annual temperature is about 25 C. Soils in Kibwezi research station consist mainly of lava boulders and sandy loam derived from a basement system. The aim of establishing Kibwezi forestry research station was:-

- To carry out research on multipurpose tree species suitable for the area
- To establish nurseries to supply enough seedlings for all planting programmes
- To undertake research on soil conservation
- To investigate other methods of propagation of species which do not propagate easily from seeds.

Today the major drawback to dryland afforestation is the lack of basic information on the candidate species and provenances. It was therefore inevitable that the station had to start with species and provenance trials. The aim of this paper was to appraise the progress of research in Kibwezi and give the results to date.

2. MATERIALS AND METHODS

All the experiments were established using a common randomized block design with several replicates in a square arrangement of 5 x 5 and a spacing of 2.5 x 2.5 m. Weeding was always done before the onset of rains. Spot hoeing was prefered to other methods of weeding because it is cheap and faster.

Nursery cultural activities involved, digging and preparation of nursery soil, seedbed preparation, seed sowing, watering, root pruning and general nursery upkeep.

Height growth and survival count were the major parameters measured regularly. This was done soon after planting after six month and thereafter annually. The objective of all these experiments was to select from a wide range of species those which can survive the harsh conditions of arid Zones typified by Kibwezi.

3. RESULTS

3.1. Species and provenance elimination trials

3.1.1. Species trial R.E 389/79

Cassia siamea showed the best performance in terms of height growth, while Leucaena leucocephala and Parkinsonia aculeata displayed the best survival (84.4%; Table 1). The performance of the genus Pinus was very poor suggesting that they will not survive in the arid and semi-arid zones.

TABLE 1 SPECIES PERFORMANCE AFTER 3 YEARS

SPECIES	Mean Survival (%)	Mean Height (m)
Eucalyptus tereticornis	43.75	3.23
Eucalyptus paniculata	21.90	-
Eucalyptus maculata	12.5	2.52
Leucaena leucocephala	84.4	2.22
Parkinsonia aculeata	84.40	2.03
Schinus molle	21.90	2.02
Cassia siamea	71.9	3.87
Azadirachta indica	46.9	-
Grevillea robusta	71.9	2.8
Pinus caribaea	-	-
Pinus brutia	6.3	0.45
Croton megalocarpus	37.5	-

3.1.2. Species/provenance trial R.E. 389/80

Three provenances of Eucalyptus camaldulensis namely BN/10182 and BN/12187 showed a good survival (Table 2). Acacia tortilis and Acacia albida also showed a remarkable performance. The rest of the species tried generally failed.

TABLE 2 SUMMARY OF SURVIVAL OF R.E. 389/80 AFTER 3 YEARS

TREATMENTS	MEAN HEIGHT(M)	SURVIVAL %	RANKING SURVIVAL	RANKING HEIGHT
1. Eucalyptus alba	1.78	6.0	13	10
2. Acacia tortilis	1.32	16.9	4	12
3. Cassia siamea	1.76	12.0	6	11
4. Gmelina arborea	-	28.1	9	-
5. Eucalyptus tereticornis	3.40	6.2	13	2
6. Eucalyptus meliodora	2.85	6.2	13	4
7. Schinus molle	1.85	6.2	13	9
8. Callitris hugelli	-	0	-	-
9. Grevillea robusta	1.15	3.1	20	16
10. Acacia spp.	1.25	9.4	12	13
11. Pistacia chinensis	1.20	6.2	13	14
12. Acacia albida	0.46	13.7	5	19
13. Casuarina equisetifolia	1.17	6.2	13	15
14. Melia azedarach	3.24	28.1	9	3
15. Croton megalocarpus	0.57	15.6	11	17
16. E. camaldulensis B/N 12437	2.01	37.5	6	8
17. E. camaldulensis B/N 10182	2.03	75.0	1	7
18. E. camaldulensis B/N 12187	2.17	62.5	2	6
19. E. camaldulensis B/N 10571	2.56	34.4	8	5
20. E. camaldulensis B/N 12139	3.36	53.1	3	1
21. Callitris robusta	0.55	6.2	13	18

KEY:

B/N 12437 - Dunham River - Australia
B/N 10182 - Murchison River - Australia
B/N 12187 - Irvine Bank QLD - Australia
B/N 10571 - Halls Creek WA - Australia
B/N 12139 - Telford NQLD - Australia

3.1.3. Species trial R.E. 396/82

This was a trial of species of agroforestry importance. Based on the results on Table 3, Acacia tortilis, Prosopsis juliflora and Acacia arabica showed best survival. Acacia melanoxylon, Casuarina equisetifolia and Casuarina torulosa all failed to survive.

TABLE 3 MEAN SURVIVAL OF SPECIES

SPECIES	MEAN SURVIVAL %	RANKING
Acacia tortilis (Kibwezi)	100	1
Prosopis juliflora (Hola)	98	2
Acacia tortilis (Makindu)	94	3
Acacia arabica	92	4
Cassia siamea	90	5
Acacia seyal	88	6
Ziziphus spina-christi	88	6
Tamarindus indica	82	8
Azadirachta indica	60	9
Acacia albida (Baringo)	52	10
Gmelina arborea	44	11
Croton megalocarpus	42	12
Leucaena leucocephala	40	13
Acacia gerrardii	36	14
Grevillea robusta	32	15
Melia azedarach	20	16
Acacia cyanophylla	12	16
Acacia melanoxylon	0	-
Casuarina torulosa	0	-
Casuarina equisetifolia	0	-

3.1.1. International Provenance trial of Eucalyptus tereticornis

From the results in Table 1, it is apparent that Eucalyptus tereticornis has a higher growth potential than Eucalyptus camaldulensis. B/N 12062 and B/N 11034 provenances are tentatively taken to be the best for Kibwezi area.

TABLE 4 SUMMARY OF THE MEAN SURVIVAL OF E. TERETICORNIS SPECIES (ONE YEAR OLD)

SPECIES	MEAN HEIGHT(M)	MEAN SURVIVAL(%)	RANKING HEIGHT	RANKING SURVIVAL
Eucalyptus tereticornis B/N 12377	0.892	36	11	9
" " 10781	1.39	62	4	3
" " 12502	1.39	67	4	2
" " 12062	1.52	55	2	5
" " 11034	1.12	70	2	1
" " 11239	1.38	57	5	4
" " 12836	0.97	24	9	15
" " 10156	1.05	49	8	6
" " 10826	0.75	39	13	8
" " 10817	0.92	26	10	14
" " 11583	0.89	27	11	13
" " 10090	1.06	22	7	16
" " 10827	1.06	19	7	17
" " 12189	1.24	31	6	10
" " 10837/ 10831	0.78	22	12	16
" " 12376	0.73	30	14	11
" " 10778/ 10816	0.62	29	15	12
" " 10954/ 10951	1.32	44	5	7
" " 11953/ 10975	1.73	49	1	6
Eucalyptus camaldulensis "	0.38	5	16	18

4. DISCUSSION

Species and provenance trials in Kibwezi have given satisfactory results (Tables 1,2,3 and 1). Several species have proved suitable and therefore recommended for areas with similar climate. In terms of survival Cassia siamea, Grevillea robusta, Leucaena leucocephala, Eucalyptus tereticornis are recommended. Eucalyptus species however, are very susceptible to termite attack and Leucaena leucocephala to browsing by wild animals.

It is evident that the main obstacle to successful tree establishment in arid and semi-arid zones is lack of sufficient moisture particularly during the early stages when the seedling has not pushed its roots to the watertable. Initial growth is important because it determines whether establishment is possible.

Research in Kibwezi was sabotaged by the arsonists in 1980/81 who set fire to a number of trial plots. Wild game, on the other hand, browsed on other species. This could be avoided by adapting proper protection such as keeping clean fire breaks, proper shamba hygiene and construction of fire watch towers to monitor all forest activities and keep away the would be arsonists.

Termites are an evil which need to be contained. The use of insecticides is not desirable because the termites may develop resistance, not to mention the pollution arising and the resultant effect on the food chain. Research should, therefore, be centred on propagating resistant tree species especially in the genus Eucalyptus. There is also need to identify the unpalatable component in other species, isolate and type it for possible commercial production.

Nursery experiments have failed because of disturbance by wild animals. The location of the nursery needs to be changed.

Late planting due to various administrative problems results in poor establishment and survival and thus in failure of a trial. It ought to be realised that the economic justification of any project may only be realised if it is successfully established, assessed and analyzed. On the other hand, programmes with long durations need well planned strategies. At times it is sad to write off an experiment after 3 years because of negligence or poor planning. Such minor errors frustrate the scientific work and discourage the scientists and donor alike.

FORESTRY RESEARCH IN RAMOGI FORESTRY RESEARCH STATION

by

J.M. Kioko

ABSTRACT

Species trials of both indigenous and exotics indicate that E. camaldulensis, Rhus natalensis, Acacia arabica and Cassia spectabilis are promising species for use in areas ecologically similar to Ramogi. Other candidate species are also reported. Studies on nursery and establishment methods are discussed briefly.

INTRODUCTION

Ramogi forestry research station is located in Siaya district, Nyanza Province. The mean annual rainfall for last five years was 500 mm and the mean annual temperature was 29 C. Soils consist of black clay with fine brown rust veins forming a dark grey soil with humic substances.

Ramogi station was opened in 1976 with support from the International Development Research Centre (I.D.R.C). It was charged with carrying out research on multi-purpose tree species suitable for the area; developing methods and techniques of tree establishment and helping in dissemination of research findings to rural communities in conjunction with the Rural Afforestation Extension Service (REAS).

This paper outlines research findings to date on nursery methods, establishment techniques and species/provenance trials carried out at Ramogi.

2. MATERIALS AND METHODS

2.1. Nursery Techniques

Four trials were established with the aim of determining better methods of raising healthy seedlings. These were: the shading material experiment, shading duration, soil mixtures and watering regime experiments. The shading material trial was set using grass, reeds and Papyrus mats while the shading ranged from one to 6 weeks of shading. E.camaldulensis was used in all the trials.

Soil mixture trials had different treatments, each consisting of different proportions of local top soil and fertilizers.

2.2. Establishment Methods

Weeding trials using E.Camaldulensis seedlings were set and 8 treatments applied at 4 frequencies. These included 2 spot hoeing, slashing and their various combinations, chemical weeding (using Dalapon) and a control. Plots were replicated 4 times and frequency of weeding varied from 1 to 4 times a year. Fertilizer trial experiments showing their performance on application of various fertilizers at different levels after planting. There were 6 treatments replicated 4 times.

2.3. Species and provenance trials

The aim was to assess the performance of a wide range of tree species both indigenous and exotic, and to select those suitable for the dry zones. A complete randomised block design with replicates was used. 25 Tree plots (5 x 5) or 16 tree plots (4 x 4) were used at a spacing of 2.5 x 2.5 m. Survival percentage and growth in terms of height were the parameters assessed.

3. RESULTS AND DISCUSSION

3.1. Nursery Techniques

Shading treatments ranging from 2 to 3 weeks gave a survival percentage of over 94%. However, they differed on the height growth. After 6 weeks the seedlings shaded for 2 to 3 weeks were taller and healthier than those shaded for 4 to 6 weeks. It was, therefore, concluded that shading for 2 to 3 weeks was appropriate. The effect of shading materials did not give any significant difference, thus suggesting that any of the three shading materials in question could be used depending on availability.

Soil mixture trials indicate that increased proportion of sand raises survival but retarded growth. A mixture of 80% local top soil, 20% sand and N.P.K. (20: 20: 12) fertilizer gave the best results.

3.2. Establishment Methods

Frequent termite attack frustrated the weeding trials. Nevertheless, after 2 years, spot weeding and vegetable slashing gave satisfactory results. However, no concrete data is available because the survival rate was too low.

Fertilizer trials, showed that Boron and Urea drastically reduced survival. The other treatments did not produce significantly better survival percentages than in the control.

3.3. Species/Provenance Trials

3.3.1. Species Trial R.E 402

Survival percentage of all species at 4.5 years was below 40% because of damage by wildlife, termites and adverse weather. Eucalyptus camaldulensis survival was greatest.

3.3.2. Species Trial - 1983 Planting

After 3 years Rhus natalensis had the highest survival rate at 76% and very low height growth. Eucalyptus species, though having a lower survival percentage showed remarkable height growth. They could, therefore, be favoured over Rhus natalensis.

3.3.3. Species Trial - 1984 Planting

In the initial stages the survival percentage of most species was quite high after which it slowly decreased. This was possibly due to climatic changes over the years. Nevertheless, Eucalyptus camaldulensis had the highest survival percentage (50%) after three years. Other species with good performance include Cassia siamea (72%) and Terminalia mentalis (50%).

3.3.4. Species Trial - 1985 Planting

Performance in these plots was very poor because of water logging, termite attack and surface run-off experienced in the year. Acacia arabica, however, managed to withstand all these events. Eucalyptus species though showing reduced survival had superior growth.

3.3.5. Ramogi Hills Species Trial - 1986 Planting

After one year the survival of most species was quite good. However, this trial is on-going and it is too early to predict the outcome.

3.3.6. Ureje Species Trial -1986 Planting

This Trial is also in progress. However, it is apparent that Eucalyptus maculata and Callitris robusta are likely to fail. Cassia spectabilis seems to have a high growth rate.

4. CONCLUSION

From all the preliminary results given, the following species can be recommended for Ramogi: Eucalyptus camaldulensis, Eucalyptus hybrid, Rhus natalensis, Grevillea robusta, Cassia siamea, Acacia arabica and Cassia spectabilis.

More work needs to be done on nursery and establishment methods. The use of fertilizer to improve soil quality also needs further investigations.

FORESTRY RESEARCH IN HOLA

by

G.K. Mwaura

ABSTRACT

Species trials of both indigenous and exotic trees in Hola have shown satisfactory results with the following species having the best performance: Acacia tortilis, Prosopis juliflora, Prosopis chilensis, Eucalyptus camaldulensis, Albizia procera and Acacia nilotica. Establishment and nursery trials have not been very good, however, the few results available are discussed.

1. INTRODUCTION

Hola forestry research station was established in 1977 with financial aid from International Development Research Centre (IDRC). Hola, 90 m above sea level is characterized by harsh weather with a scarce and erratic rainfall. Mean annual rainfall is 480 mm and the mean annual temperature is 27.5 C. Solar radiation and winds are strong. Soils are black vertisols and thus problematic, especially so during the dry season.

Hola station was established with the following objectives:-

i) To carry out studies on the suitable tree species to be planted in north eastern and north coast regions.

ii) To study the best establishment methods for the selected species, so as to improve their survival and growth.

iii) To carry out studies on the best pre-treatment prescriptions for seeds and seedlings in preparations for planting.

The aim of this paper is to present some preliminary results on the trials undertaken to date.

2. MATERIALS AND METHODS

Several species/provenance trials have been set. The main aim was to screen species and provenances which are most suitable for Hola and the surrounding environs. All the trials were set in a randomised block design with replicates at 2.5 x 2.5 m spacing in rectangular and square plots.

In some of these trials e.g., E. camaldulensis species spacing, irrigation and weeding trials were studied to see whether specific establishment methods are better than others prescribed. E. camaldulensis was chosen because it appears promising in arid zones.

The studies on nursery methods, had a common aim of seeking ways of raising healthy seedlings. Two trials on soil mixture and watering regimes have been established. Watering regime trials were set in a randomized block design with 4 treatments and 5 replications.

The treatments were as follows:-

T1 - Watering once each day in the morning
T2 - Watering 2 times each day in the morning and evening
T3 - Watering 3 times each day, morning, afternoon and evening.
T4 - Watering 4 times each day, morning, 10.00 o'clock, 2.20 p.m and 6.00 p.m.

3. RESULTS

3.1. Species/Provenance trials

3.1.1. Species trials 387/77

Acacia tortilis showed the best survival (see Table 1) followed by Prosopolis juliflora (90.9%), Albizia procera (43.8%), Terminalia brownii (50.0%), Eucalyptus microtheca (50.0%) Eucalyptus camaldulensis (31.2%). In terms of height growth the Eucalyptus genus displayed superiority other species. Nine genus had totally failed by the fifth year of assessment.

3.1.2. Species trials at Wayu R.E. 387/79

At the age of 3 years 4 species were surviving (Table 2). These were Cassia siamea, Azadirachta indica, Casuarina equisetifolia and Eucalyptus camaldulensis. Casuarina equisetifolia displayed the highest growth rates followed by E. camaldulensis.

3.1.3. Species trial R.E. 403/81

21 Plots of this experiment died because of the prolonged drought of 1981. Among the few species which survived, Terminalia brownii, Azadirachta indica and Prosopis chilensis seem to perform well (see Table 3).

TABLE 1 MEAN HEIGHT AND SURVIVAL PERCENTAGES OF SPECIES TRIED IN HOLA R.E. 387/77

TREATMENTS	AGE 3.7 YEARS		AGE 5 YEARS	RANK
	MEAN HEIGHT (M)	SURVIVAL %	SURVIVAL %	
Acacia tortilis	5.2	100.0	100.0	1
Albizia procera	7.1	81.2	43.8	5
Azadirachta indica	5.8	3.1	0	
Cassia grandis	2.0	6.2	0.0	
Cassia siamea	8.0	31.2	31.1	8
Casuarina equisetifolia	-	0.0	0	
Eucalyptus camaldulensis	5.1	9.4	0.0	
Eucalyptus camaldulensis	-	0.0	0.0	
Eucalyptus camaldulensis	9.8	31.2	31.2	6
Eucalyptus camaldulensis	8.0	31.2	18.8	9
Eucalyptus camaldulensis	7.9	9.4	0.0	
Eucalyptus microtheca	3.5	50.0	50.0	3
Eucalyptus tereticornis	8.6	3.1	0	
Eucalyptus terminalis	7.0	34.4	31.21	6
Melia azedarach	-	0.0	0.0	
Parkinsonia aculeata	5.2	18.7	12.5	10
Prosopis juliflora	6.4	96.9	90.6	2
Terminalia brownii	5.0	56.2	50.0	3
Terminalia ivorensis	-	0.0	0.0	

TABLE 2 MEAN HEIGHT DBH (cm) AND SURVIVAL PERCENTAGE OF SPECIES GROWN IN WAYU AT THE AGE OF 3 YEARS.

SPECIES (TREATMENTS)	MEAN HEIGHT(M)	MEAN DBH (cm)	SURVIVAL %
Azadirachta indica	4.2	5.2	25
Cassia siamea	7.7	7.3	100
Casuarina equisetifolia	11.9	7.7	12.5
Delonix elata	-	-	0
Delonix regia	-	-	0
Eucalyptus camaldulensis	10.6	10.3	34
Eucalyptus microtheca	-	-	0
Eucalyptus paniculata	-	-	0
Eucalyptus tereticornis	-	-	0
Terminalia brownii	-	-	0

TABLE 3 SURVIVAL PERCENTAGES OF SPECIES TRIED IN HOLA R.E. 403/81

SPECIES (TREATMENTS)	AGE 4 MONTHS SURVIVAL %	AGE 20 MONTHS SURVIVAL %
Azadirachta indica	43.5	29
Cassia grandis	59.5	0
Cassia siamea	57	0
Eucalyptus camaldulensis	56.8	15
Eucalyptus tereticornis	60.8	0
Prosopis chilensis	52.8	35
Terminalia brownii	45	47

3.1.4. Species trial R.E. 404/82

This trial was also affected by prolonged drought, thus the results do not reflect a normal growth rate. Eucalyptus camaldulensis, however, displayed the best growth (Table 4). From these results species which can survive a harsh drought could be recommended.

TABLE 4 MEAN HEIGHTS OF SPECIES TRIED IN HOLA AT AGE OF 12 MONTHS

SPECIES (TREATMENTS)	MEAN HEIGHT
Acacia albida	27.46
Acacia aneura	15.84
Acacia cyanophylla	21.30
Azadirachta indica	22.62
Cassia siamea	30.04
Eucalyptus camaldulensis	37.48
Leucaena leucocephala	18.16
Prosopis juliflora	20.66
Prosopis tamarugo	23.34
Tamarindus indica	15.92
Zizyphus jujuba	13.03
Zizyphus spina-christi	21.67

3.2. Establishment of trials

The weeding trials experiments failed due to prolonged drought. Nevertheless survival percentages ranging from 84% to 96% were recorded at the age of 2 years. Irrigation trials did not yield any significant results (Table 5). However, growth and survival was good. Very little could be deduced from this trial.

TABLE 5 MEAN SURVIVAL AND HEIGHT OF E. CAMALDULENSIS UNDER DIFFERENT WATER REGIMES

TREATMENTS	MEAN SURVIVAL 2 YEARS	MEAN HEIGHT 2 YEARS (M)	MEAN HEIGHT 4 years(M)
T1 Irrigation once a week	86.8	6.5	11.97
T2 Irrigation once 2 weeks	86.8	5.5	10.84
T3 Irrigation once 3 weeks	86.8	5.4	9.93
T4 Irrigation once 4.5weeks	86.8	5.3	9.95
T5 Irrigation once 6 weeks	86.8	5.8	10.72
T6 Control	84.4	5.1	8.72

3.3. Nursery method studies

In the watering regime trials, seedlings watered twice a day showed the highest growth rate, while equal rates were manifested in the other treatments. Trials on soil mixture indicated that a mixture of forest soil and sand produced the best results. The addition of NP-fertilizers to the quarry soil did not affect seedling growth. Most of the seedlings in the mixture of low manure and quarry chips died.

4. DISCUSSION

4.1. Species/Provenance studies

The preliminary results reported can form a baseline for the choice of species to be planted in Hola environs. So far the most successful species are Acacia tortilis, Prosopis chilensis, Prosopis julifora, Eucalyptus camadulensis, Albizia procera, Acacia indica, etc.

More work on establishment techniques e.g. on water harvesting, evapotranspiration reduction and conservation of water is required. To date the successful establishment and quick growth of Eucalyptus camaldulensis has encouraged local people to plant these in plenty despite the current debate on the pros and cons of Eucalypts. This is a clear manifestation of the need for multipurpose, fast growing tree species which can flourish

easily under harsh conditions.

4.2. Establishment studies

It is evident from Table 5, that different watering regimes have no significant influence on the survival of trees. However, the design and layout of the experiments need to be re-examined because the results are not convincing. Possibly the water was seeping from one plot to the other such that no difference in water regimes was experienced.

4.3. Nursery studies

The observation that Hola needs no addition of NPK-fertilizers suggests that the soils are rich in minerals. The mixture of forest soils and sand gave best results possibly because they are well aerated and allow easy percolation of water, thus creating a healthy environment for the roots. Cow manure caused high mortality possibly because it retains heat or pH drift. Similarly, the quarry chips could not retain water, hence death of seedlings.

A REVIEW OF FORESTRY RESEARCH IN TURKANA

by

G.M. Muturi
(Turkana Forestry Research Station)

ABSTRACT

Turkana district is mainly within eco-zones V and VI and is inhabited by 250,000 nomadic pastoralists. Recently a small number of permanent settlements have become established accompanied by localised demand for tree products.

Turkana is not suited to plantation forestry. Protection, preservation and improvement of existing vegetation has been the objective of the forestry department. The Turkana Rural Development (TRDP) KEFRI Project was established in 1987 with the objective of consolidating information and carrying out research into utilisation and management of woodland resources. Six priority areas for research have been identified; Species /provenance trials, seed, nursery studies, establishment methods, phenological studies and regeneration studies.

INTRODUCTION

Turkana district covers 72,000 km of North Western Kenya. It lies between 600-900m with isolated mountains and escarpments. The district has three major drainage basins. The Lorikipi plains in the North, Kalokol/Turkwell/Kerio lowlands along the Western shores of Lake Turkana and Sunguta basin in the South East. The district falls within eco-zones V and VI (Semi-arid and arid; Pratt and Gwynne 1977). These are characterised by high temperatures and low erratic rainfall (180 mm to over 400 mm in the south.

POPULATION AND LIFESTYLE RELEVANT TO FORESTRY:

Turkana district is inhabited by about 250,000 nomadic pastoral Turkanas. Due to epidemics resulting from drought, sedentary life styles have begun to emerge. The settlements are based on various occupations e.g. fishing at Kalokol, irrigated agriculture at Katilu, administrative nucleus at Lodwar etc. These settlements accompanied by increased demand for wood and wood products have put pressure on vegetation within their reach. The Turkanas, however, have a clear understanding of their flora and utilization (Morgan 1980), making woody plants be valued highly. Indeed the woody vegetation of the district within Turkwell river forest and Loima mist forest are the most important. Pollarding or cutting branches instead of felling whole trees is a normal practice. Turkana herd owners own "Ekwar" (literally "trees by the riverside"; Barrow 1987) and

customarily protect certain important tree species like Acacia tortilis, Hyphaena coreacea, Cordia sinensis, Dobera glabra and Acaci albida (Barrow 1986/87).

PAST FORESTRY DEVELOPMENT ACTIVITIES:

Like many other ASAL areas of Kenya, Forestry development does not aim at plantation establishment since conditions are not conducive for the practice. The general aim is to try to protect, preserve and improve existing vegetation cover as well as planting in bare sites. Past forestry work in the district has been extension and development. The forest department has successfully planted over 250,000 seedlings using microcatchments and incentives.

THE PROJECT:

The TRDP (Turkana Rural Development Project) KEFRI project became functional in mid August 1987 with the posting of an Assistant Research Officer to open up a station in Turkana. KEFRI operates other stations in arid and semi-arid areas. These include: Hola, Kibwezi, Ramogi, Larok, Bura and Kitui. The first task at Turkana was to take over all research responsibilities from the forest department, followed by building an office and laboratory.

FUTURE PLANS:

The objective of the station is to consolidate information and to carry out research into effective utilisation and management of renewable woodland resources.

Due to the harsh climate, it is clear that meaningful agriculture stands little chance of success (K. Vogt, Fodder Survey). The only option, therefore, is livestock-keeping whose success depends on availability of fodder.

Therefore, Turkana Forestry Research Station will address itself to the following priority areas.

(a) Species/provenance trials: Results of past work so far can only serve as guidelines for future research, since proper records were not kept. Therefore, proper records of research will be kept, analysed and distributed to other departments, i.e., Forest Department.

(b) Qualitative seed collection, seed pre-treatment and storage studies: Trees with desirable traits in given species will be identified and their seed collected. Seed pre-treatment studies will cover species that are known to be useful but have germination problems. Boscia coriacea, Cadaba fannosa, Grewia bicolor, Grewia villossa. Currently, no prescribed storage practices exist in either the district or at Kenya seed centre. This lack of handling, processing and storage

guidelines has caused loss of seed viability by insect damage and decay.

(c) Nursery studies: Current nursery practices are based on experience. This does not necessarily mean that the practices cater for seedling physiological quality. A problem suspected to be entomological has been observed on Ziziphus mauritiana at Kakuma and on Cordia sinensis. Salvadora persica at Kachoda has physiological problems. All these problems and many others will have an adverse effect on field performance, e.g., reduction of field survival and growth vigour for the few that survive. The Zizyphus maritiana case has been taken up by KEFRI's entomology and zoology divisions while the writer is investigating the Savadora persica problem at Lodwar and Kachoda tree nursery.

(d) Establishment methods: The microcatchment practice (water harvesting) is promising. Further research in this area is also required.

(e) Phenological studies: They aim at investigating and documenting the phenology of current and potentially useful species. This information will aid activities like seed collection and subsequent breeding programmes.

(f) Regeneration studies: There is need to carry out studies on economically important species, e.g., Dobera gabra. Along river courses and around settled centres, natural regeneration does not occur. Studies to establish the causes of this are important.

(g) Other collaborative research work going on in Turkana includes:

i) Fodder production with saline water - Israel/Kenya (KEFRI) joint project.

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The writer wishes to thank the District Forestry Officer and the entre District Forestry Personnel for cooperation rendered in setting up the station. The District Forest Officer's and Mr. E. Barrow's advise on handling technical and administrative issues are also worth mentioning. Mr. Vogt's involvement in setting up a sound research base is a recordable achievement for which I congratulate him. Lastly, but not the least I wish to thank NORAD and Director KEFRI for funding the project and posting me to Turkana respectively thus giving me an opportunity to develop a career in dryland forestry research, a field I am getting more interested in day by day.

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EMBU, MERU, ISIOLO FORESTRY PROJECT

FORESTRY RESEARCH

by

J.K. Lugadiru and M. Stewart
February 1988

ABSTRACT

The objective of the Embu, Meru, Isiolo Forestry Project is to support the Rural Afforestation and Extension Service (RAES) in the three districts. The emphasis is on the Arid and Semi Arid areas, where appropriate species and techniques are unidentified. Consequently, the project has a research component which has been operating since 1983.

The research project has contributed a lot towards RAES operations. Research on nursery techniques, land preparation and species selection has been undertaken. The research has been complemented by a dozen on farm trials.

Research activity to date includes nurseries, land preparation, species and provenance trials and on farm trials. A brief resume of the main species and provenance trials is given.

Future research activities will include seed procurement, establishment techniques, sociological surveys and continued species and provenance trials. The rationale behind these choices is discussed.

1. EMBU, MERU, ISIOLO FORESTRY PROJECT.

Embu, Meru, Isiolo (EMI) Forestry Project is one component of an EMI programme which also incorporates separate soil and water conservation, livestock and agronomy projects.
The EMI programme is designed "to assist in the working out of measures that are technically, economically, environmentally and socially viable in order to maintain and develop agriculture and livestock production in the Arid and Semi Arid Lands (ASAL) of Kenya".

The forestry project exists to support the Rural Afforestation and Extension Service (RAES) within the three districts. The project operates over the whole of the districts with the exception of the Mt. Kenya Forest Reserve. A wide variety of ecological zones and agricultural practices are therefore represented in the project area. The emphasis of the project is intended to be upon the ASAL but appropriate species and techniques for these lands are as yet largely unidentified. Consequently the bulk of technical and logistic support is still

directed to the high or medium potential areas. It is recognized that the high and medium potential zone dwellers are mining the ASAL forest resources primarily for fuel. Efforts to increase self sufficiency in the high potential areas therefore indirectly assist ASAL.

Since the forestry projects inception in 1983 there has been a research component operated by an expatriate silviculturist and a Kenya Forest Research Institute (KEFRI) research forester. The research component is directed primarily, although not exclusively, to the problems of the ASAL. The research is intended to be pragmatic, and problem solving rather than academic. In the past the research team has contributed greatly towards the operation of RAES in the project area.

Research has followed a number of avenues since 1983. Species and provenance trials have been established, nursery and planting techniques developed and phenological studies of selected species carried out. The following is a resume of research results from 1983-1987 and a synopsis of the current approach to future research in the area.

11. RESEARCH 1983-1987

1. Nursery Research

Initial research activities concentrated largely on nursery techniques and phenological studies.

As a result of studies on the nurseries, operational techniques suitable for low technology ASAL nurseries were recommended. These included a strong recommendation in favour of direct sowing into tubes rather than pricking out. Recommendations on tube size, sowing times by species, root pruning methods, shading and watering regimes were also made. The fruits of much of this work as it relates to Embu, Meru and Isiolo is contained in "A Forest Nursery Manual for Kenya". by Abell and Armstrong.

Phenological studies were carried out on a few selected species. These observations are important for planning seed collection of a range of important indigenous species. A table of seed collection times was produced in the Forest Nursery Manual for Kenya as a result of the observations.

2. Land Preparation

A limited amount of research has been carried out on the effect of microcatchments. Whilst construction of microcatchments has been recommended according to topography, there have been no quantitative measurements of their effect on tree growth. The microcatchments are shallow trenches with well firmed walls which lead water to the plant position. The tree should be planted in a normal planting pit but in a position where it is not inundated with silt or washed out of the ground during heavy

rain. Tie ridging can also be used on sloping or flat land to increase infiltration.

Black cotton soils present particular difficulties due to heaving of the seedling and rootball. Large losses have been experienced on one site as a result of exposure of the rootball in this way. The heaving is effected by the expansion and contraction of the soil in varying moisture conditions. We believe that this can be overcome by deep planting of large seedlings; this we are currently testing.

Research trials have been conducted into the effect of mulching. A trial using a moisture retaining polymer (Agrosoke) was established in Isiolo. All the trees died but in the harsh conditions of the site, this is not considered conclusive. The polymer may be effective where conditions are better.

Dead vegetation mulches have proved useful in retaining water at planting sites. On some sites, however, they attract termites which eat the seedlings.

Stone mulching was tried and found to be effective in retaining water. The degree of moisture retention has not been quantified.

The effects of weeding in forest practices are well known. In zones III, IV and V grass growth is very vigorous and aggressive and appears to have a marked effect on tree growth. Only one weeding trial has been laid down to study the effect of weeding regimes on Grevillea robusta in zone III. This trial is now only 18 months old but the effect of weeding on early growth is readily apparent. In drier areas the effect of weed competition will be greater.

3. Species and Provenance Trials

It is recognized that there is a lack of knowledge regarding species suitable for use in ASAL. A large part of the research effort in EMI has been addressed to this problem. Nine trials were established on a range of site types. The layout of these trials is described by Lugadiru and Armstrong in LRDC report P-193 (1986). Recent assessment has taken place (September 1987) but analysis is not complete. It is expected that a detailed analysis will be available shortly. The basic attributes of each site and currently promising species are described below.

a). Gategi, Embu

Ecological zone IV; Established in two phases, Dec. 1983 + Oct. 1984. Altitude 1100 m; Black Cotton Soil; ph 7.6-7.9; Rainfall 850 mm

Species showing promise:

Acacia nilotica	(Indian)
Atriplex nummularia	Australia)
Eucalyptus camaldulensis	(Petford + Kimberly, Australia)
Eucalyptus tereticornis	(Kennedy, Australia)
Parkinsonia aculeata	(Baringo, Kenya)

These species are suited to afforestation rather than farm forestry. A range of farm forestry species have been eliminated in the trial. E. camaldulensis is now subject to a recent outbreak of Bostrychid beetles.

Acacia polyacantha initially performed exceptionally well but has now been decimated by longhorn beetles (Taurotagus sp.).

b). Gangara, Embu

Ecological zone IV. Established April 1987.
Altitude 1150 m; Clay loam, ph 4.9-5.9; Rainfall 930 mm.

Promising species:

Cassia siamea	(Local race)
Eucalyptus siamea	(Kimberly, Australia)

Cassia siamea is suited to farm forestry on deep soils along field boundaries, mortality of all species on this site is high. The major cause of death was probably drought at the time of planting. Palatable species have been browsed by small game.

c). Maranga hill, Embu

Ecological zone III. Established May 1984.
Altitude 1420 m; Well drained loam, ph unknown, slightly acid?
Rainfall 1000 mm.

Promising species:

Acacia aulacocarpa	(Australia)
Acacia aulacocarpa	(Eldoret, Kenya)
Eucalyptus grandis x tereticornis	(Zambia)
Cassia spectabilis	(Local)

Cassia spectabilis has limited use for farm forestry as a provider of small poles. The other species are for plantation forestry. The above eucalyptus hybrid shows greater drought

tolerance than the local hybrid E. saligna currently planted on the hill.

d). Marimanti, Meru

Ecological zone V. Established Nov. 1983
Altitude 590 m; Deep sandy clay, ph 6.5; rainfall 750 mm.

Promising species: None.

This is a very harsh site established during the 1983 drought. Survival is negligible and those surviving have been badly damaged by goats and termites. Acacia victoriae is worthy of further interest for the few survivors growing well. It is surprising that Prosopis species fared so badly; this may be due to unsuitable provenances.

The trial illustrates the difficulties of afforesting such harsh sites with species that had been thought to be suited to the area. It further emphasizes the need to concentrate on the better soils especially those found within farm holdings.

e). Kuani hill, Meru

Ecological zone III.
Altitude 1500 m; Red/brown clay, ph 6.5; Rainfall 750 mm.
Three trials are established on this site.

i. Direct sowing trial (now closed).

This trial supports the view that direct sowing is not applicable on such sites with: Acacia albida, Acacia aulacocarpa, Acacia auriculiformis, Acacia mearnsii, Albizia lebbek, Acrocarpus fraxinifolia, Cassia siamea, Cassia spectabilis, Eucalyptus globulus, Eucalyptus saligna, Grevillea robusta, Leucaena leucocephala

ii. Kuani species trials (Nov. 1983).

No species are growing satisfactorily possibly due to nutrient deficiencies. The trial which will soon be written off has demonstrated the importance of research. If afforestation on the hill had been delayed until these negative results were available much money would have been saved. A great deal of resources have been expended by Rural Development Fund and Kenya Tea Development Authority in afforestation attempts doomed to failure on this hill. Despite three failed phases of planting RDF have just received funds for a fourth phase.

iii. Kuani Pine trial (Nov. 1985).

Ten pine species were planted, Pinus kesiya is showing promise. It is too early to make any recommendations or

conclusions on the basis of this trial.

f) . Isiolo (Red soil)

Ecological zone V. Established Nov. 1983.
Altitude 1150 m; Deep, hard red clays; Rainfall 400 mm.

No species are growing satisfactorily on this very difficult site despite the comprehensive range of species used. This trial was intended to investigate possible species for enrichment planting on the Ol Dolnyu Degishu range. The failure of almost all species to survive gives a clear indication that any attempt to carry through such enrichment planting is likely to result in a very expensive disaster. Soil erosion control works and microcatchments to encourage growth of existing indigenous trees will be established in the future.

g). Isiolo (Black soil)

Ecological zone V. Established Dec. 1983, April 1984, Oct. 1984.
Altitude 1110 m; Alkaline, sodic vertisol, ph 8.4;
Rainfall 400 mm.

With the exception of Atriplex nummularia all species suffered 100% mortality. The principal cause of mortality is possibly drought stress, sodicity and saline soils. Other factors may also have been responsible and research is continuing. This site is typical of sites around Isiolo and if a suitable fuel plantation technology can be developed it would be an important success. Amenity tree planting is also considered potentially important .

h). Merti, Isiolo

Ecological zone VI, Established Sept. 1985.
Altitude 960 m; Deep cracking clay, sodic, ph 7.6;
Rainfall 200 mm.

This trial included a variety of irrigation regimes and species. Mortality is very high, no species were growing satisfactorily in April 1987. Final assessment was made in December 1987 and the trial will now be written off.

Summary of Species and Provenance Trials

All these trials illustrate how difficult the working area is for seedling establishment. Species and techniques which were originally thought highly suited to the area and rural requirements have proved unsuitable. Despite the fact that on so many trial sites little real success has been achieved the trials have served a useful purpose.

The trials indicate the desperate need for further research before large scale forestry activities in the ASAL can be

embarked upon. Without research information a great deal more time and resources might be wasted on futile afforestation attempts.

The eucalyptus growing well in Gatego and Gangara can form the basis of institutional fuelwood plantations. However, in order for this to be practical, seed stands urgently need to be established.

Few of the species on the trial sites are suited to farm forestry. This is probably as much a reflection of recent changes in emphasis and thinking as of initial species choice and trial designs.

On Farm trials

There are a dozen on farm trials, mostly in zone III. The scientific value of these trials is limited due to numerous problems encountered in their establishment and maintenance. A good deal of useful experience has been gained regarding the unique problems of such trials. It is apparent that they should be established to research the responses of the farmer and his family rather than silvicultural aspects of tree species.

On farm trials have to meet both the interests of researchers and the farmer who is a professional land manager earning his living. The researcher wishes to evaluate new species and techniques possibly without full understanding of their ramifications within the farm unit. The farmer is always interested in new ideas but must rely on his own experience and judgement to maximize a range of benefits from the shamba. Problems encountered arise from this conflict of interest. Of course, the farmer (rightly) always has the last word.

III. FUTURE RESEARCH

The project has been looking critically at the research programme and planning the next phase. All future research will, as in the past, be pragmatic problem solving in support of RAES. It is intended to formulate a research plan which will lay down research objectives and priorities for the future. A start has been made on this process in which KEFRI should participate fully. The essential components of a future programme are outlined below.

1. Seed procurement

The three districts in the project area should as far as possible be self sufficient in seed. This task has fallen to research to coordinate. Seed stores in Embu and Meru are being equipped and staff trained with the help of the Seed Centre at Muguga. Seed stands of exotic species which do well in trials will be established and seed sources of indigenous species identified. It is envisaged that the Divisional Forest

Extension Officers will take over the operation of seed collection, storage and dispersal. They are already involved in discussions on how the system should be strengthened.

2. Nurseries

Research into appropriate nursery techniques will continue. There is scope for further research into seedling size, rooting behaviour, nursery operation timing, soil mixtures, seedling containers, watering, shading, use of stump cuttings. etc. However, at present a number of well known nursery practices are not adhered to. What role, therefore, does research have in this situation? Nurseries are also unproductive in their use of labour; - is it the role of research to examine work rates and operating methods?

3. Establishment techniques

Research is needed on establishment techniques for ASAL. This includes clearing, cultivation, construction of microcatchments and tie ridges, plant espacement, seedling size, deep planting, transport and handling etc.

4. Sociological Survey

One of the major research priorities in the EMI area is to identify suitable farm tree species for zones IV and V. The farmers' favourite species is Grevillea robusta but this succumbs to drought and termites below 900mm of rainfall. Sociological surveys are necessary to define as tightly as possible farmers requirements and available planting niches. It is essential to learn as much as possible about the perceptions of farmers and those of their families in order to identify suitable species and methods for farm use. It is possible that we may disagree with some widely held rural beliefs ("we don't need to plant trees for fuelwood") but it is important to understand why they exist. The International Council for Research in Agroforestry (ICRAF) "Diagnosis and Design" formula is based on this principle.

5. Species and Provenance Trials

There is still need for research to discover useful species for planting under a range of conditions. These can be broadly categorized:

a). Departmental hill plantings; Zone III.
b). Farm forestry; Zones IV and V.
c). Rehabilitation of degraded ex-shifting cultivation sites; Zone IV and V.
d). Fuel, poles and amenity planting ; Zone V and VI. (In this category indigenous species are likely to be of great importance.)

The requirements of each situation are different and suitable species are in short supply. It is hoped that investigations will continue with a range of species suitable for each situation.

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PAST AND PRESENT FORESTRY RESEARCH IN TURKANA

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ABSTRACT

This paper summarises trials carried out in Turkana between May 1986 and August 1987.

Eighteen indigenous and ten exotic species were selected for trial. Selection was based on local perceptions and a need for nutritional value but low palatability to stock.

Trials to compare survival and growth of the selected species under three planting regimes were established; pitting microcatchments (5 x 5 m and 10 x 10 m) and waterharvesting.

Preliminary results indicate that whilst pitting can lead to successful establishment, water harvesting and microcatchments are better. Differences in survival between techniques are more marked on drier sites. Microcatchments gave the best results, partly due to more frequent and disruptive breakages in waterharvesting structures. The 10 x 10 catchments were best, not surprisingly, as they capture four times the volume of water of 5x5 microcatchments.

The author stresses the need for the local community to be fully involved in research of this kind. The role of local people in guiding and directing his programme was of great importance. Research should be development and socially orientated and in order to be realistic involve a two way exchange of information with local people.

INTRODUCTION

Initially, I am going to give a brief history of research in Turkana. In most ASAL areas of Kenya forestry research is still very young. In Turkana this is the case since forestry development has only started taking place recently. Therefore, it may still be rather early to base conclusions on any results, as it normally takes at least several years of establishment before a species can be regarded as a "Safe Bet" to plant out in the field. However, due to the immediate needs, information must be released and shared as soon as possible, so as to help the person in the field who is trying to plant trees today especially since indications for suitable planting methods and species can now be seen. However, people must be aware that results are only tentative at this stage and that they may well change.

Research in Turkana started in 1981. At that time virtually nothing was known about appropriate trees for this area and, therefore, many different species were tried, some of which are now thought to be absolutely ridiculous. Indigenous trees to

Turkana were planted, so were exotics that were then available in the nurseries of lowland Kenya such as the Jacaranda tree, Eucalyptus spp, Delonix regia and even Grevillia robusta. These species were planted on a random basis around Lodwar in plots and were then watered on an incentive basis, where each person was paid for the number of trees he or she could keep alive during the course of each month. After three years, watering was discontinued, and as a result many of the trees died within a few months. This was found out to be as a result of the way that watering had been done. Each tree received a small amount of water, about 3 litres twice a week, and therefore the surface roots had become well developed to make use of this. However, when the watering stopped many of the trees had not developed any deeper roots and hence died. This was a very valuable piece of information and because of it watering regimes were radically altered so as to try and develop a proper root system on trees as soon as possible. The answer was quite simple, give a lot of water (20 1 approx.) with progressively longer intervals between each watering, thereby gradually weaning off the trees' dependency on artificial watering.

Now getting back to the experimental trees, when the original trees died, it was found that new replacement trees would suddenly appear, often of a different species. It was then realised that this had probably been going on all along the trials life, since the tree waterers wanted the payments to continue for each tree found alive. What simpler way than to go down to the tree nursery and get a replacement tree before the monthly inspection of trees was due. From that we learnt another lesson:- not to water trees on an incentive basis in research work since none of the trial trees may ever die! Although the plots are still being monitored, it is realised that no sound statistical data can be taken from them and that they mainly serve as an indication of which trees could or would not do well. Indeed, for the trials that followed, the information gained served as a very useful guideline on which species should be tried and which most certainly should not.

In early 1984, it was realised by the Forest Department and NORAD that there was an urgent need to establish good data on potential tree species for outplanting in Turkana. This was due to a real lack of information on suitable tree species or any other method of planting trees without watering. Therefore, a series of Browse Trials were recommended and drawn up with the hopes of establishing them by April 1984. However, no Browse Forester arrived to take up duties until December 1984 and therefore the trials were set back for over a year.

In early 1985, work was started, and in conjunction with a browse species survey, five different sites were identified and prepared for planting in Nov/Dec 1985. However, no rains were received and, therefore, no plantings took place. In March 1986 the rains started and by end of May 1986 all the trial sites were planted and, therefore, the sites are now nearly two years

old.

2. SPECIES IDENTIFICATION, SEED PROCUREMENT AND NURSERY PRACTICES

The reason why the trials were to be called "Browse Trials" is because the Browse Factor is regarded as probably the most important attribute for woody species in Turkana as they provide vital food for livestock in the dry season. Initially, a browse species survey was carried out to find out from the Turkana the most important dry season Browse providers. In addition, other alternative traditional uses were noted; as a multipurpose tree would ultimately be more useful. From this information a short list of 18 different species was compiled as listed below.

Acacia tortilis	Acacia elatior
Salvadora persica	Acacia mellifera
Acacia albida	Dobera glabra
Cordia siniensis	Hyphaene coriacea
Zizyphus mauritiana	Boscia coriacea
Balanites aegyptica	Cadaba farinosa
Balanites orbicularis	Grewia bicolor
Balanites pedicellaris	Grewia villosa
Acacia senegal	Maerua crassifolia

A great deal of thought went into the final selection of species, and the above shortlist was decided upon after a lot of discussion with the Turkana. Selection was done, as far as possible, choosing multi-purpose trees where there was not only a good browse potential but also another positive factor associated with the species, such as its fruits or medicinal value. Wherever possible, more unpalatable species were chosen where the nutritional value was estimated as being good but where the livestock only eat the trees when they are hungry. This fulfills two purposes:- it means that the trees would only be browsed in the dry times when the animals become less choosy, thereby leaving the resource until it is needed and it will also enable the plants to have time to establish themselves and recover from any browsing since they would hopefully only be browsed in the dry season. Out of these 18 species, 5 species were eliminated. One (Maerua crassifollia) because no seed could be found. And, the other four (Boscia coriacea, Cadaba farinosa, Grewia bicolor, Grewia villosa) because we couldn't germinate any of the seeds with whatever treatment we tried.

Exotic species were also chosen and their choice was very much limited by the availability of seed. Some species (notably Leuceana leucocephala) were chosen with the expectation that they would not do well especially in the drier areas of Turkana. This was so that they could be eliminated and not tried in the future. The species choice of exotics were as listed below.

Leucaena leucocephala	Cassia sturtii
Prosopis tarmarugo	Acacia nilotica sub indica

Prosopis chilensis	Acacia aneura
Prosopis juliflora	Acacia holosericea
Acacia victoriae	Acacia ligulata

For all the indigenous trees except Balanites aegyptica, seed was collected within Turkana. Prosopis chilesis and Acacia nilotica were also from local collection. The exotic seed was obtained from various sources (for more information on sources and treatments refer to the browse trials report and nursery practices also described in the report (Vogt K. 1987)). All the trees for all the trial were raised in one nursery. Nursery practices were standardised as much as possible for all the species on trial but treatment and actual time in the nursery.

3. EXPERIMENTAL DESIGN

The trials in Turkana were designed to test two main features. Firstly, species suitability and secondly, the most appropriate planting methods for Turkana. Sites choosen were considered to be representative of the larger areas of Turkana and for details on each specific site refer to the browse trials report. (Vogt K. 1987). I will only talk generally of the layout and design of the sites since it is basically the same in each one (with the exception of Kalakol).

It was intended to make the layout and design of each trial as similar as possible so as to enable easy comparison between the sites and between the treatments. Three main treatments were compared, and all species were planted at a 5 metre spacing.

i) Pitting (Control)
ii) Waterharvesting
ii) Microcatchments

In addition, ten by ten metre microcatchments were constructed at some of the sites where there was space and time to do so. These were mainly for comparison with the five by five metre microcatchments.

The trials were designed to compare 18 different species in each of the treatments. Each species is replicated twice in each treatment in plots of 9 trees each (Total 18 trees). These plots are randomly located within each treatment. In each trial the species tried in the different treatments is the same so that a valid comparison could be made of all the species. However, different species are tried in the different sites depending on where they are located. For instance wetter type species would be tried in wetter trial sites.

4. RESULTS

Results obtained so far are based on sites planted for less than two years. They can of course give an indication of what may do

well but I feel that they should be taken with a pinch of salt until a few more years have elapsed.

At this stage, the effectiveness of the different treatments can certainly be seen and it has been proved that trees can be planted on rainfall only if high survival techniques are used. The most vivid contrast between different treatments occurred in Kalatum, the driest site. All the trees were planted on an estimated 115 mm of rainfall which fell from March 1986 to March 1987. After one and a half years, total survival of all the species in the pitting treatment was 2%, waterharvesting 19.9% and microcatchments 42.1%. Taking Cordia sintensis as an example which has so far proved the most adapted species (Indigenous) survival was; pitting 5.65, waterharvesting and microcatchments both at 72.2%. These differences in survival become less and less marked the wetter the area gets but in all the sites a difference can be seen where overall survival is usually higher and a faster rate of growth occurs in the microcatchments and waterharvesting treatments. It is felt by us that although the initial investment is much higher, these high survival techniques can lead to cheaper and ultimately more successful establishment. Once the trees are planted they do not need any more watering saving a lot of time and labour. Weeding and protection are needed at least initially but this is also the case in watered trees.

Results obtained from trials can be seen in the Browse Trial report (Vogt K. 1987). No in depth statistical analysis has been made, only the mean growth rate and the number of trees surviving, have been used in the analysis. This is because the data is still very young and facilities were not available to analyse data.

5. CONCLUSIONS

In conclusion, I would like to compare the different treatments and how they seem to be suited to Turkana conditions and to ASALs elsewhere in Kenya.

Pitting was used as a control in all the sites and it is quite obviously the cheapest treatment to establish any trees. Time taken to build one 5 by 5 metre microcatchment is more than five times that for pits. In the drier areas (150 - 300 mm p.a.) pits are certainly not appropriate and both survival and growth rates have been very low compared to microcatchments and waterharvesting. It has been found that in the wetter areas of Turkana (c 450 mm p.a.) establishment can be quite good if the trees are planted at the proper time and there is sufficient rainfall. It must, however, be realised that growth is slower in comparison to high survival techniques and it may be that one is only saving time and labour in the initial stages. Since the trees may need weeding and protection for a longer period due to their slower growth.

Overall performance is better in waterharvesting than in pitting but when the former is compared with microcatchments it has fared rather poorly. Survival overall is lower and this could be for two reasons. Many species cannot withstand long periods of waterlogging and due to the heavy weed growth trees have been smothered before they could grow away. Many breakages have occurred requiring time to repair them. This means that the trees have not been able to fully utilise the structures which are bringing the water to them. Once the trees are established growth can be spectacular. It is felt by me, that at least for the time being, waterharvesting is not really suitable to Turkana. It requires a lot of work to keep it maintained and if there is one breakage often the whole waterharvesting structure fails.

Microcatchments, have the advantage of being micro instead of macro. If a breakage occurs then usually only one or a few microcatchments are affected and the majority still function. In addition trees planted can never be waterlogged and weeding and maintenance is easier. General performance (survival and growth) has been best in the microcatchment treatments. Both the 5 by 5 and the 10 by 10 have shown good overall survival with no real difference between them. It then comes to mind what is the advantage of a 10 by 10 over a 5 by 5? It takes four times as long to build and is, therefore, that much more expensive. If growth is compared between the two treatments then the real difference can be seen. Not only are the plants in the 10 by 10's taller but they are also sturdier which is not surprising since the plants are receiving four times as much water.

Presently 10 by 10 microcatchments are built in most of Turkana and with proper species choice planting time and after care good establishment should be ensured in most years. In my opinion both the 5 by 5 and the 10 by 10 microcatchments are suited to present Turkana conditions both technically and socially in comparison to the two other treatments (pitting and waterharvesting). Fast growing species can ultimately make more use of a 10 by 10. However, a word of caution if they are to be tried . It has been found that the planting time is absolutely critical when trying to achieve establishment and a difference of four or five days can lead to a resulting high mortality.

6. RECOMMENDATIONS

Before completing this paper I would like to focus attention on a few points which are often neglected concerning research. Primarily use should be made of the indigenous population prior to setting up any research. Both to understand needs and to gain information. Taking as an example the Turkana. The wealth of knowledge that I received from the locals was my main source of information on indigenous tree species. It was they who told me what was useful and why it was useful and they ultimately made the decision for me as to which species should be planted in the

trials. I think that too often researchers may be unaware of the needs of the people, that is their real needs. Quite simply, time and patience to listen to the people is needed. However, there is no time on the agenda for this and the project lifespan is too short. These are very real problems and as a result the researchers may unintentionally bulldoze in with their ideas deciding what they think is best for that particular area without realising the potential wealth of information that could have been tapped from the indigenous population.

Why are the needs of the people and their social customs so often neglected? In Turkana there are many examples of development gone wrong and I feel that forestry research could easily go the same way if care is not taken. What is the point of planting trees successfully in research when this may not be mirrored in reality? To take an example from Turkana, large scale waterharvesting structures can work in establishing trees if they are properly maintained. However, at present they are not suited to Turkana, since it is felt by the locals that the level of organisation and labour required to keep the bunds maintained is not worth the benefits that can be received. Of course research already set up should continue to be monitored, but why should research continue to be developed in this area when it has been found to be inappropriate by the Turkana? Instead of imposing unwelcome ideas is it not much better to divert funds to research which will be socially acceptable and therefore of direct use and benefit to the people?

As results do become available, reports are produced but these can often only be understood by other researchers. This is very necessary but I don't think we should lose sight of who the research is really for. The local people should be kept informed on any progress so that they can judge for themselves and make comments. In Turkana we are trying to do this by taking Forestry Course participants to the trial sites, to let them see for themselves what is happening. We also try to make sure that the watchmen of the sites know and understand the purpose of the trials so that they can talk to any locals who may arrive at the site.

I feel that the role of research is not only the gathering and analysis of information, but that it can also be a very useful extension tool. Showing different species growing under different conditions on the ground. Local people should be encouraged to visit the sites and see for themselves what is doing well and what isn't. In that way a two way flow of information can be generated where the effectiveness of new ideas can be seen on the ground and taken back to the manyatta, and where often very useful comments and observations will be made by those visiting the site.

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AGROFORESTRY RESEARCH IN SEMI-ARID TAITA/TAVETA

by

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TAITA/TAVETA DISTRICT DEVELOPMENT PROGRAMME

ABSTRACT

Taita/Taveta District Development Programme (TTDP) has carried out both a socio-economic baseline survey and an agroforestry survey in the area. It was found that fruit trees are favoured despite problems of disease, poor varieties and low market prices. Constraints in the farming system include a shortage of labour, low soil fertility, fodder and water shortages. The major constraint to tree planting appeared to be seedling availability.

Agroforestry intervention involving the use of highly productive leguminous tree species were recommended to tackle the problems of soil fertility and dry season fodder. Intercropping trials with Leucaena spp., Calliandra calothyrsus and Sesbania spp., were recommended and initial responses are encouraging.

Initially the problem of seedling availability has been tackled by the establishment of dispersed distribution centres. These distribute the production of large nurseries to rural areas. In future seedling production should be de-centralised.

BACKGROUND

TTDP is an integrated development programme which concentrates on the drylands of Taita/Taveta district. This area varies in altitude from about 600 m to 1,000 m with an average annual rainfall of 500 mm to 750 mm. Poor sandy soils are predominant in the area. Major inhabitants are the Taita, who are an agricultural people and who are increasingly being pushed into semi-arid lands due to over-population and land scarcity. Much of the land is under some form of ownership, though not always adjudicated. Severe soil erosion is among the major problems in the drier parts of the district.

SURVEY RESULTS

The programme held a socio-economic baseline survey (covering about 250 households) with the following results for the survey area (about 10,000 people):

1. Local propagation (or establishment) techniques are mainly concerned with fruit species and with construction species. Tree planting for fuelwood production is not done.

2. Local people consider seedling availability as the major constraint of tree planting (i.e., tree seedling planting).

3. Labour shortage is a major constraint: male/female ratio in age group 30 - 40 years is about 1:4!

4. Only about 10% of the farmers in the area have ever purchased any seedlings from any government agency.

Preliminary results of the agroforestry survey confirm the above and also indicate that:

1. Intercropping of trees and foodcrops is intensively practiced, especially maize and/or pigeon pea with custard apple, cashew, mango, citrus, Melia spp., Azedirachta indica, Olifeira mangifera, Syzygium cuminii and other species.

2. Fruit trees are found in a high density. Their major function is subsistence food and cash production. Yet, three major constraints seem to be significant: lack of high yielding (grafted) varieties, high incidence of disease and, therefore, low yields and low market prices for fruits.

3. Maize is the major foodcrop grown during the two rainy seasons, but seems to be subject to two major constraints: low water availability and low soil fertility. Although soil fertility is subject to great local differences, the following indicators of such low fertility have been found:

   - fallow is not much practiced, if at all, due to land scarcity

   - chemical fertilizers are not used because of the great distance between homestead and shamba (many people live in "villages" away from their shambas).

   - in many cases, improved/hybrid seed has been tried, but allegedly "failed". Local seeds are considered more productive. This indicates (among others) insufficient soil fertility.

   - in some cases, respondents mention "soil fertility" as the major problem they face on the farm.

4. The major constraints in livestock production are: shortage of grazing/feed and lack of water.

Objective No. 1: solve constraints in the farming system where appropriate with agroforestry.

The apparent constraints in the farming system outlined above favour the introduction of highly productive leguminous tree species, both for soil fertility aspects and for dry season

livestock feed. In the current farming system there is a notable lack of N-fixers. The following arguments can be carried forward to introduce intercropping of such species in maize:

- additional soil N is required from a nearby source at minimal cost to increase maize production. (Homesteads, i.e., dung are too far removed from the shambas.)

- additional fodder is needed, especially protein rich fodder, and especially in the dry season,

- farmers are used to propagating trees, especially direct sowing and planting wildings.

- farmers are used to tree/foodcrop intercropping.

Various leguminous trees are potential candidates to fill this "niche" in the farming system. Species with a high production potential are Leucaena spp., Calliandra calothyrsus and Sesbania spp., Prosopis spp. have a high crude protein content but a capacity to improve soil N in favour of maize is not proven. They have thorns which farmers don't like but they are much more drought resistant. Mbololo is probably too dry for Calliandra. It may also be too dry for Leucaena but there are two encouraging factors: Firstly, the seedlings can be planted at the trash lines where extra water penetration may be expected, and secondly, stray animals are not allowed in, even after the foodcrop is harvested. Atriplex nummullaria is a hardy fodder crop worth trying. They are available in the Voi nursery.

Leguminous tree intercropping is an entirely new concept in the area of concern (Mbololo), and all proposed species are also new for the area. It is, therefore, necessary to test the concept through on-station and on-farm trials. Therefore, experiments have been established with 12 trial farmers and Mwakiki seed farm. The main variable is species but it also includes microcatchments and soil conservation structures.

The trials at the seed farm are more or less governed by the conditions laid down by MOA (fodder plot). The trials on the 10 trial farms are designed through a dialogue between farmers and project staff. Potential trial farmers are a subsample of the agroforestry survey.

Objective No. 2: How can seedling distribution to local farmers be improved and what is the impact of such improvement?

MENR and MOA (supported by DANIDA) can give immediate assistance by improving the accessibility of the Mbololo farmers to Forest Department and MOA seedlings. There is a clear need for seedlings and the current production of construction/shade/protection trees by the Forest Department and of fruit trees by MOA is large. The MENR nursery at Voi (25 km from Mbololo) has a stock of 250,000 seedlings of which a very small proportion is

actually distributed. The seedlings can be made available during the rainy season through a system of local seedling distribution centres. The seedlings are then provided within fair walking distance and at normal government prices. In the longer term, decentralised seedling production should be stimulated.

RESULTS TO DATE (FEBRUARY, 1988)

The trials have been established and show encouraging results. Some species show good growth of about 1.5 m in 3 months, despite low rainfall (only about 50% of the average for that period). Local farmers are very enthusiastic about the idea of trees for fodder and soil fertility (with fuelwood as a by-product) which is among others indicated by the seedling sales. The trees are well protected, sometimes mulched or even watered without being asked to do so.

The trials are administered by the divisional extension forester (Voi) with copies at the district HQ in Wundanyi. Responsibility will be shared with the local MOA TAs, who are increasingly incorporated in agroforestry R & D in Taita/Taveta.

THE SEEDLING DISTRIBUTION SYSTEM AND ITS IMPACT

A network of temporary seedling distribution centres has been established during the November rains and the distribution has been closely monitored. Some of the results to date are:

- Previously only 10% of the farmers had ever purchased any seedlings from government nurseries. During the November '87 rains, about 50% of the farmers purchased seedlings just during the 4-week period of rain. (Sample area: 1,400 households.) The research also comes up with species preference of the local communities which shows a complex pattern.

Research into survival and growth is the next step.

FORESTRY RESEARCH IN THE BURA IRRIGATION SETTLEMENT PROJECT TANA RIVER DISTRICT, KENYA.

by

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ABSTRACT

This paper presents the activities of the FINNIDA supported Bura Forestry Research Project. The paper outlines the background, objectives and main activities, and also presents some preliminary results. Finally, the paper discusses aspects of forestry development in connection with irrigated agricultural schemes with special regard to the Bura Irrigation Settlement Project.

INTRODUCTION

The Bura Irrigation Settlement Project (BISP) is a project which is aimed at developing the irrigation potential of the Lower Tana River Basin. Since the late 1970's about 2,000 tenant farmers have been settled in the Bura Division cultivating an area of 2,500 ha of cotton and maize. Currently, the scheme's population is about 13,000 people with an additional 3,000-4,0000 people consisting of BISP staff, government administrators and business community. The traditional Malakote and Orma population is estimated at about 10-15,000 people. However, the BISP infrastructure development has been provided for the extension of the project up to 6,700 ha of cultivation and the settlement of 5,500 tenant families.

Bura is situated in the semi-arid bushland on the West bank of the Tana River. Rainfall is about 300-350 mm/a, very erratic, and the potential evaporation is 2,5000 mm/a. The project area lies on an old alluvial terrace of the Tana River and soils mainly consist of Entisols, Aridisols, and Vertisols. From a vegetation point of view, the riverine forest is the most significant harbouring several rare and endangered species of flora and fauna.

The Bura Forestry Research Project (FORP) is a sub-component of the FINNIDA (Finnish International Development Agency) funded Bura Fuelwood Plantation Project (BFPP). The main objective of the BFPP is to ensure the fuelwood supply for the scheme population, primarily by establishing 600 ha of irrigated fuelwood plantations. Also other forestry related needs are in the scope of the project.

The research component started in 1984 and it is implemented

jointly by the Department of Silviculture at the University of Helsinki, Finland and the Kenya Forestry Research Institute (KEFRI). The objectives of the forestry research in Bura are to produce information needed in the implementation of the BFPP on such silvicultural aspects as the choice of species for different afforestation purposes as well as on stand establishment and management aspects. One central task is to analyze the interaction between the human population in the area and the surrounding environment in order to be able to develop strategies to prevent further land degradation as well as strategies for sustainable management of the ecological zones found in and around the scheme. In addition, the FORP aims at increasing the general knowledge of irrigated as well as non-irrigated fuelwood production, and it is geared towards strengthening the local research potential through training and development of a sustainable research programme in Bura.

2. RESEARCH APPROACH

A number of pre-set factors initially determined the scope for the forestry research in Bura. Basic silviculture information, especially on irrigated plantations was urgently required. The natural woody vegetation was being degraded both in the bushland and the riverine forest. The scheme area and the villages in particular were in urgent need of amenity and protective planting.

The first silvicultural data were obtained in 1984 from field trials established by the National irrigation Board in Hola. Species and management trials were soon replicated at the plantation site in Bura. Simultaneously, contacts were established with the organizations in order to facilitate the planting of future research needs.

During Phase I of the FORP (1985-87) the scope of activities has gradually been broadened. Preliminary studies on natural forests indicated an urgent need to monitor the rapid changes taking place in them; consequently, much emphasis has been given to development of conservation and management methods for both the bushland and the riverine forests.

The fact that irrigation water is not available to the extent originally perceived has also shifted the focus more towards such activities as the rainfed fuelwood production, water harvesting and the use of drainage and seepage for the crops.

3. MATERIALS AND METHODS

Currently about 105 different species, excluding provenances, have been included in the species screening although larger field scale trials are in the process for the main species in order to study plantation performance. The general experimental design for the species trials has been randomized blocks with five replications usually with 25 tree plots in a 5 x 5 planting

pattern.

In experiments where for instance the effect of land preparation, irrigation or spacing was studied on different species, a split plot design was used. The former comprise the main plot and the species the sub-plot.

In the studies on indigenous vegetation different methods were applied. In order to monitor changes in the forest and to establish the standing volume, nine permanent sample plots were established. The plot size was 0.08, 0.24. and 0.32 ha depending on the density of the forest. In 1985 a strip survey was carried out along transect in the bushland in connection with the development of biomass equations for Acacia reficiens and A. zanzibarica.

An ethno-botanical approach was adopted in conducting a botanical survey in the Bura Division as well as in the study on the traditional uses of trees and shrubs among the Malakote and Orma in the Bura area.

4. SOME PRELIMINARY RESULTS

4.1. Species and provenance selection

So far, the greatest potential has been found in several Prosopis species, which have reached MAI's of 13 m3/ha/a to 20 m3/ha/a in irrigated plantations. All other species, including the eucalyptus produced less than 10 m3/ha/a. However, the results were based on observations during the first few years of development only. The most promising one is Prosopis juliflora of the less thorny Baobab Farm (Mombasa) provenance, of which there also is a progeny test established in Bura. However, Prosopis pallida has also been performing well and it seems to produce almost no natural regeneration which is a great advantage in irrigated plantations. For the rainfed plantations the local (provenance unknown) Prosopis juliflora seems most suitable because of its rapid early development, it's protective thorns as well as its profuse pod production and easy natural regeneration.

An irrigated Eucalyptus microtheca provenance trial indicated that the best provenances were Mt. Isa-Hughenden, QLD; Walgett NSW-N Mungindi, QLD; Jericho-Longreach-Blackhall, QLD, and Fitzroy River, QLD. Their respective MAI (considering the survival rates) after two years were: 11.0, 9.8, 9.4, and 9.2 m3/ha/a.

Most other trials (see Appendix I) are still too young to allow any conclusions to be made. These trials include a number of different aspects such as, rainfed species trials, rain water harvesting, windbreaks, local indigenous species trials.

4.2. Stand establishment and management

In 1984 a biomass equation was developed for irrigated Prosopis juliflora in Hola. Separate equations were prepared for the whole tree and different components of the tree. In 1985 two other biomass studies were conducted. In Hola, volume equations were developed for irrigated Eucalyptus camaldulensis and Terminalia brownii and in Bura biomass equations were developed for Acacia reficiens and A. zanzibarica indigenous to the bushland surrounding the scheme.

A comparison between planting and direct sowing of Prosopis juliflora under long-furrow irrigation on two different furrow-types (shallow and deep) indicated that planting is a more secure alternative for plantation establishment. Survival when planted was 98% (shallow) and 88.9% (deep) after two years, whereas at sowing the survival was 78.8% and 42% respectively. The MAI for planting was 14 m3/ha/a (shallow) and 15 m3/ha/a (deep), and for sowing the respective observations were 12 and 13 m3/ha/a.

A comparison between Prosopis juliflora and Eucalyptus camaldulensis on the same two land preparation methods and on four different planting spots was established in 1984. After two years the results indicated that from the point of view of growth performance there was little difference between the treatments except for between the species. The MAI of P. juliflora was significantly higher than that of E. camaldulensis. The MAI of the former ranged from 13.8 m3/ha/a to 15.9 m3/ha/a the highest of which was observed for planting in the bottom of the shallow furrow. For E. camaldulensis the range was from 6 to 6.4 m3/ha/a.

A study on the effect of four different irrigation levels on the early development of P juliflora indicated that after one year there was little difference with regard to height development between the irrigation levels. Height was 3.5 m at 1,000 mm/a whereas at 1,500 mm/a and 500 mm/a height was 3.45 m and 3.25 m respectively. In the non-irrigated treatment height was 1.31 m. Survival ranged from 88% (non-irrigated) to 93% (1,000 mm/a).

The preliminary results from a study on the Rhizobium-Prosopis juliflora symbiosis indicated that drought seemed to prevent the nodulation on young trees. Also it was discovered that root nodules were generally found in the moist soil layer, i.e., in the uppermost 15 cm soil layer. The nodulation trial further revealed that it may be possible to increase biomass production if a competitive and ecologically well adapted Rhizobium inoculant can be found. However, Prosopis juliflora seems to tend to form nodules with ineffective Rhizobium strains.

A spacing trial in Hola revealed a rather surprising observation regarding Prosopis juliflora. The highest MAI after 5 years was observed at closest spacing (6,173 trees/ha) with 13.3 m3/ha/a, and at the spacing of 1,610 trees/ha where MAI was 12.6 m3/ha/a.

The observations for the other treatments were ranging from 8.1 m3/ha/a (4,274 trees/ha) to 8.4 m3/ha/a for 1,089 trees/ha. For Azadirachta indica in spacings closer than 2,525 trees/ha the MAI was ranging from 3.5 - 3.9 m3/ha/a. At wider spacing survival and MAI were drastically reduced.

4.3. Population - environment interaction

The permanent sample plots had been assessed in 1984 and again after about two years in 1987. Six of the plots are situated in what can be characterized as riverine forest. In 1987 the average number of trees was 2,400 trees/ha ranging from 1,513 to 3,663 trees/ha. Average standing volume was 159.6 m3/ha varying from 78.9 to 260.2 m3/ha. The average stocking in the three plots in the transitional zone between the riverine forest and the bushland was 1,476 trees/ha ranging from 1,108 to 2,175 trees/ha. Average standing volume was 24.5 m3/ha ranging from 11.6 to 42.6 m3/ha.

Along the bushland transect the average biomass for the two dominant species (A. reficiens and A. zanzibarica), and A. tortilis and Cordia sp. was 4,670 kg/ha or 3.9 m3/ha. It was also found that the same biomass function applies to both acacias. Moreover, pilot tests with Acacia tortilis indicated that the equation would also be applicable for this species.

During the ethno-botanical study a total of 232 indigenous trees and shrubs were identified by their vernacular Malakote, Orma and Somali names as well as by their scientific names. Moreover, the traditional uses for different purposes such as fuelwood, building, material items, food, medicinal as well as religious and other social uses have been established among the Malakote and the Orma. Based on this information, seed collection, nursery and field trials with different indigenous species have been initiated.

An inventory of amenity tree planting in some of the BISP villages was conducted in 1985. At the time of the study it was found out that the major obstacles for large scale participation in village afforestation was uncontrolled grazing and lack of water. However, both of these problems have been overcome by now. Also, a list of trees suitable for amenity purposes was compiled and it was found that fruit trees had a high priority among the farmers.

5. DISCUSSION

The main objective of the forestry research was to provide the fuelwood plantation project with operational information. Despite the rather short period of research, preliminary recommendations have been given regarding species selection, provenances, site preparation, plantation management aspects as well as general afforestation strategies.

During the course of the work it has become obvious that afforestation in irrigated agricultural schemes is in it's concept quite different from ordinary afforestation activities in ASAL areas. There are some particular features worth mentioning in connection with irrigated land development which have implications regarding forestry activities. Firstly, the availability of water in theory allows a much wider range of species and approaches to be included. However, the experience in Bura as well as from a number of similar much larger projects in the Sudan indicate that the water supply rarely is reliable. Consequently, the availability of direct irrigation water is usually limited for forestry development. Secondly, irrigation invariably means a high concentration of people in areas where the normal carrying capacity is low. Thirdly, land use is very intensive and technical level of operations are fairly sophisticated requiring skilled and efficient project management. Hence, the sequence of agricultural operations is pre-set, usually fairly tight and requires good timing in order to produce the expected outputs. By the nature of operations decision making as well as agricultural activities such as land preparation, irrigation, spraying and harvesting are rather centralized with little room for flexibility. Finally, the natural production potential under rainfed conditions is very low but through irrigations yields of tree crops can be increased up to 5 - 10 times the yield of any rainfed crops.

The implications regarding forestry development in Bura are:

(1) Despite that the potential yield of systematically irrigated tree crops can be much higher than under rainfed conditions the unreliability of water calls for a broader afforestation strategy;

(2) The concentration of people has lead to a severe depletion of the woody biomass from the surrounding bushland as well as the riverine forest;

(3) The multi-ethnic nature of the settlement in combination with a new environment as well as the entirely new mode of agricultural production, which is manifested through partial labour shortage, is a limiting factor;

(4) The level of technology is fairly high which also enables a more intensive technological input in the forestry development.

Based on the preliminary results and findings during the project period (1984-87) a number of strategies are proposed. The short-term approach would be geared towards maximum production of wood within the scheme by integrating different forestry and tree planting strategies in the agricultural development and priorities of the BISP. A long-term strategy would be geared towards integrating the BISP, particularly the forestry component, into the overall development of the division or

district. This would call for a stronger extension input in order to gain momentum from the involvement of people in the implementation. However, both strategies, which eventually are geared towards a sustainable management of the natural resources, should be supported by a strong research component.

Some specific aspects in the short-term strategy are:

It is important that the area developed for the irrigated forestry plantations is fully utilized since the yields from the 600 ha are about 9,000 m3/a, which is more than 50% of the total BISP demand (at 1 m3/c/a). A total potential of about 1,000 ha can be developed with little additional cost. If this area can be planted up to 80% of the demand can be met from the irrigated plantations. The water constraints will prevent systematic irrigation but the process of irrigating when water is available will still result in yields which are substantially higher than those from any rainfed plantations.

It is equally important that the BISP management recognizes that domestic energy supply as well as the protective aspects of tree planting (protecting houses, irrigation structures and increasing crop yields) are an essential part of the success of the settlement or agricultural development. In this respect, it would be important that during excess pumping capacity and off-peak agricultural seasons priority to water is given also to forestry.

All potential drainwater, overflow and seepage areas need to be identified and planted. Experience in Bura indicated that the availability of water in these areas is often more reliable than in the irrigated forestry areas. This would be in the form of block plantations, windbreaks, shelterbelts, canalside plantations as well as roadside plantations.

Water harvesting methods such as the method used in Bura where contour ploughing is done with a heavy site preparation plough seems to be a successful way to establish rainfed plantations of Prosopis juliflora. Consideration should also be given to the potential of diverting small seasonal watercourses in order to provide establishment and seasonal irrigation for tree crops.

Alongside this, the development of a strong extension component is necessary in order to involve both tenants as well as the traditional settlements in forestry activities. In the long-term, tree crops may become an important source of employment and supplementary income for both groups.

During the project it also became apparent that local knowledge about trees and their uses can greatly facilitate research on indigenous species as well as the implementation of the forestry project. The preliminary experience indicates that the use of indigenous trees for protective and amenity purposes as well as for fruit production may be successful due to better ecological

adaptation and acceptance by the indigenous people.

However, the perspective of the long-term forestry development in Bura is faced with several aspects of uncertainty due to the lack of research results and practical experience upon which to base decisions. Particularly, aspects such as sustainable management of indigenous forests, the use of indigenous species for different afforestation purposes, the degree of interest to grow tree crops on an individual basis among the tenants as well as the indigenous population call for additional research efforts.

APPENDIX I

FIELD EXPERIMENTS INCLUDED IN BURA-FORP

ACRONYM	EXPERIMENT
HOPH I	Umoja Forestry Trials, Phase I, Species Trial (NIB, Hola) Year established: 1979 Year assessed: 1984 Objective: To test 12 species under 4 irrigation levels
HOPH II	Umoja Forestry Trials, Phase II, Species Trial (NIB, Hola) Year established: 1980 Year assessed: 1984 Objective: To test 11 species under 4 irrigation levels
HOPH III	Umoja Forestry Trials, Phase III, Spacing Trial (NIB, Hola) Year established: 1981 Year assessed: 1984, 1985, 1986, 1987 Objective: To test 3 species under 5 different spacings
HOPH IV	Umoja Forestry Trials, Phase IV, Eucalyptus Provenance Trial (NIB, Hola) Year established: 1982 Year assessed: 1984, 1986, 1987 Objective: To test 12 different eucalyptus provenances under 4 irrigation levels
PROMAS	Prosopis juliflora Biomass Equation Year conducted: 1984 Objective: To develop a biomass equation for Prosopis juliflora in order to enable the quantification of growth
BUPP	Inventory of Pilot Prosopis juliflora plantation in Bura Year established: 1983 Year assessed: 1984, 1988 Objective: To test the effect of irrigation on different distances from the irrigation source, and to make an inventory of plantation establishment. In 1988 to assess the growth of a plantation which has only received initial irrigation for one year; thereafter, rainfall only
TANFOR	Permanent Monitoring Plots in the Tana River Forest Year established: 1984 Year assessed: 1984, 1987 Objective: To monitor changes in the natural vegetation and to investigate the structure and stocking of the

natural forests.

EMIPRO — International Eucalyptus microtheca Provenance Trial
Year established: 1984
Year assessed: 1984, 1985, 1986, 1987, 1988
Objective: To test 16 provenances under irrigation

BUSP. 1 — Bura Species Trial, Phase I
Year established: 1984
Year assessed: 1986, 1986,1987, 1988
Objective: To test 12 species under irrigation

BUIRM — Bura Irrigation Method Trial
Year established: 1984
Year assessed: 1986, 1986, 1987, 1988
Objective: To test two species under 2 furrow designs and 4 planting spots

PROEM — Prosopis juliflora Establishment Method Trial
Year established: 1984
Year assessed: 1986, 1986, 1987, 1988
Objective: To compare direct sowing and planting of Prosopis juliflora on two different furrow-types under irrigation

PRODIR — Prosopis juliflora Direct Sowing Trial
Year established: 1985
Year assessed: 1985, 1986, 1987
Objective: To test the seed requirement of Prosopis juliflora in direct seeding under irrigation

ETVOL — Volume functions for Eucalyptus camaldulensis and Terminalia brownii
Year conducted: 1985
Objective: To create volume function for one exotic and one indigenous species which were promising under irrigation

BIOMAC — Biomass equation for Acacia reficiens and A. zanzibarica
Year conducted: 1985
Objective: To establish biomass function for two indigenous bushland acacias in order to facilitate the calculation of the potential production of the bushland

BUAME — Inventory of the Success of Amenity Tree Planting in Bura
Year conducted: 1985
Objective: To make an inventory of the BISP village afforestation and to establish the causes for success or failure and to establish the aspirations of the tenants

PROPRO — Prosopis juliflora Progeny Test and Seed Orchard
Year established: 1987
Year assessed: 1987
Objective: To test the progenies of selected thornless plus trees of Prosopis juliflora, Baobab Farm, (Mombasa) provenance and to establish a small seed orchard

BUSP. 2 — Bura Species Trial, Phase II, OFI Species Trial
Year established: 1987
Year assessed: 1987
Objective: To test 16 species in cooperation with KEFRI and the OFI under irrigation

BURVEG — Botanical identification of the Plants of Bura
Year conducted: 1986, 1987
Objective; To identify all trees and shrubs in the Bura area by their botanical as well as vernacular (Malakote, Orma, Somali) names in order to facilitate any activities concerned with the natural vegetation

PRONOD — Prosopis juliflora Nodulation Trial
Year established: 1986
Year assessed: 1986, 1987
Objective: To test selected seedlots of Prosopis juliflora on 4 different levels of irrigation and to provide the material for the study on nitrogen fixation

PROIN — Prosopis juliflora Inoculation Trial
Year established: 1987
Year assessed: 1987, 1988
Objective: To test the field performance of Prosopis juliflora inoculated with 15 strains of Rhizobia partly isolated from the PRONOD

CASIN — Casuarina equisetifolia Inoculation Trial
Year established: 1987
Year assessed: 1987, 1988
Objective: To test the field performance of Casuarina equisetifolia inoculated with Frankia

PROSOD — Prosopis juliflora Seed Germination Test
Year established: 1986
Year assessed: 1986
Objective: To test the germination of seed used by the project

PROSOW — Prosopis juliflora Sowing Depth Test
Year established: 1986
Year assessed: 1986
Objective: To establish the optimum sowing depth of Prosopis juliflora under irrigation

BUTRUS Traditional uses of Indigenous Trees and Shrubs in Bura Division
Year conducted: 1986, 1987, 1988
Objective: To establish the traditional uses of trees and shrubs among the traditional Malakote and Orma people of the Bura area in order to facilitate the use of local tree species for different tree planting purposes

BUSP.3 Bura Species Trial, Phase III, Acacia species
Year established: 1987
Year assessed: 1987, 1988
Objective: To test 15 indigenous and exotic Acacia sp. under rainfed conditions using traditional plantations establishment techniques .

BUSP.4 Bura Species Trial, Phase IV, ASAL species
Year established: 1987
Year assessed: 1987
Objective: To test 13 indigenous and exotic species under irrigation

BUWIB Bura Windbreak Trial
Year established: 1987
Year assessed: 1988
Objective: To test the suitability of 7 species for windbreak planting and to use it as a demonstration area for farmers

BUIRIT Bura Irrigation Interval Trial
Year established: 1987
Year assessed:
Objective: To test 4 species on 5 irrigation intervals

BUSP. 5 Bura Species Trial, Phase V, Rainfed Water Harvesting Trial
Year established: 1987
Year assessed:
Objective: To test 18 species under rainfed conditions on a site prepared by a heavy site preparation plough for more effective water harvesting.

APPENDIX 2

BURA FORESTRY RESEARCH TECHNICAL REPORTS

1. Johansson, S., 1985: Forestry Development in the Bura Irrigation Settlement Project. Final Report for 1984 (Draft). University of Helsinki and Kenya Forestry Research Institute.

2. Makela, M., Johansson, S. and Luukkanen, O., 1985: Success of Amenity Tree Planting at the Bura Irrigation Settlement Project. University of Helsinki and Kenya Forestry Research Institute.

3. Sarajarvi, I., Johansson, S. and Luukkanen, O., 1985: Biomass Functions for Irrigated Prosopis juliflora plantations in Tana River District, Kenya. University of Helsinki and Kenya Forestry Research Institute.

4. Sarkeala, J., Johansson, S. and Luukkanen, O., 1985: Volume Functions for Eucalyptus camaldulensis and Terminalia brownii in Irrigated Fuelwood Plantations in Tana River District, Kenya. University of Helsinki and Kenya Forestry Research Institute.

5. Vertanen, A., Johansson, S. and Luukkanen, O., 1986: Biomass Equations for Two Indigenous Acacia species (Acacia reficiens and Acacia zanzibarica) with Special Reference to the Composition and Biomass of the Savanna Forest in Bura, Tana River District, Kenya. University of Helsinki and Kenya Forestry Research Institute.

IN PREPARATION

6. Gachathi, N. et al., 1987: A Check-list of Indigenous Trees and Shrubs of Bura, Tana River District, Kenya with Malakote, Orma and Somali names. University of Helsinki and Kenya Forestry Research Institute. (In preparation.)

7. Miettinen, P., Luukkanen, O., Johansson, S. and Mulatya, J., 1987: Studies on the Rhizobium-Prosopis juliflora symbiosis in the Bura Irrigation Settlement Project, Tana River District, Kenya. University of Helsinki and Kenya Forestry Research Institute. (In preparation.)

8. Mulatya, J., 1987: Results from a nursery soil mixture trial. University of Helsinki and Kenya Forestry Research Institute. (In preparation.)

9. Alakoski-Johansson, G., et al., 1988: Traditional uses of trees and shrubs among the Malakote and the Orma in the Bura Division, Tana River District, Kenya. University of Helsinki and Kenya Forestry Research Institute. (In preparation.)

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3. Johansson, S., 1984: Silvicultural Pilot Research Programme for 1984. In: Hakkila et al., 1984. A revised Implementation Plan for the Bura Fuelwood Plantation Project. FINNIDA, Helsinki.

4. Johansson, S., 1984: Silvicultural Pilot Research Programme - Detailed Working Plan.

5. Johansson, S. and Vainio-Mattila, A., 1984: Rural Development in the Bura Irrigation Settlement Scheme. Case study presented on the 12th internordic course on forests and forestry in developing countries, 17-28 September, 1984, Helsinki.

6. Johansson, S., 1984: Proposal for the Outline of the Forestry Research Component at the Bura Irrigation Settlement Scheme. Background paper for the FINNIDA Bura Forestry Project Appraisal and Planning Mission, 29 October - 15 November, 1984.

7. Luukkanen, O. and Johansson, S., 1985: Fuelwood Production at the Bura Settlement Scheme (Tana River District, Kenya)- Project Document, FINNIDA, Helsinki.

8. Makela, M., 1985: Success of Amenity Tree Planting in the Bura Irrigation Settlement Scheme, Tana River District, Kenya - Research Plan.

9. Sarkeala, J., 1985: Volume Functions for Eucalyptus camaldulensis and Terminalia brownii in Irrigated Fuelwood Plantations in the Tana River District, Kenya - Research Plan.

10. Vertanen, A., 1985: Biomass Equations for some Indigenous Tree Species with Special Reference to the Composition and Utilisation of the Savanna Forest at Bura, Tana River District, Kenya - Research Plan.

11. Johansson, S., 1985: Preliminary List of Potential Species for Afforestation and Experimentation in the Bura Irrigation Settlement Project.

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15. Luukkanen, O., Johansson, S. and Saarainen, T., 1986: Arid Region Afforestation Studies in the Sudan and Kenya - Paper presented at the Meeting of the Nordic Sahel Group. Kotka, 11-12 September, 1986.

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NOT YET FULLY COMPLETED

22. Odera, J., 1987: Development of Dryland Afforestation Systems and Modules of Sustainable Utilization of Plant Genetic Resources. A project proposal for funding by FINNIDA and the Government of Kenya presented during the annual programme consultations between the governments of Finland and Kenya, February, 1987, Nairobi.

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24. Alakoski-Johansson, G. and Gachathi, N., 1987: Preferences of indigenous species for firewood and charcoal among the Malakote and Orma peoples in Bura, Tana River District, Kenya. Background paper prepared for the planning team of the Bura Fuelwood Plantation Project Phase II.

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26. Kaarakka, V., 1987: Reference literature issued by the Bura-FORP to the Kenya Forestry Research Institute in Bura.

27. Gachathi, N., 1987: The State of the indigenous forest in Bura, Tana River District. A background paper for the Kenya Forestry Research Institute.

28. Johansson, S., Alakoski-Johansson. G., Luukkanen, O., Mulatya, J. and Gachathi, N., 1987: Ethno-botanical approach to seed procurement, experience from Bura, Kenya. Paper presented at the International Symposium on forest Seed Problems in Africa, 22 August - 2 September, Harare, Zimbabwe.

29. Miettinen, P., Luukkanen, O., Johansson, S., Eklund, E. and Mulatya, J., 1987: Rhizobium nodulation in Prosopis juliflora seedlings at different irrigation levels in eastern Kenya.

30. Alakoski-Johansson, G., Johansson, S., Kaarakka, V., 1987: Local knowledge contributes to tropical forestry research: An ethno-botanical case study from Bura, Kenya. Paper presented at the internal seminar on Special Problems in Tropical Silviculture (MH 36), Department of Silviculture, University of Helsinki, 30 September, 1987.

31. Gitonga, J., Johansson, S., Mulatya, J., 1987: Irrigated forestry in the Sudan. Report from a study tour to the Sudan, 02-15 October, 1986.

32. Mulatya, J., 1987: Summary notes of the proceedings of the International Symposium on Forest Seed Problems in Africa, 22 August - 2 September, Harare, Zimbabwe.

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preliminary results from BUSP. 1, BUIRM, PROEM, PERODIR, HOPH.4, TANFOR and PRONOD.

DISCUSSION SESSIONS

1. SILVICULTURE

Chairperson: Dr. J.A. Odera

1.1. Inadequacy of information and lack of a clear understanding on appropriate establishment techniques i.e., water harvesting and how to raise hardy, balanced seedlings was recognised. It was agreed that a summary of available but scattered information by different research projects be compiled for dissemination (including problems such as pit sizes, micro-catchment and establishment costs, etc.). KEFRI was charged with the responsibility of undertaking the necessary investigation to furnish answers to the problems.

1.2. Widespread incidence of encroachment by man and livestock on public land areas, and conflicting land use, especially where land is communally owned were recognised as big problems in Kenya. It was recommended that acceptable land use strategies that integrate tree planting, grazing and other uses, based on results of socio-economic studies, be developed.

1.3. There is a lack of precise information on the raising of nursery stock and timing of planting out and follow up. It was recommended that information on the existing state of the art as practiced by different agencies (short term) be documented, and to ensure that copies of such information be deposited at KEFRI headquarters.

1.4. It was recognised that tree planting is crippled by a limited range of candidate tree/shrub species and provenances. It was recommended that the KEFRI Seed Centre initiate co-operation with international centres such as CSIRO or Central American Seed Centres with similar ecological zones.

1.5. It was recognised that inadequate information exists on the performance (growth vigour and survival) of given trees/shrubs on given sites, making it difficult for farmers to select species rationally. To solve this problem, it was recommended that attempts be made to classify or adopt existing classifications, to cover the potential of trees and shrubs incorporating their adaptability and productivity per unit of land, time and labour.

1.6. It was recognised that plant and grassland communities in semi-arid areas suffer from widespread incidence of damage by pests and diseases. It was recommended that field officers should refer all cases to the Entomology and Pathology Divisions of KEFRI at Muguga; that the experts should undertake to document the range of pests and

diseases of candidate species of the ASAL, and, consequently, mount comprehensive studies of their ecologies and possible avenues of control.

2. BIOLOGY AND ECOLOGY

Chairperson: E. Murugi Kariuki

2.1. What has been done:

Some of the natural forest/bush/grasslands in ASAL have been protected and managed, others are in the process of being protected, while others are not protected. Many are managed productively by indigenous peoples.
Long term objective - to attain sustained management of indigenous forests, bush and grasslands in ASAL.

2.2. Problems:

1. Insufficient knowledge of water use and requirements/water relations in trees.
2. The riverine forests are threatened with extinction due to river training and damming.
3. The grasslands and bushlands carrying capacity is extensively reduced by over-exploitation.
4. Most natural forests are not protected.
5. There is increasing pressure on the natural forests.
6. There are seed problems of species in these natural forests (i.e. germination and procurement).
7. Regeneration mechanisms in ASAL woodlands are little known.

2.3. Recommendations:

1. There should be protection and controlled exploitation of the forest and its products.
2. Awareness of potential productivity and fragility of the ecosystems should be hastened. Control may be backed up by judicious use of the Chief's Act. There should be a national policy to cater for ASAL.
3. An inventory of these forests should be conducted.

   - require maps, aerial and satellite photographs to show forest size and composition.

   - identification of all the species in a given forest.

1. Regeneration studies:

   - phenology
   - enrichment planting
   - aided natural regeneration
   - natural regeneration
   - establishment of permanent sample plots (protected and unprotected)
   - studies of yield in the permanent sample plots, also biomass studies.

5. Investigate ways of improving hinterlands (natural bush and grasslands) to increase carrying capacity, e.g. enrich with fodder species Prosopis riverine forests.
6. Investigate development of water harvesting techniques in the bush and grassland to increase regeneration of trees and improve soil to increase infiltration.
7. Decide on priority species for enrichment planting.
8. Conserve genetic base, eg. identify endangered species and increase their population. It was pointed out that a 1984 report (? name) is available on endangered species.
9. Conduct physiological studies in nurseries and natural conditions, eg. rooting, behavioral shooting, root ratio, seeding size.
10. Riverine forest should be studied for effects from reduction of water by dams eg. Tana and Turkana, in order to advise decision makers of the long term repercussions of such structures. Information is available from Bura on impact of upstream development.
11. Compiling of data recorded in ASAL trials that has not been analysed, published or printed and also dissemination of this information to ASAL projects and other interested parties.
12. There should be an investigation of tree/water relationships with a special emphasis on fast growing species thought to use a lot of water.

2.4. Additional points:

- The subject of charcoal was mentioned. Studies into the management and use of charcoal need to be made. Acacia zanzerbarica was mentioned as an example from Bura irrigation scheme. It is a species which could potentially produce charcoal on a sustainable basis. It was emphasised that the whole issue of charcoal, its production and usage was a very delicate one which would need to be handled with great care. Generally, the opinion was that research could cope with these delicate issues but no final concrete recommendation was made.

3. UTILIZATION

Chairperson: B.G. Wamugunda

Utilization can be defined in a narrow forestry sense (forest products, especially timber usage) or in a broad sense. The group considered utilization in a broad sense.

3.1. Recommendations:

1. A check list of indigenous species is urgently required, to include botanical and traditional (local) names, uses and properties.

   - KEFRI to implement with special funds allocated.

2. More efficient methods of fuelwood and charcoal utilization are needed. The Bellerive Foundation is already pursuing this. A marketing investigation is required. KEFRI should take an active interest.

3. The medicinal uses of trees needs highlighting. Information on this is needed from KEMRI.

4. A greater fruit tree stock should be available in RAES and other nurseries. Liaison the Agriculture Department will be necessary to avoid e.g. the spread of disease.

5. Research into alternative species for valuable carving wood is urgently required. Present slow growing species such as Dalbergia melanoxylon are in danger of annihilation.

6. A study on how the management of communal land should/ could be controlled is needed.

7. Plant extractive and their production potential should be evaluated as there is a great potential for their utilization. It was suggested that an investigation should be made into e.g. Gum Arabic in potential areas of Kenya.

8. Development and Research of cash crops was thought to be a good idea such as the prickly pears, Zizyphus spp and others. It was also felt that more emphasis be placed on local indigenous food plants and that their potential be developed as well.

9. Research into medicinal uses of trees by indigenous people is needed. This information is in danger of being lost. The methodology of collecting this information is questionable. KEFRI should collate information already available.

1. RESEARCH CO-OPERATION

Chairperson: Dr. R. Zimmermann

4.1. Problems

a. There is no policy document equivalent to recent comprehensive review of agricultural research (which also establishes research priorities binding on future research).

b. KEFRI does not automatically review all forestry research reports and proposals.

c. KEFRI is NOT a comprehensive depository for all past forestry research reports (scattered among other Ministries, donors, NGOs, UNESCO, etc.).

d. KEFRI does not review, modify and monitor on-going research, at least not systematically.

e. This informal research co-ordination network is very erratic and haphazard and too dependent on the personalities involved (and the bars they frequent).

f. The 1983 Forest Research Seminar and Report are badly out of date.

g. FAO, IUFRO, etc., research priorities should be taken into account.

h. Poor linkages between KEFRI and its own out-stations (especially in regard to data reporting).

i. All projects that do forestry research should have at least a KEFRI desk officer (bigger ones, one officer) assigned to them in the field.

j. Projects should be at least in contact with the relevant KEFRI field station.

k. KEFRI Newsletter does not systematically review on-going research and disseminate preliminary research results.

l. KEFRI Newsletter does not reach most forest research officers and stations in Kenya.

4.2. Recommendations:

1. A national workshop convened by MOPND (as co-ordinator of ASAL programme and of development projects) and organised by KEFRI should review the current status of forest research in Kenya, and produce a policy that outlines the

overall framework and priorities of forestry research, including ASAL research;

2. KEFRI is to review all project documents and proposals that include forestry research (including ASAL research);

3. All formal progress and final reports on forestry research are to be deposited with KEFRI;

4. The KEFRI Newsletter should review and spell out its editorial policy with a view to:

   - informing on current forestry research
   - disseminating preliminary research results
   - listing all research reports and publications pertaining to Kenya
   - systematic distribution of the Newsletter to all forestry research officers, stations and projects.

5. KEFRI should issue through the FD more Technical Notes/ Orders that disseminate mature research so as to avoid repetition and duplication of this research.

6. KEFRI should issue guidelines and carry out in-service training that promotes the standardization of forestry research methodology and the reporting of research data;

7. That this workshop group review on that reviews and, if necessary, modifies manuals, guidelines and other R & D publications produced by projects for the purpose of adopting and disseminating these ready-made publications as official FD technical directives;

8. KEFRI should commission as a special project the assembly at KEFRI of copies of all forestry research reports, and preparation of an annotated bibliography based on these reports that will help KEFRI (as well as research proponents) to screen all future research proposals for duplication or insufficient originality.

9. KEFRI should constitute a working group on ASAL which can draw on other projects and agencies within the country.

10. Donor projects involving research and/or development should add an element of training of KEFRI staff, so that KEFRI can fulfill its research monitoring and co-ordination role.

1.3. Additional points

- It was highlighted early on that there would be a current inability for KEFRI to be able to cope with all the recommendations due to a shortage of manpower. This problem was partially solved under recommendation No.10 but it was also felt that in the short term:

    a. Students could be used to review and summarize reports.

    b. Short courses, for example in statistics, to boost members of KEFRI at the Oxford Forestry Institute.

- Should research data be analysed at the station or at KEFRI headquarters? At present, staff are not always qualified to analyse research at the station but under recommendation No. 10 this problem could soon be rectified. If possible, data should be analysed at the station and then copies of the reports and the new data can be sent to KEFRI.

- Under Research Co-operation a comment was made on whether KEFRI is a member of EAJFA. Indeed, KEFRI is and people should be made aware that they can write articles to this journal if they so wish.

DISCUSSION SESSION GROUPS

I. Silviculture.

Chairperson: Dr. J.A. Odera/C.K. Kiriinya

NAME

1. Klaus Wetterberg
2. Tom Nyachae
3. J.M. Kioko
4. M. Hori
5. B.O. Muck
6. C. Kiriinya

II. Biology and Ecology.

Chairperson: Murugi Kariuki

1. R.K. Chirchir
2. G. Muturi
3. Felix Ngunjiri
4. Martin Stewart

III. Utilization.

Chairman: Ben Wamugunda

1. J.W. Ngumi
2. J.M. Gitonga
3. Kees Vogt
4. Hugh Evans

IV. Research Co-operation.

Chairperson: Dr. R. Zimmermann.

1. Stig Phausson
2. Eliud Kireger
3. Paul Kherkoff
4. G.K. Mwaura

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Mr. Stig Johansson	Bura Forestry Research Project (FINNIDA/KEFRI) University of Helsinki, Dept. of Silviculture.
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Mr. Nigel Spiers	V.S.O. Forester, MERU, RAES.
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