KENYA FORESTRY RESEARCH INSTITUTE

MUGUGA REGIONAL RESEARCH CENTRE

ANNUAL REPORT

JULY 2007 - JUNE 2008

PREFACE

Muguga Regional Research Centre (MRRC) is one of the 6 Research Centres of the Kenya forestry Research Institute (KEFRI). The Centre is situated in Kikuyu Division, Kabete District, Central Province at longitude 36° 34" East and latitude 1° 11" South. It is located about 25 km north west of Nairobi city and two kilometers off the Nairobi-Naivasha-Nakuru highway.

The centre's pivotal roles are:

- Identifying problems with users of research findings
- Planning and implementing research projects
- Providing linkages between headquarters and stakeholders
- Dissemination of research findings and technology transfer

During the year the Centre had 25 research scientists supported by 60 technical and 72 support staff making a total of 157.

The centre has mandate to undertake research and development activities in the highlands east of the Rift valley. Though based at Muguga, it has a sub-centre at Nyeri. There are large number of scientists coordinated by the centre but with activities in other parts of the country. As a result this report presents both regional and other research activities accomplished from July 2007 – June 2008 within the country. The results are presented according to the achievements made by the centre under different research activities in farm forestry, natural forests, plantation forestry and dryland forestry.

A significant portion of the activities included problem diagnosis, development of technologies, experimentation, evaluation of results, dissemination and impact assessment. A close working relationship was maintained through several community based organizations (CBOs), KFS field staff and NGO's.

We thank the Director (KEFRI) and the Government of Kenya for facilitating the center in meeting its research obligations in the region and support to other activities nationally.

We encourage you to get in touch for further information especially in areas of possible collaboration and technology transfer in forestry related activities.

Finally I take this opportunity to thank all staff for their efforts during the past year. With more effort we are capable of improving the standard of research.

Ely J.M. Mwanza
Centre Director

1.0 STUDIES IN FARM FORESTRY

1.1 IMPACT OF INTEGRATED SOIL FERTILITY MANAGEMENT PRACTICES IN THE CENTRAL HIGHLANDS OF KENYA

By Jayne Mugwe

Introduction

The highlands of central Kenya has high population pressure, coupled with a growth rate of about 2.9%, therefore rising demand for more food. Production of more food is constrained by declining soil fertility and the high costs of inorganic fertilizers (Kihanda, 2003). Research results indicate that integrated soil fertility management (ISFM) involving the judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraint and increase yields within the smallholder farms (Bationo et al., 2004) but adoption by farmers low (MOA, 2002). A project on ISFM was initiated in the central highlands of Kenya in 2000. The main aim of the project was to demonstrate and promote adoption of ISFM technologies by farmers through participatory approaches. After seven years, apart from data emanating from biophysical assessments and monitoring and evaluation of what farmers were doing, information was lacking on the impact of the project on farmers livelihoods. There was therefore need to carry out an impact assessment study. Impact assessment is the systematic analysis of the lasting or significant changes-positive or negative, intended or not-in people's lives brought about by a given action or series of actions (Lilja and Dixon, 2008). It involves an evaluation of how, and to what extent, change has occurred. Results of impact assessment contribute to priority setting and also play an important role in accountability. The objective of this study was to evaluate the impact of using ISFM technologies by farmers in Meru south District.

Methodology

The study was carried out in three project sites; Murugi, Mukuuni and Machang'a, where farmers had participated in ISFM activities. A list of all farmers who had participated in the project activities formed the sampling frame. From each of the three sites, 50 households were randomly selected. These households were interviewed in February 2008 using a standard interview schedule. Information collected comprised of ; demographic characteristics, socio-economic characteristics, household nutrition status, access to information, fodder production, utilisation of crops, cultivation practices, farmer perceptions/experiences

The data was subjected to descriptive analysis. To determine the changes that had taken place as a result of the project, baseline data collected in 2004 was compared with the current data.

Results and discussions

Demographic characteristics

The mean age of the farmers varied by site with Murugi having 53 yrs, Mukuuni, 55yrs while Machanga had 50 yrs. The education level of the farmers was average with majority having attained primary level (58%). This scenario was similar to that of 2004. The average farm sizes varied with Murugi having the least farm size of 1.1 acres while Mukuuni and Machang'a had 3.5 acres and 4.1 acres, respectively. Family sizes were 6.8 members per household in Murugi and 7.1 and 7.3 members in Mukuuni and Machanga, respectively.

Uptake of integrated soil fertility management technologies

Most farmers (79%) had taken up manure plus fertilizer (Table 1). A good number was also using sole inorganic fertilizer (74%). The use biomass transfer from trees (calliandra and tithonia) was popular in Murugi and Mukuuni. In Machanga, manure and fertilizer was the most commonly used inputs, an indication that livestock manure has a big role to play in improving soil fertility in the area. This is in agreement with other studies that have reported the importance of manure in improving soil fertility in livestock arable framing systems (Lekasi et al., 1998; Kihanda, 2003; Kimani et al., 2004; Mafongoya et al., 2006)

Table 1: Soil fertility management inputs farmers were using during 2007/2008 short rains season.

Input	Murugi (N=50)	Mukuuni(N=50)	Machanga (N=50)	Total
Calliandra	18 (36%)	30 (60%)	0	48 (32%)
Fertilizer	36 (72%)	50 (100%)	24 (48%)	112 (74%)
Manure +fertilizer	37 (74%)	36 (72%)	46 (92%)	119 (79%)
Tithonia	15 (30%)	27 (54%)	1	43 (29%)
Manure	28 (56%)	1	0	29 (19%)
Tithonia +fertilizer	2 (4%)	9 (19%)	0	11(7%)
Others (mix of organics	10 (20%)	13 (26%)	2	23 (15%)

Changes in household food security and food production

While the majority, 76.0% of the households were food secure for only 4-6 months in 2004, showing poor food security status, this situation had improved in 2008 (Figures 1 & 2). In 2008, majority (58%) were food secure for 10 -12 months in a year. Similarly,

the number of farmers who were food insecure for 4- 6 months had decreased to 11%. These results demonstrate that the household food security status has improved, and this is a very positive contribution by the project.

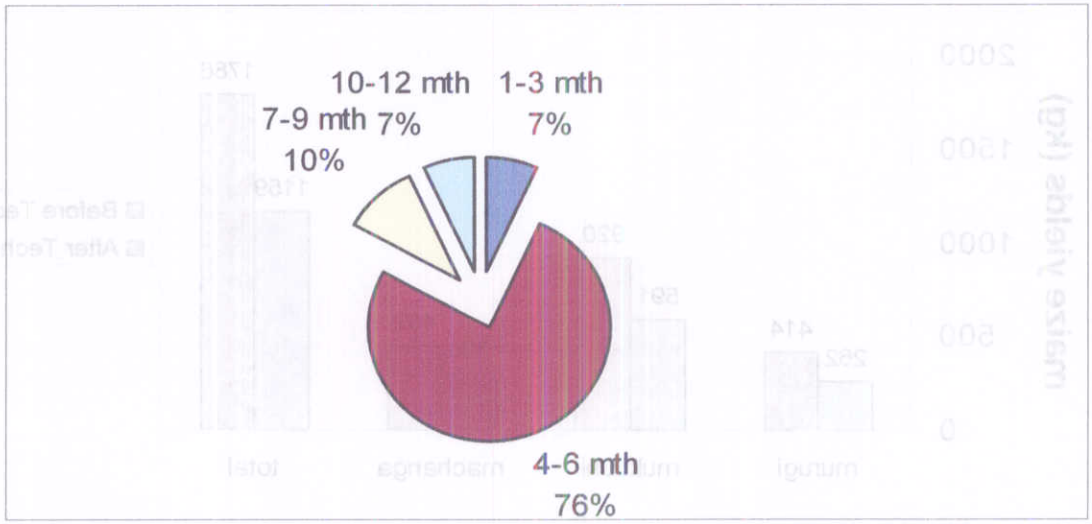

Figure 1: Number of months households are able to consume food harvested from their farms in 2004

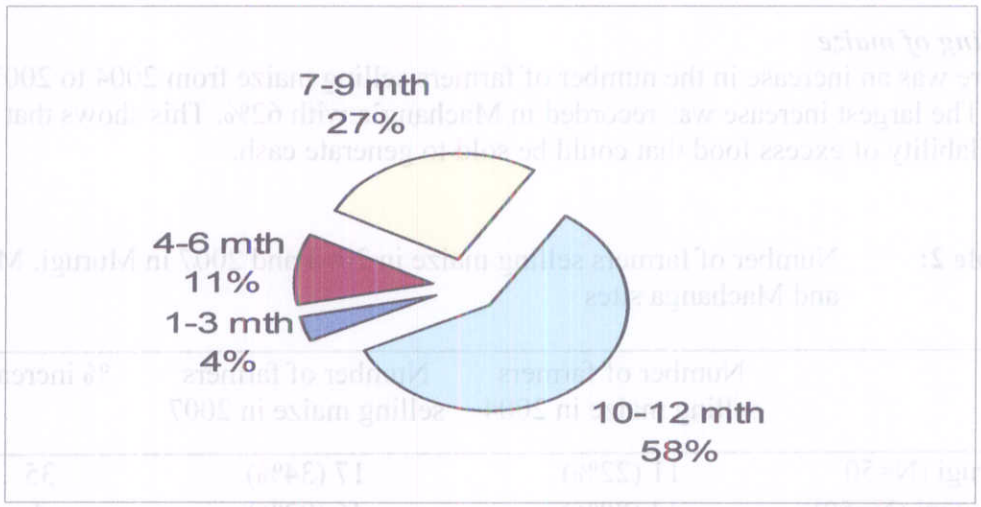

Figure 2: Number of months households are able to consume food harvested from their farms in 2007/08

In terms of changes in food production, maize yields at the farm had increased in all sites as a result of taking up of the new ISFM technologies (Figure 3). Overall, for all the sites

the increase was 54%. The highest increase was registered in Mukuuni having 77%, followed by Murugi, 54% and lastly by Machang'a with 48%. These results agree with those of Jama (2000) and Mugwe et al. (2007) who reported maize yields increases following application of organic materials into the soil.

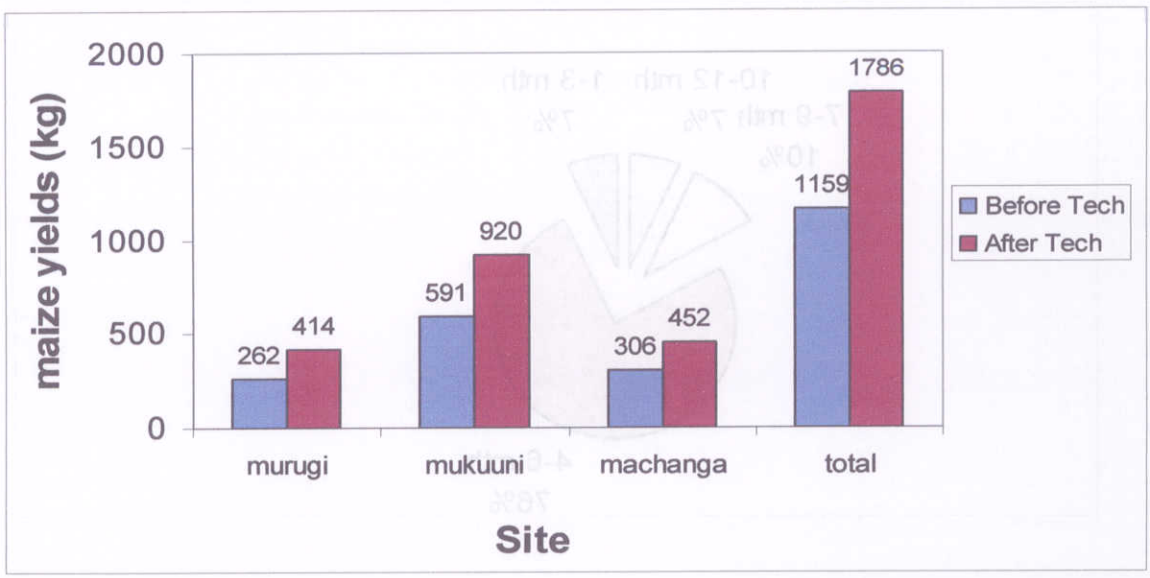

Figure 3: Maize yields before and after technology adoption by farmers in Murugi, Mukuuni, and Machang'a, Meru south district, Kenya

Selling of maize

There was an increase in the number of farmers selling maize from 2004 to 2007 (Table 2). The largest increase was recorded in Machang'a with 62%. This shows that there was availability of excess food that could be sold to generate cash.

Table 2: Number of farmers selling maize in 2004 and 2007 in Murugi, Mukkuuni and Machanga sites

Site	Number of farmers selling maize in 2004	Number of farmers selling maize in 2007	% increase
Murugi (N=50	11 (22%)	17 (34%)	35
Mukuuni (N=50)	44 (88%)	46 (92%)	4
Machanga (N=50)	6 (12%)	16 (32%)	62
Total	61(40%)	79 (52%)	23

Planting of leguminous trees

At the start of the project, tree nurseries managed by farmer groups were initiated, with an aim to propagate seedlings of calliandra and leucaena for on-farm planting. In 2004, farmers had less than ten trees on their farms but in February 2008, they had increased to 344 tree per farmer (Table 3). This is an indication that there was a positive impact of the nurseries on tree planting. These trees provide both products (fodder and fuelwood) and also play an important role in soil conservation when planted on steep slopes.

Table 3: Number of tree planting on farms in February 2008 in Meru south district, Kenya

Site	Number of calliandra trees	Number of leucaena trees	Total
Murugi (N=46)	123	79	301
Mukuuni (N=36)	269	224	493
Total	196	148	344

Conclusions and recommendations

Several positive impacts were realized as a result of farmers using the new soil fertility inputs. The major positive impacts registered were increased maize yields and improved food security status. The number of months that household bought food reduced as a result of farmers using the new inputs. Farmers were also able to sell their excess produce thus generating income for the household. This has potential to contribute to poverty reduction among households. The number of leguminous trees (calliandra and leucaena) on the farms increased to about 300 trees per household. Due to the positive impacts, more farmers in the area and other similar regions should be encouraged to adopt the ISFM strategies.

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1.2 GENETIC VARIATION BETWEEN PROVENANCES OF *JATROPHA CURCUS*

By J Machua

Introduction

Jatropha curcus L. or the 'physic nut' is a drought-resistant tree in the family Euphorbiaceae. Originally from central and South America it is currently widespread in Africa, Asia and a host of other countries. Jatropha is a shrub or tree that grows up to 6 m, with spreading branches and stubby twigs, with milky or yellowish frutescent exudates. The species is adapted to arid and semi-arid conditions and its distribution shows that it has been most successful in the drier regions of the tropics with annual rainfall of 300-1000 mm. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. Although oil palm is considered more energetically promising, the clear oil expressed from the seeds of *Jatropha curcus* has been used for illumination, lubrication and more recently has been suggested for energetic purposes. One ton of seed was found to yield 70 kg refined petroleum, 40 kg "gasoil leger" (light fuel oil), 40 kg regular fuel, 34 kg dry tar/pitch/rosin, 270 kg coke-like char, 200 kg ammoniac water, natural gas, creosote, etc. One of the by-products of the oil production (press cake) is a good organic fertilizer. The foregoing therefore makes *Jatropha curcus* a candidate species for dryland economic empowerment programs. *Jatropha curcus* is currently being commercially introduced in Kenya as a biofuel plant. However, in spite of the isolated introductions of *Jatropha curcus* in Kenya no genetic diversity studies have been carried out and seed collection continues sporadically from such populations for further planting. Concerns have been raised that the current *Jatropha* populations might have originated from a narrow genetic pool and therefore predisposing the intended plantations to diseases and pest attacks. This study seeks to establish the current genetic diversity and structure of *Jatropha curcus* populations in Kenya using DNA marker techniques in order to advice prospective farmers on the Jatropha genetic resource base.

Objective

To understand the genetic diversity of *Jatropha curcus* in Kenya in order to hasten its utilization as a means for diversifying options for optimum income generation in the ASALS.

Materials and methods

Six populations were identified and mapped on a physical map of Kenya using GIS technology (Fig. 1). These included; Namanga, Nguruman valley, Kitui, Kibwezi, Voi and Likoni. A total of 20 samples per population were collected and stored in silica gel awaiting DNA extraction and analysis.

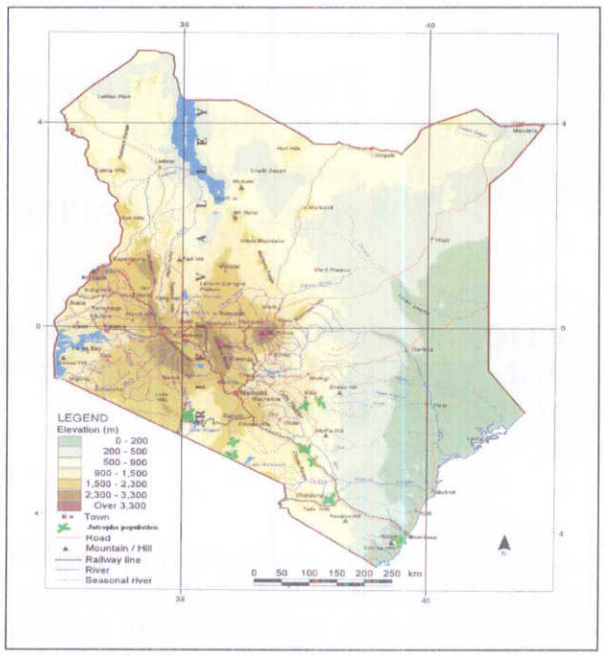

Figure 1. A physical map of Kenya showing the mapped South Eastern populations of *Jatropha curcus* (Green X marks).

Results

DNA Isolation

DNA was isolated from leaf material by a modified version of the method described by Edwards et al. (1991). DNA was quantified to be between 75 to 250ng/µl (Fig 2) A total of 40 primers are being screened for scorable results.

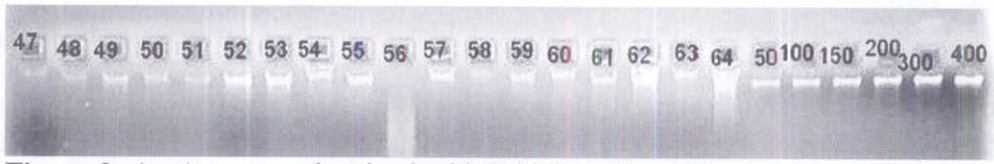

Figure 2. An Agarose gel stained with Ethidiaum bromide showing DNA isolated from Jatropha (47 – 64) against DNA standards (50 – 400)

Initial PCR

An initial PCR to screen positive RAPD primers is still being carried with some positive results (Fig 3).

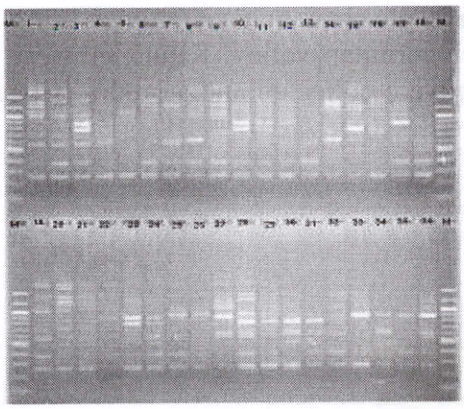

Figure 3. An agarose gel stained with Ethidium bromide showing genetic profiles of *Jatropha curcus* probed with a RAPD PCR primer

1.3 NITROGEN FIXATION ABILITY OF SELECTED LEGUMES UNDER INTEGRATED SOIL FERTILITY MANAGEMENT IN SITES WITH CONTRASTING MOISTURE REGIMES

By Jacinta M. Kimiti

Introduction

There is a trend towards soil fertility loss in many soils in the semi-arid zones of Africa and planting multipurpose legumes may arrest this trend. Legumes are unique in that they acquire atmospheric nitrogen (N) through symbioses with bacteria collectively called rhizobia in a process commonly termed biological nitrogen. Biological nitrogen fixation (BNF) is an important aspect of sustainable and environmentally friendly long-term productivity. Several methods have been used to estimate BNF and the most commonly used methods are: (1) Nitrogen difference method also called N balance method. (2) ^{15}N-isotope dilution either with enriched ^{15}N-fertilizers. (3) Xylem-solute method, where N is estimated by measuring changes in ureid content in the xylem sap and, (4) Acetylene Reduction Assay (ARA). In this study, the main objective was to determine the effect of integrated soil fertility management on nitrogen fixation under contrasting moisture regimes.

Materials and Methods

Plant samples of selected cowpea varieties were taken from two on-farm trial sites, Kavuthu (wetter site) and Ndunguni (Drier site) in the semi-arid Makueni District. Treatments in the trials included a control (no amendment used) (T1), manure at 2.5 t/ha (T2), 15 kg/ha P applied as TSP (P_2O_5) (T3) and a combination of manure+TSP (T4) at the singly applied rates. Eight non-N-fixing plants, consisting of shrubs and herbs from both sites were used as reference plants. The amount of nitrogen fixed was assessed using the ^{15}N natural abundance method. %N fixed was calculated as follows:

100[(Non-fixing– Legume sample)/(Non-fixing – 100% fixation value)]

A $\delta^{15}N$ value of 0 was assumed for plants fixing 100% of their nitrogen. Data were analysed using two-way ANOVA.

Results

A large and significant differences ($p<0.05$) was found between amounts of nitrogen fixed at the two sites with plants at site the wetter site fixing 46-53% of their nitrogen (Figure 1) while only one treatment fixed 12% N at the drier site.

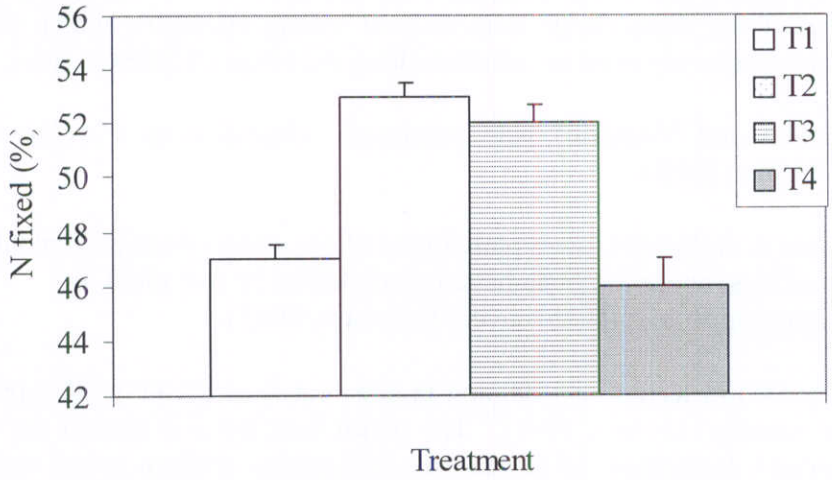

Figure 1. Amount of nitrogen fixed (%) in the wetter site (Kavuthu) in treatments 1 to 4 (T1-T4).

Discussion

Biological nitrogen fixation was recorded in the wetter site (Kavuthu), where it varied from 46 to 53%. Nitrogen fixation at the drier site (Ndunguni) was most probably limited by low and unevenly distributed rainfall recorded in the site that could have caused water stress to the cowpea plants to the extent that nitrogen fixation was inhibited. Sprent (1971) suggested that water stress reduces the formation and longevity of leguminous root nodules thereby reducing nitrogen fixation in nodules.

Conclusions and Recommendations

Nitrogen fixation took place in the wetter site indicating the need for water for effective BNF. This observation indicated the need to breed legume varieties that are resistant to drought and that would fix N under harsh conditions of the Kenyan ASALs.

Literature Cited

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2.0 STUDIES IN PLANTATION FORESTRY

2.1 MONITORING OF CYPRESS APHID BIOLOGICAL CONTROL PROGRAMME

By *Otieno B. O and Mutitu K.E.*

Introduction

Cinara cupressivora (Homoptera: Aphidae) as described by O'Neil (1998), are brownish soft-bodied insects, often with a grey waxy coating. They are about 2.4 mm long. Adults are winged or wingless. They often occur with several young (nymph), which they produce rapidly. They are commonly seen in colonies along the twigs of infested trees.

C. *cupressivora* (Watson and Voegltin) was preciously identified as *C. Cupressi* (Buckton) (Kairo and Murphy, 2005)

Kenya, has the largest area of industrial forest plantations of *Cupressus lusitanica* planted on about 86,000 ha, out of this, about 5,153 ha have been infested by the aphid to variable damage levels ranging from slight to severe (Mwangi, 2002).

C. cupressivora was recorded in Kenya in 1990 and in one year had spread to all cypress growing regions of the country (Owuor, 1991). The major host trees in Kenya are the Mexican cypress, *Cupressus lusitanica*, Miller and the indigenous African pencil cedar, (*Juniperus procera*). These two major host species, covers a total area of 280,000 ha in plantations and natural forests (Day *et al*, 1994). Cypress aphid being an exotic pest, classical biological control programme was identified as the most appropriate and environmentally friendly management option to be implemented. In early 1990's, *Pauesia juniperorum* (Hymenoptera: Braconidae) was identified as a potential biological control agent and was introduced in Kenya in the year 1994 (Day *et al,* 1995).

Adults of *P. juniperorum* are about 10mm long, with a black head, brown-black thorax, yellow legs and a yellowish abdomen, which becomes darker in older insects. *Pauesia juniperorum* lays its eggs in live aphids (one egg per aphid). The eggs then hatch into larvae, which start feeding on the aphid, killing it in the process. The dead aphid hardens to form a tough cocoon usually referred to as a "mummy". The pupa is formed inside the remains of the dead aphid. The pupal state lasts six days at the end of which the adult emerges (Kairo and Murphy 2005). *P. juniperorum* has several attributes that make it a good biological control agent.

The populations of the cypress aphid and the biocontrol agent have been monitored for a period of nine years with an objective of establishing the effect of parasitoid, *Pauesia juniperorum* on the population trends of cypress aphid (*Cinara cupressivora*) and its damage to trees.

Materials and Methods

The study was carried out in permanent sample plots (PSPs) each comprising of 900 trees established in major cypress growing areas. The plots were sampled every quarter of

financial year. The damage to the trees caused by aphids was rated on a four point scale denoted 1-4 where category 1 represented no damage while 4 represented highest damage. The number of aphids, emerged mummies, unemerged mummies and other natural enemies were counted on one randomly selected branch of young cypress plant in plantations with open canopy. The populations of the aphid was compared in various locations and related to that of the other natural enemies

Results and Discussion

Most of the trees were observed to be in the clean category although some mature trees were observed with severe aphid damage outside the established permanent sample plots especially in the Londiani and mount Kenya regions.

Figure1. Mean cypress aphid population in different cypress growing regions

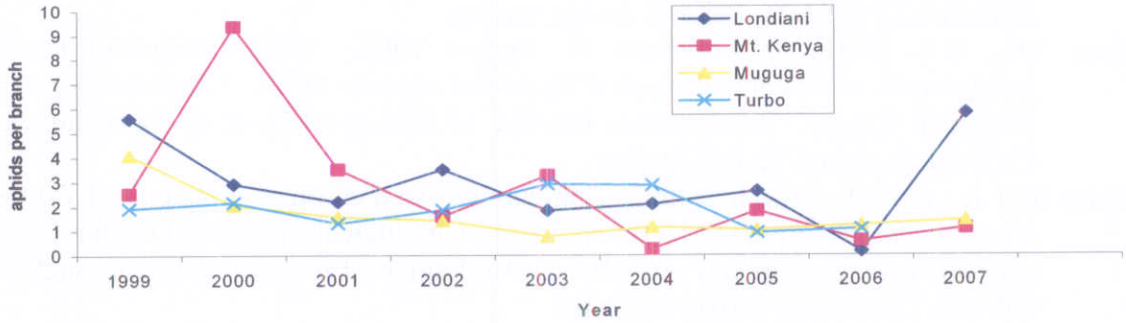
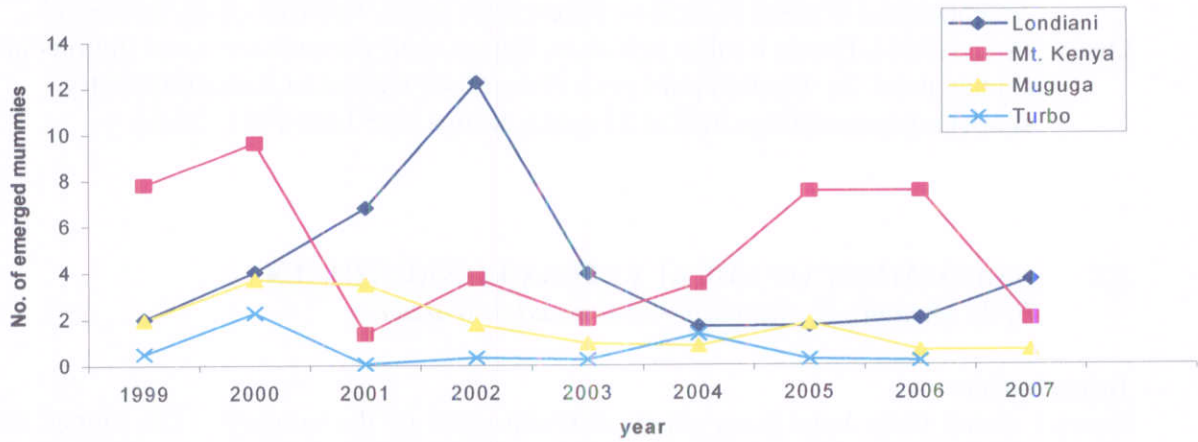


Figure 2. Mean population of *P. juniperorum* in different cypress growing regions



The population of the aphids have reduced overtime apart from the exaggerated peak observed in Londiani in the year 2007 (Fig. 1.)

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observed in the three regions in the yr. 2006 is 8.6%, 18.0% and 3.2% compared to 3.2%, 1.9%, and 1.8% in yr. 2007 for Londiani, Mt. Kenya and Muguga, respectively.

Conclusion and way forward

Weather data needs to be incorporated in the analysis to explain the behaviur of aphid and *P. juniperorum* populations in different parts of the country and aid in forecasting any population increases of cypress aphid.

Alternative monitoring methods that are economical and time saving need to be tested for future use.

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2.2 ASSESSMENT OF EUCALYPTUS CLONAL TRIALS

By L. Mwangi, B. Otieno, E. Mutitu and S. Wakaba

Introduction

Several clonal trials have been set in different parts of the country. The clones were introduced from Mondi forests, South Africa in 1997. Subsequently several other clones, have been introduced and established in other trials in various parts of the country. These consist of mainly GC clones (*E. grandis x E. camaldulensis).* Pure species of *E. camaldulensis, E. tereticornis, E. grandis,* and *E. saligna* have also been included in the trials. In a few trials GU clones (*E. grandis x, E. urophylla)* have also been included. KEFRI has been involved in the establishment and assessment of these trials for

performance and monitoring of pests and diseases. The latter is presented in this report for the year.

Materials and methods

In year 2007/08 eight Eucalyptus clonal trials were assessed for pests and diseases. These were Turbo, Yala, Kuja River, Kabage, Meru, Gede, Sokoke and Msambweni. The assessments of the trials are done annually in order to detect any new pests or diseases.

The assessments were done intensively since all trees in all the plots and trials were inspected for presence or absence of pests and diseases. Any existing or new pest or disease was noted. For BGC, the assessments were done using the established categories of infestation. These are; **Cat 1**-Seedling/trees with no gall damage (None) **Cat 2**-Seedling/trees with galls less than 25% of total shoots (Minor) **Cat 3**- Seedling/trees with galls on between 25-50% of total shoots (Moderate) **Cat 4**- Seedling/trees with galls on more than 50% of total shoots (Severe). In addition samples of pests and disease were collected and taken to Muguga for identification. Insect pests were identified using the reference collection at KEFRI. For diseases, samples collected were placed on 2% malt extract agar to isolate the pathogens.

Results and discussion

Insect pests

Table 1. Blue gum chalcid infestation in five clonal trials.

Germplasm	Sites				
	Gede	Sokoke	Msambweni	Yala	Turbo
E. camadulensis	+	+			
E. tereticornis	+				
E. grandis					+
E. urophylla	-				
GC3				+	+
GC10					+
GC12				+	+
GC14	+	+		+	+
GC15					-
GC167	-	+		-	+
GC514	+	+	+	+	+
GC522					-

GC540	+	+			
GC564				-	
GC581	-		+	-	-
GC584	+			-	+
GC642				-	+
GC784	+	+			
GC785	-	-			+
GC796	+	+		+	+
GU7	-	+		+	+
GU8	-	-		-	+
GU21	+	-			

Key + blue gum chalcid present
- blue gum chalcid missing

At present no BGC has been found in Kiutine (Meru) and Kabage. BGC infestation is still low in Msambweni. This is expected, as the infestation is usually serious on young trees. The absence of BGC in Kuja River was because the trial was burnt and trees have started coppicing. Last year several clones and species were found infested by the pest. *Gonipterus* was found on ET, GC 581, and *E.urophylla* in Gede, GC 522 in turbo, GC 581, GC 785 and *E. camadulensis* in Sokoke. *Apion* species was found on GU 7 in Gede, EU in Msambweni. Scale insects were found on GC 540 in Gede. White flies on GC 581, GU 8, GU 7, EU and GC 785 in Msambweni

Diseases

Gede trial

Botryosphaeria canker disease was found on GC581 (2 trees), GC540 and *Eucalyptus camaldulensis.* Leaf spots were found on GC785. In 2006 *Botryosphaeria* and GU7 infected only one tree of GC581. On GU 7 and GU8, the spots were quite extensive especially on the lower branches and had developed into leaf blotches.

Sokoke trial

Botryosphaeria was found on GC581, GC14, GC796, GU8, and EU. This is the only trial at the coast where GC796 had survived. In 2006 only one tree of GC581 had *Botryosphaeria* hence the disease is spreading to other hybrid clones.

Msambweni trial

The only clone affected by *Botryosphaeria* was GC581 (3 trees). However in terms of growth it was one of the best clones. In 2006 there was no tree affected by the disease, which must have appeared in 2007. Samples were collected from two trees. Leaf spots were found on *E. tereticornis.*

Kiutine trial (Meru)

The trial was assessed In April 2008. *Botryosphaeria* was found on GC522, (3 trees) GC784 (1 tree) GC 12 (1 tree), GC 10 (1 tree), MAU 11 (1 tree), EH (7 trees). It is interesting to note that in October 2007 GC 522 was not affected. The disease thus seems

to be spreading. Two trees of EH had already died due to the disease and possibly termite attack. The most affected was E.H, which seems to be highly susceptible on this site. Leaf spots were common on most trees but mainly confined to lower branches leaves. The trial is now three years old.

Kabage trial

In this trial *Botryoshpaeria* was still prevalent on GC514 and GC 540. In 2008 the disease had spread to TAG 5 on this site. The only other site where this clone was attacked was at Gede where it was planted outside the blocks.

Turbo trial

In this trial *Botryosphaeria* was found only on local grandis (EC 5, EG 02). The disease must have appeared this year, as it was present in year 2007. It possibly has spread from the adjacent Eucalyptus plantation where the disease was detected earlier.

Leaf spots were mainly found on EG progenies. Some of the trees had moderate attack and it is hoped that the condition might not get worse. The only clone affected by leaf spots was GC 642.

Yala trial

In this trial *Botryosphaeria* was found on *E. camaldulensis* and GU7 (3 trees). Leaf spots were found on *E. camaldulensis,* GU8, GU 7, GC 167 and GC 3. These were in block 3 of the trial.

Kuja River

This is the most recently established trial and was first assessed in 2007. At that time there were leaf spots on GC 3, E.U, EG and EC. However the trial was burnt in early 2008. Some of trees have started coppicing, which could be used in assessment for next year

Conclusions and Way forward

The most common insect pest was Blue gum chalcid. It was mainly confined to areas where the pest spread mainly in Nyanza, Western, Rift valley and Coast provinces. From the assessments carried out in the Eucalyptus clonal trials *Botryosphaeria* canker disease is the most common on clones GC 581, GC 540, GC 514, EH and ES. These appear to be more susceptible to the disease in several sites. The disease has subsequently spread to sites where it was not present such as Kiutine (Meru), Turbo and Msambweni. In some sites more clones have been attacked since the last assessment. This shows that the disease is spreading, thus the need for further monitoring. Leaf spots found have not been serious and may not affect the trees growth. The monitoring is to continue on the pests and diseases.

2.3 PESTS AND DISEASES DIAGNOSIS, ADVISORY SERVICE AND DATABASE

*By Otieno B., Mutitu E.K.*and *L. Mwangi*

Introduction

The Monitoring of pests and diseases continued in the financial year 2007/2008 as part of the activities within the entomology and pathology sections of KEFRI. Specimens were sent from the field using the technical order No. 40. In addition visits were made to areas where problems were reported. Specimens were also collected during the visits. Identification of insects and isolation and identification of fungi was carried out in laboratories at Muguga. The diagnosis and advisory service is considered as an important service provided to the public.

Insect pests

During the reporting period 71 technical order number 40 were received.

Insects

The major insect pests encountered were:

- Scale insects on *Calliadra calothyrsus*
- Sap suckers on *Olea africana*, *Spathodea campanulata* and *Prunus africana.*
- Beetles *Calidea dregii* and anthona species on *jatropha curcus, Neem*
- Termites on *Eucalyptus camaldulensis* and *Grevillea robusta*
- Eucalyptus snout beetle (*Goniptera sculellatus*)
- Aphids on queen of the night and cypress

Other insects encountered were:

Gall insects, mites and psyllids and mealy bugs. Whenever possible, advice was given on how to control the insect pests. In most cases the use of insecticides was recommended especially on nursery plants.

Diseases

The major diseases found were;

- Cutting rot of *Osyris lanceolala* caused by *Fusarium*
- Dieback on *Eucalyptus* sp, C*uppressus lusitanica, C. pramidalis, Ficus benjaminania, Pinus maximinoi*, *E.saligna* and Thika frame (Thika palm)
- Botryosphaeria canker on GC IO, GC 522, *E.henrii* and TAS 5 in Meru clonal trial.
- Leaf spots on GC 15, *E.grandis*, *Prunus africana*, *E.camaldulensis* mainly caused by *Mycosphaerella.*
- Root rot of *Jatropha curcas* and Deurn palm, *Acacia polyacantha* caused by *Fusarium.*
- *Armillaria* root rot
- Powdery mildews on *Jatropha curcas, E.grandis, E.camaldulensis* and Rose mery hedge.

- ❖ Where appropriate advice was given on how to control the diseases. Foliage diseases can easily be controlled by use of systemic fungicides.

Way Forward

- Database will continue to be expanded for both insect pest and disease causing organisms. A querying system for the database was initiated and it is at an advanced stage.
- Advisory services will continue to be provided to the farmers on pests and diseases.
- Research on identified major pests and diseases should be carried out in order to generate more information
- It was recommended that a consultancy document should be prepared for monitoring pests and diseases on a regular basis as opposed to adhoc visits at KSMS. These could also include training on landscaping and identification and labeling of flowers and trees planted within KEFRI compound.

2.4 MONITORING OF BLUE GUM CHALCID IN KENYA

By K. E. Mutitu and B. Otieno

Introduction

Eucalyptus species are the most widely planted exotics in the tropics with several species grown in over 80 countries. The popularity of *Eucalyptus* species is attributable to being generally adaptable to a wide range of agro-ecological zones, fast growing with the potential for producing sawn wood and processed wood products, high calorific value fuelwood and a variety of environmental and ornamental uses. In Kenya, many agencies promote the planting of *Eucalyptus* which farmers consider an important source of fuelwood, construction materials and source of income. Since introduction in Kenya Eucalyptus species have had no serious threatening pests or diseases. However, recently an exotic pests has infested Eucalyptus species.

In Kenya, Blue gum Chalcid (BGC), *L. invasa* (Hymenoptera: Eulophidae) infestation on *Eucalyptus* species was first reported in November 2002 in the western Kenya region. By 2004, BGC infestations had been reported in Nyanza, Western and Coast provinces. These are areas with large tracts of land planted with *Eucalyptus* species (Mutitu, 2003). These regions of early infestations have about 14% of the attacked hosts in the severe damage category showing deformity and stunted growth in the meristematic plant parts. By 2006, the pest had spread to other provinces like Rift Valley, Central and Eastern. The rapid spread of BGC in major host tree growing areas within a period of less than 4 years can be attributed to its fast population growth, thelytokous pathenogenic reproduction (producing females only), mulivotinous development (overlapping generations) and absence of its principal natural enemies. It is also possible that the extensive planting of *Eucalyptus* species, poor species-site matching and general lack of control over the movement of infested planting materials in the country facilitated the rapid spread of *L. invasa*. This is confirmed as the mode of invasion in both Coast and Central provinces. Several suitable hosts of the insect have been reported including; *E. camaldulensis, E.*

grandis, E. globulus, E. saligna, E. tereticornis, E. robusta, Eucalyptus hybrids, and the introduced South Africans clones. This wide host range coupled with the observed fast spread of the pest makes it a perceived threat to Eucalyptus growing. It is also important to note that very litte is known about the pest and no specific management recommendations exist. Since its invasion, KEFRI has been monitoring the spread, population and damage dynamics in the invasion areas. This report gives some interim results on this subject.

Materials amd Methods

BGC monitoring for damage and population trends started in May 2006 and is being carried out from the lowest altitude 42 metres above sea-level (masl) to as high as 2200 masl. At present about 10 Permanent Sample Plots (PSP's) have been established in the infested areas (Table 1).

Table 1: BGC Permanent Sample Plots in Kenya

PSP's Name	District	Altitude (masl)	Species
Komaza Farm	Kilifi	42	S. African Clones
Adhuman Imam Farm	Malindi	91	**E. camaldulensis**
KWS Farm	Kwale	416	**E. camaldulensis**
Aloise Farm	Busia	1185	**E. grandis**
Mugendi Farm	Busia	1240	**E. grandis**
Wetangula Farm	Turbo	1348	**E. grandis**
Homalime Farm	Nyando	1454	**E. grandis**
Kakuzi Ranch	Maragwa	1584	**E. grandis**
Homalime Farm	Nyando	1640	**E. camaldulensis**
Lungatso Farm	Turbo	1854	**E. grandis**
Kibe Farm	Nakuru	2030	***S. African Clones***

Each PSP consist of 60 trees where three clusters of 20 trees each are randomly identified. To determine the damage levels, BGC galls foliage density on the tree canopy foliage is used to quantify the severity of attack and scored on a four-point scale as shown below for all the 20 randomly selected trees in each sample plot. The damage categories are as follows:

- Category 1: None- Seedlings/trees with no gall damage.
- Category 2: Minor- Seedlings/trees with galls less than 25% of total shoots.
- Category 3: Moderate- Seedlings/trees with galls between 25-50% of total shoots
- Category 4: Severe- Seedlings/trees with galls more than 50% of total shoots

For each cluster, 10 randomly selected trees are assessed for BGC populations by beating a one metre branch shoot end and BGC insect adults counted using a tally counter and a pooter.

Results and Discussion

The report covers September 2006 to Aug 2008.In later 2006 the population of BGC per sample unit was high in 2007 on *Eucalyptuys grandis* compared to *E. camaldulenis*. A low population on both species was experienced in the months of June to August 2007, with the lowest of less than one being recorded in the month of September. This low population is likely to be due to the long rains coupled with lower temperatures that do not favour insect development and spread.

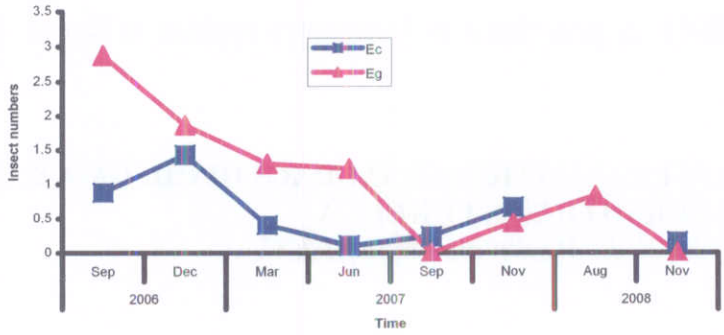

Figure 1. *L. invasa* population trend at Homalime PSP.

The monitoring of damage continued for that same period in the same PSP – Homalime on the same two species. Results showed that the damage ranged between damage category 1 and category 2. The damage trends on both species are very similar. (Figure 1 and 2).

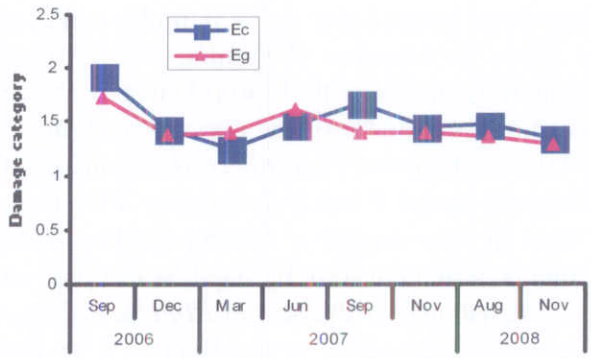

Figure 2. *L. invasa* damage trend at Homalime PSP

This kind of BGC damage trend can be explained by the high and bimodal rainfall in this area. Trees planted in the appropriate agro-ecological zone are less damaged compared to those that are off-site. This is likely to explain this kind of damage trend observed on this PSP.

Recommendations

- To determine the population and damage trends of BGC and factors associated with the trends
- Further monitoring and increase of PSP
- Further data analysis should be carried out for other PSP's to find out the trends and their likely associated factors.

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2.5 EFFICACY EVALUATION OF IMIDACLOPRID (IMAXI®) AS A FOREST TERMITICIDE IN KENYA

By Otieno B., K. E. Mutitu and Kimani J. G.

Introduction

Termites cause serious damage to crops, forest trees, wooden buildings and pastures in many regions of the tropics. All the growth stages of trees are attacked, with young exotic species being the most susceptible (Harris, 1971). *Macrotermes spp*, *Odontotermes spp* and *Microtermes spp* are known to cause the most serious losses to young exotic species such as the Eucalyptus, in the dry regions of Africa and Asia (Cowie *et al*, 1989). Termite damage to seedlings and crops includes debarking of roots and stems; cutting off at ground level and hallowing out from within the root and stem system, resulting to death of the plant (Amadalo, 1992).

Use of organochlorines has been banned due to their undesirable environmental effects while others are highly toxic to humans (Nkunika, 1992). Currently the standard recommended termiticide is Regent 3G with Fipronil as the active ingredient.Fipronil works by disrupting the normal functioning of the nervous system. It kills by contact and ingestion (Hamon *et al.*, 1996). However Fipronil causes human hazards including eye and skin irritation (US Environmental Protection Agency 1996) and it is non-selective (Hamon *et al.,* 1996), thus it has negative effects to the ecosystem. Resistance development against chemicals, when continually used, is rampant in insects as Ageng *et al* (2006) observed 300 fold resistance to fipronil in *Pluttela xylostera* with 5 and 6 fold resistance against dieldrin and endosulfan, respectively. It is due to this resistance development that, other pesticides available in Kenya for control of other insect pests in crops with potential for control of termites need to be tested to provide farmers with alternatives to Fipronil.

The molecule Imidacloprid (Imaxi®) is considered by the World Health Organization to be moderately toxic and it is selective in nature; affecting insects more than warm-blooded animals. The chemical works by interfering with the transmission of stimuli in the insect nervous system. It is effective as contact and via stomach action.

Materials and Methods

A laboratory bioassay was carried out to determine the most appropriate dosage to be used in the field. Two trials have been set up on-farm one in Western and Eastern provinces of Kenya i.e. Busia and Kibwezi Districsts respectively, which are known to be termite prone areas.

The experiment was set up in a randomized complete block design. There were 5 and 6 treatments in Busia and Kibwezi respectively. The treatments comprised of control with water only, 33 gm of Reagent 3G (Fipronil) as standards, and different concentrations of Imaxi.

Preliminary Results and Discussions

Only data from Busia site has been analyzed and therefore the preliminary results presented are only for Busia.

Table 1. Percentage of trees in each damage category at Busia 5 months after transplanting

Species	Treatment	Damage Category			
		1	2	3	4
E. grandis	Control	47	0	5	48
	Fipronil	82	0	5	13
	Imaxi 4ml/l	98	0	0	2
	Imaxi 2ml/l	100	0	0	0
	Imaxi 1ml/l	85	0	2	13
G. robusta	Control	65	0	13	22
	Fipronil	60	2	19	19
	Imaxi 4ml/l	98	0	0	2
	Imaxi 2ml/l	98	0	0	2
	Imaxi 1ml/l	97	3	0	0

There was high seedling mortality especially in control treatment due to termites attack since there was no termite control measure applied. Trees mortality was due to ring barking and root debarking by termites. There was significantly lower termite damage in Imaxi (imidacloprid) exposed trees comparing to the rest of the treatments indicating that Imaxi have better protection capability on trees that fipronil. Imidacloprid, which is a chlorinated nicotine like-molecule similar to nitromethylenes (Pearce, 1997) interferes with the nicotigenic acetylcholine receptors of insects, changing the social behavior of termite, reducing its feeding and resulting in eventual death.

Trees exposed to Imaxi showed generally higher growth vigor (Table 2) with Imaxi Upper (4ml/l) having the highest growth vigor comparing to rest of the treatments in both species. This high increase in growth can be attributed to imidacloprid, which is the active ingredient in Imaxi having positive beneficial effect on the growth and performance of *E. grandis* and *G robusta*. Imidacloprid has been found to enhance plant growth and stress tolerance (Thielert 2006).

	Treatment	Means	
		Diameter	Height
E. grandis	Control	2.044	132.2
	Fipronil	1.790	120.5
	Imaxi 4ml/l	2.087	135.0
	Imaxi 2ml/l	1.911	122.1
	Imaxi 1ml/l	1.862	121.8
G. robusta	Control	1.348	84.3
	Fipronil	1.430	83.2
	Imaxi 4ml/l	1.697	88.3
	Imaxi 2ml/l	1.366	85.9
	Imaxi 1ml/l	1.468	86.9
s.e.d		0.1756	7.629

Table 2. Mean of growth parameters (height and diameter) at Busia 5 months after transplanting

Conclusion and the way forward:

- Data collection needs to continue to generate more conclusive results.
- Imidacloprid (Imaxi) is effective against termite attack and it has beneficial effects on trees growth.
- *G. robusta* seems to tolerate termite attack better than *E. grandis*
- Trees mortality due to Termite attack were higher in untreated plots than chemical treated plots.

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3.0 STUDIES IN NATURAL FORESTRY

3.1 BIOPHYSICAL AND SOCIO ECONOMIC STUDIES OF TUGEN HILLS FOREST

By E. Obonyo, P. Ongugo, D. Langat

Introduction

Tugen Hills is located in Baringo district of the Rift valley province. It borders Turkana and Samburu District to the North, Laikipia to the East, Nakuru and Kericho South and Uasin Gishu, Elgeyo Marakwet and West Pokot to the west. The longitudes of Turgen Hills site is located between 35 "30' & 36 "30' East. The latitude is 0010 South &140'North.

Baringo District is one of the arid and semi-arid Districts in the country, but some areas around the Hills and the highlands have the potential of agriculture. The District has two major rainy seasons. The long rains are from March to July and the short rains start from September to November.

Lake Baringo is the largest source of water in the district. It is also one of the two important fresh water lakes in the Kenyan Rift valley that is primarily arid in nature. The lake is an important source of water for domestic use and livestock production. It is inundated by several fresh water inflows from the Mau and Tugen hills (Kenya-Lake Baringo, 2002). Despite the poor quality of water, it can be used for irrigation if proper attention is paid to crop selection, drainage and leaching. Rivers Molo and Perkerra, which drain into Lake Baringo, have their catchments in Mau escarpment and Tugen hills to the West and Laikipia escarpment to the East, respectively. These rivers play a major role in the biological and physical-chemical characteristics of Lake Baringo. The Rivers support a lot of biodiversity and many ecological functions in the lake and the surrounding area like Tugen hills, which is very important locally and nationally.

Objectives of the study

- To make a revisit of Tugen Hills forest
- To establish a new Suitable Agricultural and natural Resource Management (SANREM) site in Tugen Hills forest

Methodology

The study on Tugen Hills forest was carried out using a combination of International Forestry Resources and Institutions (IFRI) instruments and SANREM methods.

IFRI /SANREM tools

IFRI research instruments were used to collect both biophysical and some socio-economic data. The forest data (biophysical data) was collected using random sampling method whereby plots were randomly selected using UTM grid co-ordinates. The approximate positions of the plots on the maps were located using the last four figures of the Eastings and Northings. Once the reference point was established, bearings and distances to the plots were calculated using a compass and pacing the distances between

the plots. The position of each plot on the ground was recorded using a GPS. In total, data was collected from 30 plots, all distributed within the selected IFRI forest. Tree heights and diameters were measured but for shrubs and samplings only estimates were taken.

Different IFRI forms were also used to collect data on the socio economic characteristics of the site. We also used Participatory Rural Appraisal methods (PRA) to gather more socio-economic data.

SANREM household data was collected from a total of 100 households. The selection of the homes was randomly done.

Discussions (major highlights)

Training was conducted prior to the site visit in Tugen Hills Forest. A total of 40 participants were trained and the major focus was on the new Forest Act that has decentralized forestry management in Kenya to include community members in decision-making and general forest governance. The training sessions included both community members and government officials.

A total of 100 households were sampled in Tugen out of which 84 (84%) were male headed and the remaining 16 (13%) were headed by women. This had a critical effect on matters relating to acquiring assets and decision making especially on land use and general property ownership.

A large number of community members in Tugen Hills are neither members of local organizations (forestry or non forestry) nor do they take part in group activities. Some of the existing organizations had members outside the settlement and this proved to be a big constraint especially when trying to reach a large number of people within the settlement. It was also clear that impact from that site may not be as high as in other areas because groups are more effective than individuals. We therefore encouraged them to form new groups or join existing ones. We informed them that groups will play a very integral part of future forest governance through the new forest act and it was mandatory for them to be in groups if they wanted to take part in decision-making.

Property rights emerged as a major problem in Tugen Hills. There are major problems involving 'squatters' who believe that the forestland is rightfully theirs and they should be allowed to live in the forest. Some members were re-settled elsewhere but they claim these people who were resettled were government beneficiaries and were not the real 'right holders'.

Both government and non-governmental organizations are working closely with the community in the area. The community therefore has strong external links. The community needs to form a strong umbrella association as required by the new forest act to work closely with the Kenya Forest Service in forest management.

The community depends highly on the forest for both subsistence and cash income.

3.2 BIOPHYISICAL AND SOCIO ECONOMIC STUDIES OF RAMOGI HILLS FOREST

By Emily Obonyo, Paul Ongugo, Vincent Oeba and *Emily Kitheka*

Introduction

The Ramogi Hill forest is located in Yimbo, Bondo District on the North Western shores of Lake Victoria 4 Km from the lake. The forest, which is 5 Km long and 2 Km wide, covers an area of 283 ha and is divided into three parts. These are Ramogi, which is closest to the settlement, Unyenjra, which is closest to the swampy ground facing the lake and Dudi, which is the middle block, and in some areas adjacent to the community. The Ramogi forest is a highland equatorial forest in otherwise dry savannah woodland.

The forest has for a long time been managed by the local community held in trust by the County Council of Bondo. However, the Kenya Forestry Research Institute (KEFRI) and Forest Department (FD) have for a long time played a big role in its management. There are however plans to gazzete the forest.

Although the County Council is the custodian of the forest, it has not played any significant role in its management. However, due to recent developments, it has taken some interest in eco-tourism in the area. It has also been sourcing for funds and collaborators in the development of the area. The National Museums of Kenya (NMK) has had interest in the area. In 2003, it started a project where a National Committee for Conservation was formed. A Community Based Organization (CBO) and Village Development Committee (VDC) were initiated and registered to manage these activities on behalf of the community.

Got Ramogi has always held a central position within social and cultural life, inspiring respect through a great number of taboos and norms. The sacred groves, where the remains of royal ancestors lie, are the sources of many medicinal plants and have therefore been zealously protected for centuries.

Prior to the site visit, training was conducted and a total of 83 participants were informed about and trained on the expectations of the New Forest Act that focuses on the participation of communities in forest management in the country. The participants were told of the necessity to form Associations made up of different stakeholders who would manage and govern different sections of the forests as expected in the decentralized system. The participants were made up of community members, government officials and members of the civil society.

10 young people (6 women and 4 men) were further trained on IFRI/SANREM data collection methods. This team of ten community members worked closely with the SANREM team on data collection and organizing meetings with community members.

Methodology

Sociological Data Collection

Socioeconomic data collection was done using PRA methods such as historical profiling, focus group discussions with members of the community and key informants. Focus group discussions were undertaken to obtain information on the history of the area, user group and product information and to capture major changes in the area and the relationship of the users with forest resource managers.

Biophysical data collection

Biophysical data was collected from 30 forest plots randomly located within the forest. Since the forest is small, plots were randomly placed to cover the whole forest area. Transects were calculated on the map and the plots were then located on the ground using compass and pacing the distances between the plots. In total thirty plots were established following this procedure. Data on the height and DBH of trees, shrubs and saplings was collected. Data on the number of seedlings, percentage of crown cover per plot, soil type, moisture content and color was collected. Data on human/environmental impacts on the vegetation was also recorded and documented in some cases using visual observation.

Results and Discussions

The initial results indicate that the economic condition of the community members is very low. As is typical in most of Kenya's dryland areas, the agricultural output from the land is low. The community depends on fishing as the major economic activity and this has also been affected by the hyacinth that has blocked the lake and reduced the fish population drastically. The only other natural resource is therefore the forest and the community's livelihood is centred on the forest.

There are very few conservation efforts and it is only in the recent past that NMK through RPSUD has initiated an eco-tourism project with community members. The project is also backed by other organizations outside the community such as Maseno University which is working on the historical aspects of Ramogi while Moi University is working on the forest biodiversity.

The community has also established a forest association known as the The Got Ramogi Community Forest Conservation Trust. This trust will eventually oversee the running of the eco-tourism projects in the area on behalf of the community.

But the community is yet to form an umbrella association for all the forest associations and CBO's in the area. There are small CBO's in the area and other associations directly or indirectly dealing with forests. These need to be collated to form one umbrella association to represent the whole forest community.

Conclusions and Recommendations

In Ramogi, the agricultural output from the land is low, and fishing (the main economic activitiy) has been hampered by the hyacinth that has blocked Lake Victoria and reduced

the fish population. The community's dependence on the forest is high so there is need for diversified means of livelihood.

There are few conservation efforts in Ramogi and it is only recently that the National Museum of Kenya has initiated an eco-tourism project with community members in collaboration with other organizations.

Several CBO's exist but they work independently. The need to form a unified umbrella association is therefore also high in this site.

3.3 STATE OF ENVIRONMENTALLY SENSITIVE AREAS (ESA) IN SOUTH NANDI, NORTH NANDI AND KAKAMEGA DISTRICTS

By Tom Omenda and David Langat

Introduction

One of the aims of the Green Zones Development Support Project (GZDP) is restoration of degraded forests that had been previously cleared by the Nyayo Tea Zone Corporation (NTZC) but were not planted with tea for various reasons. Some of these sites are considered environmentally sensitive due to their physiography and environmental functions. NTZC has prioritized this Environmentally Sensitive Areas (ESA) for rehabilitation. Before the process of restoration is initiated it is important to map the extent of degradation or level of disturbances in the environmentally sensitive areas (ESA). Detailed baseline surveys were undertaken to generate information that inform rehabilitation approaches and also to develop appropriate indicators for monitoring effectiveness of the proposed rehabilitation efforts. This report gives detailed information of the biophysical and socioeconomic assessment in the ESA from studies undertaken in November and December 2007 period in four districts (Kericho, Nandi, Kakamega and Meru).

Methodology

Floristic diversity

Based on the reconnaissance surveys it was established that the once cleared areas were strips ranging between 100m to 1000m in some areas and therefore the selection of plots for biophysical assessment was based on nearness to ecologically sensitive areas (near water courses, along riverine and steep areas. 2 to 4 temporary sample plots (TSPs) were established along the strips to capture representative areas. In each plot 3 concentric plots of 10m, 3m and 1m radii were established. Within the 1 m radius, all plant species present were counted to determine their frequencies. In the larger plot with a radius of 10 m, the structure of vegetation cover was determined by obtaining the diameter at breast height and height of trees and shrubs larger than 2 m in height.

Soil conditions

Plots were inspected for any evidence of soil erosion and the type and extent. The depth of the litter layer was determined using a graduated metric ruler. Soil physical properties

were obtained using soil colour charts to determine colour and texture of the soil. Soil – pH was measured using a portable pH meter inserted into the soil at a specific depth.

Forest disturbance factors
Assessments were made on the plots to identify evidence of human disturbance as follows: cattle tracks, charcoal kilns, tree stumps and foot paths.

Socioeconomic surveys
The study was undertaken in villages adjacent to NTZC cleared forest areas. Household surveys were undertaken with the assistance of local chiefs and village elders. Lists of households within forest adjacent areas were obtained from local administration and village elders and these were used in selection of respondents in household surveys. From the village list, the households were categorized into groups based on relative distance from the forest (Far, moderate and near) and their wealth status (wealthy, middle and poor). Sample households were randomly selected from these categories as detailed in Table 1. Household information captured socioeconomic variables (household size, endowments, etc) and the type of use of forest and quantities of products extracted and the perception on the present state of the forests and the priority services and products desired from rehabilitated areas.

Table 1: Selection criteria for respondents in sampled villages

SOCIAL STATUS	DISTANCE FROM THE FOREST			
	Far	Moderate	Near	Total
Wealthy	9	9	9	27
Middle	9	9	9	27
Poor	9	9	9	27
Total	27	27	27	81

Results and discussion
3.3.1 South Nandi – Tinderet Forest
Most of the areas opened for conversion to tea buffer zones are in Tindiret forest at Kebeneti within Kericho district. Forest clearance was initiated in 1988 and mainly through local people participation, whereby there were allowed to salvage trees as compensation for their labour. The original vegetation was a primary forest dominated by old growth specialist such as: *Prunus Africana*, *Olea capensis* subsp.*welwitschii* and *Adolfi friederecii*. The NTZC intended the clear buffer zone of 100meters from the forest boundary but due to supervision lapses local people encroached beyond the 100m limits. It is estimated that the strip lies between 400m to 1000m and is more than 800ha. The Nyayo tea zone area extends along the forest edge and borders four villages namely: Kebeneti, Chepkechei, – Ndubusat, Kituiya, Kapkoros and Teldet.

Plant diversity
The following species were identified: *Olea capensis* subsp.*welwitschii* (Elgon teak), *Prunus africana*, *Adolfi friederrecci*, *Croton macrostachyus*, *Polysicias fulva*, *Syzygium quenensii*, *Ensente ventricosa*, *Podocarpus latifolia* and *Vernonia lasiopa* and *Neubowtonia platicalyx* at the forest edges. The areas that were cleared and less disturbed have regeneration of *Croton macrostachyus*, *Vernonia* spp, *Syzigium quenensii*, and *Nuxia congesta.* According to local people these tree species are not palatable to goats and therefore not browsed.

Forest use
Forest adjacent households obtain firewood, water, honey, herbal plants, poles, charcoal and graze their animals in the forest. A typical household collects on average of about two hundred and fifty back-loads, 400 pieces of construction poles, 40 bags of charcoal and 5kg of honey per year. Grazing of domestic animals is active with 60% of the forest adjacent households graze their domestic animals within the forest area and about 35% of households reporting use of the forest through out the year for cattle grazing but less after maize harvest.

It is estimated that there are 300 to 500 cattle and more than 500 sheep grazing in open grassland in Kebeneti and Ndubusat villages alone. On average each household has 8 heads of cattle and 12 sheep grazing in the nearby forest.

The forest acts as headwaters for several streams and rivers. There are six streams that either originate from the forest or are draining through the forest areas that were cleared. Indeed, according to the local people they have seen notable changes in stream flow volumes and water quality.

Human impacts
There are human activities, which have impacted negatively on the state of the forest. Among the most prominent of these are: charcoal burning, illegal cultivation and over grazing. These activities were identified by the local people as having had a negative impact on the state of the natural forest.

Tree species for restoration
The candidate tree species were obtained from analysis of the existing vegetation in the adjacent forest and historical reconstruction through discussions with the local people and observations of natural regeneration and the adaptability of tree species to intense human pressure.

The following tree species were listed by the local community as priority for restoration: *Olea capensis* subsp.*welwitschii* (Elgon teak), *Prunus africana, Adolfi friederrecci, Croton macrostachyus, Polyscias. fulva, Syszgium quenensii, Ensente ventricosa, podocarpus latifolia and vernonia lasiopa, Neubowtonia platicalyx* at the forest edges. The areas that were cleared and comparatively less disturbed have plentiful regeneration of *Croton macrostachyus, Vernonia spp, Sysigium quenensii, and Nuxia congesta.*

According to local people these tree species are not palatable to goats and therefore not browsed.

3.3.2 Kapchorua forest area

According to the local residents the forest used to be inhabited by forest dwellers - the Okiek Community who were later joined by some pastoralists who kept cattle and grew food crops. The forest was cleared through participation of local people by NTZC for planting a tea buffer zone in 1992 but the area is yet to be planted with tea. During clearance, there was marked charcoal burning; in fact it was the main subsidiary activity after tree felling. The cleared areas were followed by cultivation of maize, millet, potatoes, finger millet and vegetables till 2003 when the government banned cultivation in public forests. There are six villages neighboring the forest and use the forest for grazing. These villages are: Cheronto, Kolongei, Tereno, Uson, Kapsokyot and Kapchanga.There are some steep areas, which are susceptible to landslides.

There are about 436 ha that were cleared by the Corporation which, until recently was used by local people as grazing grounds. The corporation has initiated rehabilitation through tree planting mainly with firewood species. Blue gum trees (Eucalypts) have been planted in most areas while indigenous tree species are planted on steep and sensitive areas like watercourses. In total 387 ha is to be planted with eucalypts and the rest with indigenous tree species.

Indigenous Original Vegetation

According to the local people the following tree species were common and still common in the undisturbed forest namely*: Prunus africana; Acacia lahai, Neubowtonia platicalyx, Syzigium quenensii, Polyscias fulva, Sysizigium cordatum, Schefflera alata, Croton macrostachyus, Martit (Nandi), Cordia abbysinica, Adolfi friederecci, Ficus natalensis*

Forest use

The local communities obtain firewood, water, honey, herbal medicine, poles, charcoal and graze their animals in the forest. A typical household collects on average about one hundred and sixteen back-loads, 2300 pieces of construction poles, 18 bags of charcoal and 8kg of honey per year.

Grazing of domestic animals is active with 65% of the forest adjacent households grazing their domestic animals within the forest area and about 35% of households reporting use of the forest through out the year for cattle grazing but less after maize harvest (September to December (Fig. 9). A typical household has 9 cattle, 4 sheep and at least a goat grazing inside the forest. In general terms the forest adjacent households rate the dependency on forest very highly (88 %, N=29).

Perception of the importance of the forest to local people

Eighty percent of the local residents said they have access rights to the local forests and collect various products for domestic use and occasionally for sale. Most of the residents regard the forest as important for their subsistence needs but not so important as a source of household income.

The perceived non-importance of natural forest to household income is mainly because, the local people do not see the direct benefits from sale of products for cash income, however, the non –economic benefits (water and soil conservation) are ranked very high.

Human impacts

The local people have used the forest legally and illegally and these have often impacted negatively on the state of the forest. In this forest the local people have identified grazing, illegal tree harvesting as the important human activities impacting on the state of the forest.

The existence of a good forest is determined by many factors, key among them is the attitude of the local people towards the public resource. It is recorded from discussions with local people that forest conservation is interpreted differently depending on the pressing needs of individual households, policy environment and the general socio-economic situation of individual actors. Local residents consider the presence of the forest as a direct source of products for domestic consumption (55%) and 28% values it for environmental functions. Based on these statistics, the most important attribute which may guide forest restoration is the importance of direct use values and environmental services to the locals.

Priority tree species preferred by local people for restoration

The following tree species were listed as priority for restoration: *Olea capensis*, *Prunus africana, Adolfi friederrecci, Croton macrostachyus, P.fulva, Sysygium quenensii, Ficus capensis, Juniperus procera, Acacia lahai, Diospiros abbysinica*. For use values, they mention exotic tree species such as cypress and eucalypts as priority tree species for planting in areas further from the ecologically sensitive areas. In the disturbed sites pioneer species like *Neubowtonia platicalyx, Vernonia lasiopa, Solanum spp, Dombeya torrida, Allophyllus abbysinica* have emerged. There is one herb, which has disappeared as result of forest disturbance. These are also potential species, which can be used in enrichment plantings

3.3.3 North Nandi, Kapchekok forest

The site was originally a thick rainforest but a portion was cleared for human settlement between 1959 and1969. The forest since then remained intact till 1985 when the Nyayo Tea Zone Corporation allocated the 100m strip to the locals to clear in anticipation of planting a tea buffer and from field observations the 100m strip was followed. After clearance, the local people were allowed to grow maize and vegetables till 2003 when the government stopped cultivation in public forests.

Indigenous Original Vegetation

Transect walks and discussions with local informants revealed that the original vegetation was mainly: *Syzigium quenensis* (Lameiywet), *Polyscias fulva* (Aonet), *Adolfi friederecii* (Chepkoibet), *Ficus natalensis* (Simotwet), *Croton megalocarpus* (Masineito) (Nandi), *Taebona Montana staffiana* (Rerendet), *Diospiros abbysinica* (Cheptuiyet), *Caessarea batiscombei* (Chepchabayet) and *Zanthozyllum gilletti* (Sagaiwaita).

Forest use

There are 5 villages adjacent to the forest (Kamosopwo, Singoro, Ngatatyat, Kapchekok and Kipsoi) the residents obtain firewood, poles, charcoal and graze their animals in the forest. A typical household collects on average about three hundred and forty backloads of firewood, Eight thousand pieces of construction poles, four bags of charcoal, 1kg of honey and 3 back-loads of thatching grass per year.

Grazing of domestic animals is active with 85% of the forest adjacent households grazing their domestic animals within the forest area and about 55% of households reporting use of the forest through out the year. Atypical household has 9 cattle, 4 sheep and at least a goat grazing inside the forest. In general terms the forest adjacent households rate the dependency on forest very highly (88 %, N=29,).

Perception of the importance of the forest to local people

Eighty five percent of the local residents said they have access rights to the local forests and collect various products for domestic and occasionally for sale. Most of the residents regard the forest as very important for their subsistence needs, income and for water and soil conservation.

This high dependency on the forest is mainly because the farmers adjacent to the forest graze their livestock in the natural forest and earn a higher income from livestock and attribute this to the importance of the forest.

Human impacts

There are a number of human influences, which have been cited by the local people as impacting negatively on the state of the forest. These are: overgrazing, illegal tree harvesting and corruption by government officials.

The existence of a good forest is predicated upon many factors and in most cases determined by the attitude of the local people towards the public resource. It is recorded from discussions with local people that forest is interpreted differently depending on the pressing needs of individual households, policy environment, general socio-economic situation of individual actors. Local residents consider the presence of the forest for environmental functions (89%) and less than 10% for direct use values.

Priority tree species preferred by local people for restoration

Taking the interests of the local people into consideration, the preferred tree species species for restoration should mainly be for non-economic functions as opposed to direct use values and therefore the following species are suggested for restoration: *Diospiros abbysinica, Olea capensis*, *Prunus africanum, Croton macrostachyus, P.fulva, Syzygium quenensii, Syzigium cordatum, Scheflera volkensii, Fagaropsis angolensis and Zanthozyllum gilltetti.* For use values, exotic tree species such as cypress and eucalypts as priority tree species for planting in areas further from the ecologically sensitive areas.

3.3.4 North Nandi, Kamungei forest

The forest area cleared was originally a thick indigenous forest with a wide diversity of tree species such as: *Syzigium quenensii, Croton macrostachyus, Celtis africana, Croton megalocarpus, Prunus africana, Diospiros abbysinica, Markhamia lutea, Nuxia congesta, Albizia gummifera, Trichoclydus ellipticus*, Acacias and few scattered trees of Elgon teak. Some portion of forest was cleared by Forest Department in early 1970's to plant exotics tree species for Webuye Paper mill. About 900ha of the plantations were harvested in 1995 to pave way for tea growing by the Nyayo tea Zone Corporation. After harvesting, the local people were allowed to grow maize for 3 years (1995 to 1998) and cultivation was stopped over conflicts over forest plot allocations and the area has remained a grazing ground since 1998. There are scattered patches of forests along riverine areas, which were cleared and those forest areas used by local as cultural sites.

Along the riverine areas, there are few indigenous species such as: *Trichoclydus ellipticus, Markhamia lutea, Ehretia cymosa, Ficus natalensis and Polyscias .fulva.*

Forest use

There are seven villages adjacent to the forests that use the natural forest and Nyayo tea zone area. The villages are: Litei, Kamungei, Kapkele, Chepnyogoson, Kiptangus, Chepkongi, Kiptarany and Kurgong. Residents obtain firewood, poles, and charcoal and graze their animals in the forest. A typical household collects on average about three hundred and twenty backloads of firewood, one hundred and seventy running feet of timber, seven hundred and eighty pieces of construction poles, forty bags of charcoal, 15kg of honey and 20 back-loads of thatching grass per year.

Grazing of domestic animals is active with 92% of the forest adjacent households graze their domestic animals within the forest area and about 75% of households reporting use of the forest through out the year. Atypical household has 9 cattle, 4 sheep and at least a goat grazing inside the forest. In general terms the forest adjacent households rate the dependency on forest very highly (88 %, N=29).

Perception of the importance of the forest to local people

All the local residents said they have access rights to the local forests and collect various products for domestic and occasionally for sale. Most of the residents regard the forest as very important for their subsistence needs, water and soil conservation but not important for cash income.

Human impacts

There are a number of human influences, which have been cited by the local people as impacting negatively on the state of the forest. These are: illegal harvesting, and charcoal burning.

Local residents consider the presence of the forest as a source of future agricultural land and for environmental functions.

Priority tree species preferred for restoration
The following species are suggested for restoration: *Diospiros abbysinica, Cassipourea malosanas, Croton macrostachyus, P.fulva, Syzygium quenensii, Syzigium cordatum, Scheflera volkensii, Fagaropsis angolensis and Acacia lahai.*

3.3.5 Kakamega forest, Madzo, Ileho and Jorban sites

The area was originally a thick rainforest dominated by *Prunus africana, Croton macrostachyus, Croton megalocarpus, Olea capensis* and *Maesopsis eminii* but the area was cleared in early sixties and seventy's for exotic plantations.

This area was planted with cypress and pines before it was harvested in 1985 to pave way for tea growing but some parts of the cleared area are not suitable for tea. When the area was left vacant there are pioneer tree species, which have covered the area and these, are: Quavas, *Croton macrostachyus, Markhamia lutea, Maesopsis eminii, vernonia,* Nandi (*Spathodea nilotica)* flame. The corporation intends to expand tea in this area and plant some steep areas other areas not suitable for tea with energy plantations.

Forest use
Local residents obtain firewood, poles, and charcoal and graze their animals in the forest. A typical household collects on average about three hundred and ninety backloads of firewood, 4 back-loads of thatching grass per year.

Grazing of domestic animals is active with 72% of the forest adjacent households grazing their domestic animals within the forest area and about 35% of households reported use of the forest through out the year. A typical household has 5 cattle, 4 sheep and at least a goat grazing inside the forest. In general terms the forest adjacent households rate the dependency on forest very highly (88 %, N=29).

Perception of the importance of the forest to local people
All the local residents said they have access rights to the local forests and collect firewood for domestic consumption and for sale. Most of the residents regard the forest as very important for their subsistence needs, water and soil conservation but not important for cash income.

Human impacts
There are a number of human influences, which have been cited by the local people as impacting negatively on the state of the forest and prominent among these are: illegal harvesting, and charcoal burning and overgrazing.

Local residents consider the presence of the forest as government property and as an economic good. This attitude indicate high level of exclusion in the management of resource and the locals have no stake in the management of the forest resource. If the

restoration efforts have to succeed then the locals have to be part of the process so that this negative attitude is reversed.

Species preferred for restoration

The following species are suggested for restoration: *Eucalypts spp, Cuppressus lusitanica, Diospiros abbysinica, Croton megalocarpus, P.fulva, Syzygium quenensii, Syzigium cordatum, Cordia abbysinica, Prunus africanum, Maesopsis eminii, Bridelia micrantha and Olea capensis* sub spp *welwitschii.*

Conclusion

The areas cleared under Nyayo tea zone program are extensive and areas left without vegetation should be restored. To be able to do this, it is important that the right actions are informed based on the current state of ESA and the desires of the local communities. Different localities require unique approaches in terms of species mix and specific needs of forest adjacent communities. The areas, which were cleared by the NTZC, are extensive and this can have environmental consequences if the deforested areas are not reforested. In the interim the potential species are a mix of indigenous trees and fast growing exotics have been listed for each site.

3.4 TRAINING MANUAL ON PARTICIPATORY FOREST MANAGEMENT

By Joram K. Kagombe, MTE Mbuvi and B. Owour

Background

The adoption of Participatory Forest Management (PFM) at the local level depends on ability of the local community to formulate local rules that can form recognized guidelines to be used to manage forests. It is important that the rules formulated address local needs, but at the same time be inline with national policies, legislation and consider global concerns. The community understanding of the Forestry policy and the Forest Act and other related legislations are therefore important. Implementation of PFM in the grass root will succeed if supported by other government/NGO middle and senior level staff as this will create harmony in the field. The Forest ACT 2005 and the Water Act requires that new institutions in form of forest associations and water users associations be established at the local level to over see the management of forests and water respectively. Local level leadership is crucial for the success of these institutions. The ability of the leaders to facilitate meetings to discuss and generate local initiatives cannot be over emphasized. Community leaders are expected to lead forest association members to keep the service informed of any developments, changes and occurrences within the forest, which are critical for conservation of biodiversity. It is therefore important that the communities are sensitive to changes taking place in the forest and their role of monitoring and reporting the changes. They are also expected to formulate and implement forest use programmes that take into consideration local needs. These programmes need to have in built monitoring mechanisms and that the programmes should be gender sensitive and incorporate aids awareness messages.

It is for this reason that the training manual was developed to equip the various actors with necessary knowledge and skills. Its also expected to create uniformity in capacity building leading to better PFM implementation. Therefore this manual is being developed to:

- Hasten the process of PFM implementation and institutionalization
- Capacity build all implementers
- Create linkage of conservation and livelihood in development

Approach to Development of Manual

A training needs assessment was conducted in Naivasha in 2003 targeting problems experienced by community members while implementing PFM. During this workshop, solutions were suggested to the identified problems. This was later followed by development of Training Module I materials for community members through a series of workshop/meetings. The material developed has since been tested in four trainings where 120 community members were trained. Module II materials were developed based on field experience, module I materials and experiences gained from MSTCDC Arusha as well as Uganda. Materials were tested in three training sessions in Kitui where 90 participants were trained. Module III materials were further developed from module II and tested in Kitui where 30 officers were trained.

The manual development has been informed by: Collaborative Forest management manual for Uganda, PFM implementation experiences, PFM experiences from other countries like India, Nepal etc, Regional PFM training in MSTCDC Arusha, Tanzania and FAO manual on PFM training

Goal and objectives

The goal of the manual is to instill good practice of PFM in the Kenya. The Manual objectives

- To facilitate the introduction of PFM into forestry management
- To enhance the capacity of stakeholders to implement PFM

Results: Key highlights of the Manual

Each module has a specific goal that guides the general objective and specific objectives for the target group. Specific objective guide the training contents. Training contents are supported by training activities. The manual provides a stepwise training topic from initiating to implementation through forming a CFA and developing partnerships through guidelines. This is supported by illustrative case studies emphasizing the concepts which are meant to provide the participants with real field experiences as means for guiding them on how to adopt/adapt the process to different forest conditions and participating community types. This manual places more emphasis on facilitation instead of training and the participants will be expected to learn from each other with the trainer guiding the sessions.

Training Approach

The training will emphasize participatory adult learning approaches where participants will have an opportunity to experience, analyze, reflect and apply. The participants will identify the issues and develop their own set of questions, work out their own

conclusions, relate their learning experiences to their own values, beliefs and previous experiences and use and test a new skill and receive feedback on their performance. Facilitators will use experiential activities in which participants work out their own conclusions. The facilitators will match activities (presentations, games and role plays) with desired learning outcomes.

The training manual has three modules each targeting a category of officers as shown in table 1.

Table 1: PFM implementation categories

Training module	**Target officers**
Module I	Community scouts/community forest guards KFS forest guards and frontline extension staff KWS rangers CFA officials and members
Module II	KFS foresters (management and extension KWS assistant wardens Officer from GoK departments of similar rank and related responsibilities NGO officers of same rank as foresters
Module III	DFO and PFO KWS wardens District waters officers Other government officers of same rank and related responsibilities NGO officers of same rank like programme officers

Manual over view and scope

This training manual is designed to facilitate the introduction of PFM into the management of forests within a framework of decentralized management of forests with communities taking up a major management responsibility. Therefore, this manual can be used in other sectors undergoing similar management reorientation. These include:

Ministry/Department	Organizational structure
Ministry of Water and Irrigation	Regional water authorities and community water users associations
Kenya Forest Service	Forest Conservation Committees and community forest association
National Environmental Management Authority	Various devolved management bodies and committees
Parliamentary Service Commission	CDF committees at the constituency which rely on prioritized projects developed from the grassroots
Ministry of Planning and Development	Administrative hierarchy development committees from the District Development Committee to the Village Development Committee
Ministry of Local Government	Community structures to access LATF etc

Conclusion and recommendation

The manual is a useful guide to trainers in Participatory Forest Management enabling uniformity in PFM approach. It requires periodic review to make it answers emerging issues. A hand book containing details in areas of training require to be developed. This will be used by trainers while training. Proper use of manual will equip implementers thus achieving sustainable forest management and improved livelihood for participating community members. Government, donors and stakeholders should support training of implementers in PFM

Module Course Content

1. ***Climate Setting***
    - Introduction –
    - Recording Participants interest and fears
    - Setting rules and assigning roles and responsibilities
    - Negotiating Training Program
    - Key note address

2. ***Introductory Topics***
    - Historical development of Forestry in Kenya
    - Introduction to NRM Policies and Legislation
    - Reforms process in Public Sector
    - Land and Resource Tenure
    - PFM- What and Why?
    - PFM and Rural Development
    - PFM Principles and Process

3. ***Participatory Situation Analysis***
    - Policy Analysis
    - Feasibility Assessment
    - Attitude Change
    - Stakeholder Analysis
    - Institutional Arrangement for PFM
    - Resources Assessment
    - PFM and Livelihoods

4. ***Negotiating for PFM***
    - Negotiation and Consensus building
    - Conflict Management
    - Power relationship
    - Communication skills
    - Facilitation skills
    - Community mobilization
    - Team building
    - Management Plans
    - Management agreements
    - Governance

- Gender and Equity

Sustaining PFM

- Participatory approaches and tools
- Forest Extension services and PFM
- Costs and Benefit sharing
- Organizational development
- Advocacy and networking
- Institutionalization of PFM
- Resource mobilization
- Participatory Monitoring and Evaluation

5. Way Forward

- Action Plan
- Follow up
- Monitoring Impacts of PFM

3.5 NATURAL FOREST REHABILITATION: ESTABLISHMENT OF DEMONSTRATION PLOTS AT KIKUYU ESCARPMENT FOREST

By Tom Omenda, Giathi Gitehi, *Bernard Kamondo, Jason Kariuki and John Kiamba*

Introduction

The rehabilitation site is located in Ngobi forest block of the Kikuyu Escarpment. The area is on the eastern side of the Rift Valley wall in Kiambu District of central Kenya. The block is a parcel of the continuous Kikuyu Escarpment that is 38,312 hectares. Part of this stretch - Ngobi block was converted into *Juniperus, Olea* and Eucalypt plantations in the early years of the 20th century to provide fuel wood for the steam engine for the Uganda railway.

Kikuyu Escarpment was originally gazetted in 1932. Further gazettements were done in 1934 and several times before 1943. Together with the Aberdare's and Kipipiri, the forests were declared crown land forests in 1964 at which time their combined area was 170,510 hectares. This forest occurs in a transition zone between the dry and the high potential region and can be referred to as a "dry montane forest". Kikuyu escarpment forest is managed from Uplands and Kinale forest stations.

The Aberdares, Mount Kenya and the Kikuyu Escarpment forests constitute the main catchment areas of the eastern Rift Highlands. Rivers flowing westwards from the Kikuyu Escarpment into the Rift Valley drain into the catchment of the Kedong River and then into Lake Naivasha. Kikuyu Escarpment Forest provides a variety of goods and services to the local communities. These include: timber, wood fuel, construction material, medicines, fodder, fruits, poles and posts, tool handles, ropes, bee forage and as a source of springs.

Management

This forest was under selection felling management system prior to the ban on exploitation of natural forests in mid-1980s. Logging for timber mainly targeted *Juniperus procera*, *Olea aeuropea*, *Teclea spp*, *Euclea divinorum* and other species for charcoal. Currently, this forest is degraded into almost grassland vegetation. Livestock grazing and firewood collection are the major form of exploitation going on.

Methodology

A plot measuring about a hectare was demarcated for rehabilitation in 2007. Line clearing was done at interval of 3.5 m. Then along the lines holes were dug at 3.5 m interval. Different tree species indigenous to this forest type together with those observed to perform well in the surrounding farm were planted in April 2007. This plot was extended by half a hectare in April 2008 at a spacing of 2 m x 1m. The species planted in this plot included *Podocarpus falcatus, Warbugia ugandensis, Dovyalis abyssinica, Croton megalocarpus, Prunus africana, Juniperus procera, Xanthoxylum gilletttii* among others.

Results on survival

Plot Planted in 2007

This plot was planted in April 2007 at a spacing of 3.5 x 3.5 m. Beating up was done in April 2008 and inspection for survival was seven months later and the survival was about 75%. The species mortality was as indicated in the table below.

Table 1. Tree species mortality by count

No	Tree species	No of dead trees
1	*Cordia abyssinica*	40
2	*Podocarpus falcatus*	24
3	*Vitex keiensis*	15
4	*Warbugia ugandensis*	15
5	*Olea europea var Africana*	12
6	*Brachylaena huillensis*	14
7	*Prunus africana*	14
8	*Erythrina abyssinica*	14
9	*Markhamia lutea*	16
10	*Juniperus procera*	10
11	*Polyscias fulva*	12
12	*Teclea nobilis*	18
13	*Albizzia gummifera*	9
14	*Others*	20

The main causes of mortality were identified as livestock grazing, theft and drought. *Podocarpus falcatus and Cordia abyssinica* were the most affected by the drought.

Tree Species Planted in 2008
This plot was planted in April 2008 at a spacing of 2 x 1 m. The species planted are shown in the Table 2.

Table 2.

No	Tree species
1	*Podocarpus falcatus*
2	*Zanthophleom gillittii*
3	*Warbugia ugandensis*
4	*Olea europea var Africana*
5	*Dovyalis abyssinica*
6	*Brachylaena huillensis*
7	*Prunus africana*
8	*Erythrina abyssinica*
9	*Croton megalocarpus*
10	*Polyscias fulva*
11	*Teclea nobilis*
12	*Albizia gummifera*
13	*Ehretia cymosa*
14	Others

The way forward

- 2009/10- maintain the plot and review performance of various tree species planted.
- Start rehabilitation work of Gachuthi forest-KEFRI indigenous forest at Veterinary.

3.6 DEVELOPING TECHNOLOGIES FOR RAISING MERU OAK THROUGH ROOTING STEM CUTTINGS

By G. Giathi, J. Machua and V. Oeba

Introduction/Background
Vitex keniensis Turrill belongs to Verbanaceace family. It is a deciduous tree up to 35 m high with a clear straight bole. Bark is pale brown with vertical grooves. Leaves are compound, divided into 5 leaflets, on a long hairy stalk. Flowers are white or purplish with one dark mauve petal lobe. Mature fruits are black, round, about 1.5cm across, usually containing 1 to 2 seeds or rarely 3 to 4.

The species occurs in moist evergreen forest, between 1300-2100m, prefer deep sandy loam soil. Mean annual rainfall of 1400-1900mm. It is common on the eastern slopes of Mt. Kenya and it is widely planted in plantations.

Flowering occurs between January and April. Pollination is by insects. Seed maturity takes about 5 months. The green fruit of about 1.5 cm turns black when ripe. The timber is hard and durable, very pale and similar to teak. The heartwood of trees over 60 cm in diameter is often dark and very decorative. The wood is also suitable for firewood. It is a popular ornamental tree and is sometimes planted as a windbreak. The fallen leaves produce a useful mulch of litter improving the soil. The fruits are edible but in most areas only eaten in times of food shortage.

The species conservation status is classified as vulnerable. Its natural habitat is threatened by; agriculture, land management of non-agricultural areas, extraction of wood and selective logging, and clear-cutting ,infrastructure development, human settlement and invasive alien species.

The aim of this research is to develop cheap and effective methods of raising Meru oak seedlings through stem cuttings for genetic improvement and conservation by determining the best rooting media and hormone concentration.

Methodologies

8-10 cm long and pencil-thick stem cuttings were harvested from one and half year old seedlings. The cuttings were treated with fungicide then different levels of IBA rooting hormones were applied. The IBA concentrations applied were 0,0.5, 1.0, and 2.0%. The rooting media tested included; sub-soil alone, Peat: sand 1:1, sand soil alone, forest soil, and peat alone

The experimental design was a Split plot design with three replicates and ten cuttings per replicate. The trial was run in a non-mist propagator unit located at Muguga research nursery. The data on the following characters; rooting, callusing, no change, rotting and sprouting/shooting was collected at seventh week.

Results and Discussion

The results showed that no rooting of cuttings was observed in sub soil and there were varying rooting percentage across the rooting media and IBA concentrations. Forest and sand soil had relatively higher number of rooting across the IBA concentrations followed by Coconut peat (Table 1).

Table 1: Percentage of stem cuttings rooted under different rooting media and IBA concentration at 7th week

	Percentage cuttings rooted under different rooting media and IBA concentration			
Rooting media	**0%**	**0.5%**	**1%**	**2%**
Coconut peat	63.3	83.3	65.0	56.7
Forest soil	40.0	60.0	90.0	90.0

Table 1: Percentage of stem cuttings rooted under different rooting media and IBA concentration at 7th week

	Percentage cuttings rooted under different rooting media and IBA concentration			
Rooting media	**0%**	**0.5%**	**1%**	**2%**
Coconut peat	63.3	83.3	65.0	56.7
Forest soil	40.0	60.0	90.0	90.0
Sand soil	53.3	93.3	90.0	63.3
Sand soil + peat	23.3	60.0	80.0	90.0
Sub soil	0	0	0	0

0.5% and 1% of IBA had greatest influence on rooting of the cuttings. 0.5 % of IBA with sand soil gave highest rooting of 93.3 %, this was followed by 1% IBA with forest and sand soils at 90% (Table 1 and Figures 1).

Figure 1:Mean percentage rooting under different rooting media

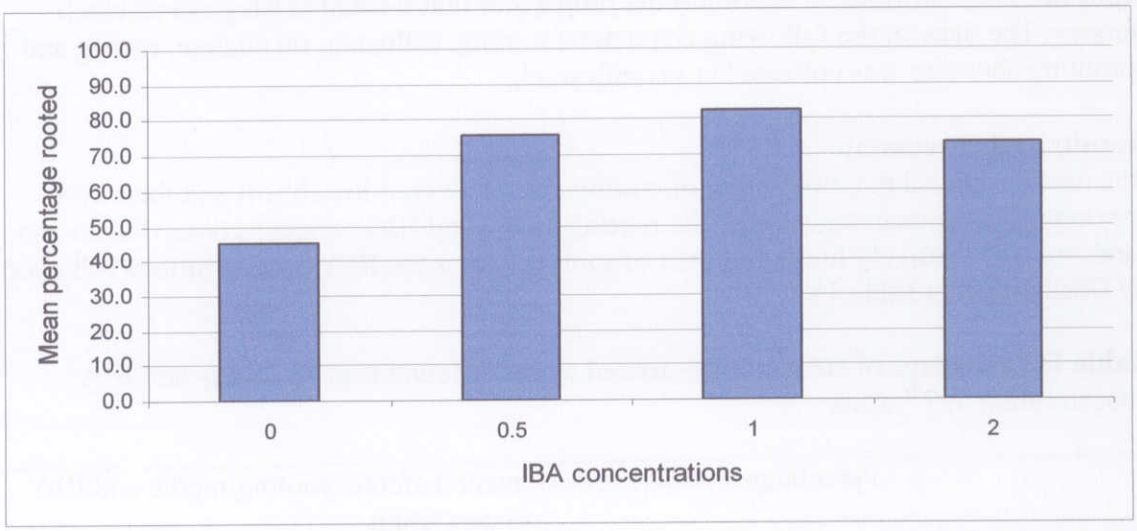

Figure2: Mean rooting percentage of cuttings under different IBA concentrations

The control or 0 % IBA had the least rooting. This show that application of IBA hormone promoted rooting of cuttings in all rooting media. However,the magnitude of the effect varied with the concentration of hormone and also the type of rooting medium.

From the results, sandy soil and 1% IBA had the best rooting percentage and also the highest number of root formation. Tentatively, this combination may be recommended but more work needs to be undertaken on the cost of different types of rooting media and also IBA hormones .

Plate 1. Cuttings of Meru oak under different treatments after seven weeks

Conclusion

Different rooting media and IBA concentrations recorded varying levels of rooting success in the meru aok stem cuttings. No rooting was recorded in the red sub soil. The best rooting was given by a combination sandy soil and 1% IBA. Tentatively, this may be recommended but more work on the cost of different types of rooting media and also IBA hormone is needed.

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3.7 DEVELOPING TECHNOLOGIES OF ROOTING CAMPHOR STEM CUTTINGS FOR MASS PRODUCTION

By G. Giathi, J. Machua, V. Oeba

Introduction/Background.

Ocotea usambarensis (East Africa camphor wood) belong to family lauraceae. It occurs in the wet montane forests of Kenya, Tanzania and is sparse in Uganda. It grows naturally between 1375 and 2600 m above the sea level but it is more prevalent between

1830 and 2156 m. In Kenya its found on the southern and eastern forests of Mt. Kenya and on the eastern slopes of the Aberdares mountains ranges. *O. usambarensis* tree can attain a diameter at breast height (dbh) of 200cm and maximum height of 45m with a clear bole of 9-15m.

This species is classified as threatened due to high exploitation pressure and difficulties in natural regeneration. It seeds once in eight to ten years but majority of seeds are dropped pre-maturely due to attack by gall-insects and birds (Bussmann, 2001). This problem has been so acute that since the inception of the Kenya Forestry Seed Centre in 1985, no successful collection of the species has been possible. Also, its seeds are recalcitrant and therefore cannot stay for long without losing even under most favourable conditions.

In nature *O. usambarensis* has been observed to regenerate from suckers growing from stem bases and old roots but the importance of this mode of regeneration in the *O. usambarensis* regeneration dynamic has been not investigated. When young trees are cut, coppices develop on the stump but their subsequent growth and development has not been documented. Under natural conditions few seedlings manage to establish but they suffer heavily from herbivory.

In spite of this regeneration problems the *O. usambarensis* natural populations in the wild continue to shrink at an alarming rate due to illegal and legal exploitation pressure, encroachment on the forestlands and excisions. In order, to save this species from extinction other means of propagation should therefore be developed and exploited for conservation and domestication of the *O. usambarensis*

Overall objective

- To develop simple and effective technology for vegetative propagation of Camphor through rooting stem cuttings.

Specific Objectives

- To search for and/or develop suitable sources of Camphor stem cuttings for research and production purposes
- To determine the optimal IBA rooting hormone concentrations for rooting of the Camphor stem cuttings
- To determine the best rooting medium for rooting of the Camphor stem cuttings.

Methodologies

Sources of Propagation materials.

Surveys were conducted in most of the Camphor natural distribution range of the Aberdares mountain for availability of suitable sources of juvenile stem cuttings. The most preferred materials are the vigorously growing young coppices, seedlings and saplings. The surveys covered Nyamweru, Kereita, Kieni and Kinale forest blocks.

Rooting Trials 1

- *Objective:* To determine the effect of different concentrations of IBA rooting hormone on the rooting of Camphor stem cuttings with subsoil as the rooting medium.

The Hormone concentrations tested were 0mg, 0.5mg, 1.0mg, 3.0mg, 5.0mg and, 10 mg IBA\l

Juvenile leafy stem cutting measuring 10-15 cm long and pencil-thick from primary and secondary branches of a five years old sapling growing at Muguga were harvested and transported to research nursery in cool box. They were treated with a fungicide by immersing them in a suspension of broad spectrum Dithane M-45 fungicide (Mancozeb-active ingredients) for 20 minutes. Then cuttings were immersed overnight (15hrs) in different concentrations IBA.The experimental layout was a Complete Randomized Design (CRD) with 6 treatments (hormone concentrations) in 4 replicates. Each replicate had 15 cuttings. After placing the cutting into the rooting medium, it was watered thoroughly and containers kept in the non-mist propagator. A high moisture level in the chamber was maintained through regular spraying. The rooting progress per cutting was reported as; rooting, callusing, no change, dying/dead.

Results

Sources of Propagation materials

The sources of suitable juvenile stem cuttings were scarce. However, some young coppices were found at Nyamweru in Upland forest station. No suitable material were found in Kereita and Kinale forest blocks. Mt Kenya forest was not explored.

Rooting.

- So far no cutting from coppices or sapling has rooted. They only developed leaves then died off.

Developing Alternative Approach of Rooting Camphor stem cuttings.

From work done in other countries, hardwood tree species are multiplied vegetatively through use of cuttings from seedlings. The available seedlings are cut into small cuttings, which are then rooted. This was tried at Muguga on preliminary basis and gave encouraging results (Plate 2)

Plate2: Rooted cuttings from seedlings.

Recommendation

All vegetative propagation research would be directed to stem cuttings from seedlings. The rooted cutting would first be used to establish a cut hedge for further supply of suitable vegetative propagules both for research and commercial production in the years to come.

Reference

Bussmann, R. W. 2001. Succession and regeneration patterns of Eastern Africa mountain forest trees. Syst Geogr. 71:959-974

3.8 EASTERN AFRICAN BAMBOO PROJECT (EABP), KENYA

By Gordon O. Sigu and Geoffrey Maritim

Introduction

Bamboo is a grass with immense potential, which has not been exploited fully locally like in other countries and in particular the Asian countries. There are 1,250 species of bamboo known to date and 70 % are in Asia. The rest are spread in other parts of the world and this includes 43 species found in Africa covering about 1.5 million hectares. Out of this, Ethiopia has the most bulk of bamboo resources covering an area of 1 m ha with 2 bamboo species namely *Yushania alpina* and *Oxytenanthera abyssinica*.

On the Kenyan side, there is only one indigenous bamboo species *Yushania alpin,* which grows in higher altitude areas ranging from 2,400 m to 3,400 m above sea level covering about 150 000 ha. This has been a bigger shortcoming to the Kenyan populace who do not have access to this important resource because they are located in government gazetted forest and there is a ban which was imposed in1986 on harvesting and movement of bamboo culms. However, there are some few patches of bamboo left on private farms but this cannot meet the demand of culms required in existing market if the ban is not lifted.

It is for this reason that EABP (K), which is a project within KEFRI has been promoting bamboo cultivation and utilisation with greater emphasis on the following components namely:

1. Technology transfer and skills development for increased productivity
2. Developing capacity for the sustainable supply of raw materials
3. Increasing market access through crafting of value added bamboo products

Materials and Methods

The project has been undertaking bamboo trainings in all the project sites through hands on approach which involves both minimum theory in class and more practical work carried out in the fields. The trainings have been targeting the project beneficiaries, artisans and Forest extension staff of Kenya Forest Service (KFS) in the project sites. The trainings have been centred on technology and skills development, capacity building on sustainable supply of bamboo as a raw material and increasing market access of bamboo value added products.

Farmers in all the sites have undergone training on propagation, establishment and management of bamboo as a resource commodity so as to develop the capacity for sustainable supply of raw materials. This has been very successful with establishment of several bamboo nurseries which are managed by the farmers who are the beneficiaries of the project. For smooth running of nursery activities, the project bought and gave the farmers basic tools and equipments and later provided them with two bamboo booklets namely Guidelines for Growing Bamboo and Raising bamboo from stem cuttings. Frequent visits have been made to the sites to monitor the progress. There has been transfer of exotic bamboo species from Muguga nursery to all the sites with very positive results witnessed in Shinyalu compared with Olenguruone and Lari divisions.

On the training on bamboo processing/utilisation, the artisans have been trained on both simple and advanced bamboo product making with the provision of sets of hand tools which were imported from India and Ethiopia, respectively and later fabricated by the Jua Kali artisans in Nairobi. Five different bamboo cottage industry manuals have been distributed to the artisans during training for further skill development on bamboo product processing namely:

1. Techniques for Making Bamboo Furniture,
2. Bamboo Mat Weaving Techniques and Applications,
3. Techniques for Plane Woven Bamboo Products,
4. Raw Materials and Tools for Bamboo Applications,
5. Three Dimensional Woven Bamboo Products.

Results and discussion

Bamboo propagation has led to increased production of seedlings in the nurseries because of increased demand of the seedlings in and outside the areas of the project. The farmers currently have an estimate of 5,000 assorted seedlings. In addition, the project beneficiaries have used some of the seedlings to establish their own bamboo plantations in their farms in which some bamboo are almost ready for harvesting while the rest have bamboo plots which are 1 and 2 years old. Due to increased demand of the seedlings, some farmers have initiated their own private nurseries which are managed at family level thus increasing number of seedlings production in the area. As a result of the capacity development effort, the numbers of bamboo seedlings planted and managed annually are increasing significantly. From this, it can be seen that, the project sites and its environs will be potential areas of supplying bamboo culms to the available markets in future.

The trainings on bamboo processing accompanied by provision of hand tools have resulted in the production of high quality bamboo products for the artisans who have ventured in bamboo cottage industry and that they are getting income from the business thus improving their economic status. Some artisans have identified sites for assembling and selling bamboo products and because of this they have witnessed increased sales in some of their products required by their customers.

Recommendations/conclusion

The project would facilitate more training on bamboo propagation, cultivation and management so that high quality raw materials are availed to the market to enable the artisans to have easier accessibility of raw materials. The project would conduct further training on bamboo product development so that the artisans can learn new techniques of making diversity of bamboo products. Through this, bamboo market would be widening thus enabling the artisans to sell and earn more revenues from bamboo products.

On the marketing aspect, the project would participate actively in most exhibitions such as in Agricultural shows in Kenya, Nairobi International Trade Fair, and KEFRI Open Days and in other exhibitions. These forums would be used to create awareness on the importance of bamboo as a commercial crop that has the potential to generate income and create employment to women and particularly the youth in both rural and urban areas.

3.9 TISSUE CULTURE OF BAMBOO

By J. Machua

Introduction

In the tropics bamboo is a very important plant, providing livelihood for over 500 million people and providing housing and shelter for over 1 billion people (Gielis *et al.,* 2002). In Kenya, overexploitation of Bamboo from conserved forests led to a total ban on exploitation in 1980s. Extensive bamboo cultivation has been limited by factors such as infrequent flowering, insufficient and irregular supply of seeds and inadequate technical knowledge on alternative propagation techniques. Consequently, conventional methods suffer serious drawbacks for large-scale propagation and establishment of bamboo.

Vegetative propagation offers the most feasible method for mass propagation of bamboo species. Over the years different vegetative propagation techniques have been proposed for bamboo such as clump division, rhizome and culms cuttings (Banik, 1994; Banik, 1995). However, such methods suffer serious drawbacks for large-scale propagation. Hence, for mass scale propagation (> 500,000 plants per year) classical techniques are largely insufficient and inefficient.

The application of biotechnology, promises to improve the quality of plants through methods such as mass propagation of plants with desired traits through tissue culture. Tissue culture techniques have therefore found ready application principally in the propagation of plants that have seeding problems. Indeed, the order of magnitude for the demand of bamboo planting materials worldwide indicates that micropropagation will inevitably be necessary for mass scale production (Subramanlam, 1994; Gielis, 1999). However, tissue culture techniques need to be carefully developed because the use of starting material (seeds or adult plants) and choice of propagation method are crucial (Gielis, 1999). Previous studies have shown that a rooting percentage of 77% can be obtained for adult *Dendrocalamus giganteus* in three to four weeks (Ramanayake and Yakandawala, 1997). On the other hand, little success was achieved during acclimatization and planting out.

The current study attempted to develop novel techniques for rapid and mass proliferation of bamboo microshoots, initiate rhizogenesis and optimize acclimatization and planting out of giant bamboo.

Objective

To develop a tissue culture protocol for mass production of giant bamboo (*Dendrocalamus giganteus*)

Materials and methods

Shoot proliferation

Several *in vitro* trials of the giant bamboo were set up in the laboratory to determine the phytohormone concentrations necessary for shoot proliferation. These experiments contained nutrient media based on Murashige and Skoog, (1962) at varying levels of auxins and cytokinins. The growth hormones were formulated in order to induce mass shoot proliferation. Giant Bamboo tends to overgrow the growth vessels and hence various vessel types were tried out.

An initial experiment was carried out with five treatments of varying concentrations of 6-benzyl-aminopurine (BAP). All treatments were supplemented with 11.8 µM of Indole-3-Butyric Acid (IBA) as shown in Table 1.

Table 1. Experimental set up with varying concentrations of 6-benzyl-aminopurine (BAP) supplemented with 11.8 µM (2.4mg^{-1}L) of Indole-3-Butyric Acid (IBA).

Treatment	(0.3mg^{-1}L)	(0.5mg^{-1}L)	(0.9mg^{-1}L)	(1.5 mg^{-1}L)	(3 mg^{-1}L)
6-benzyl aminopurine (BAP)	1.3 µM	2.2 µM	3.9 µM	6.6 µM	13.3 µM

Root induction

Root induction experiments were initiated for the proliferating microshoots. Two experiments were set up based on a varying concentration of two auxins NAA (0,0.1,0.5,1.0, 1.5)µM and IBA (0, 2.03, 10.15, 20.3, 30.45) mg/l against varying concentrations of the cytokinin BAP (0, 0.225, 1.125)µM. All explants were raised on a full strength MS agar media.

Proliferation of explant material

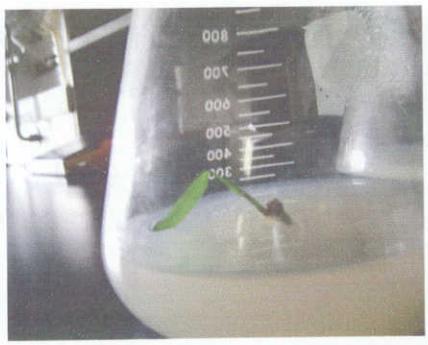
Proliferation of source explant material was continued in the glasshouse

Results

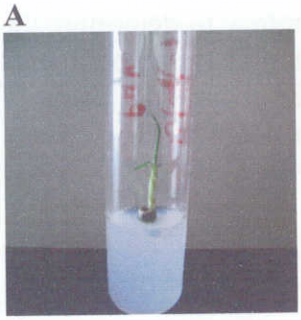
Shoot proliferation

Giant bamboo microshoot proliferation continued to be achieved through tissue culture of nodal explants using the protocol developed in this study.

A



B



C

D

Plate 1: Proliferating shoots in various propagation vessels before transfer to rooting media (A – 30 ml Universal McCartney bottles; B – 1L Elemeyer flask; C and D- 70 ml Test tubes)

Root induction

Root induction media failed to initiate rhizogenesis of the proliferated shoots. Microshoot cultures were maintained in the rooting media for eight weeks after which time most of them they dried out without rooting.

Proliferation of explant material source in the glasshouse

The source of explant material was improved by transferring the giant bamboo seedlings into bigger pots (Plate2) and replenishing their nutrient media (Plate 3)

Plate 2: transferred giant bamboo seedlings into bigger pots

Plate 3: Replenished nutrient media for giant bamboo seedlings

Discussion

The current study has succeeded in establishing *in vitro* microshoots of giant bamboo. However, no *in vitro* rooting was achieved after various attempts. The failure of *in vitro* rooting may be attributed to several factors such as presence of cytokinins in the rooting media or availability of appropriate growth vessels. *In vitro* rooting difficulties in bamboo has been experienced before; two species investigated by Nadgir *et al.* (1984), namely *Bambusa vulgaris* and *Bambusa arundinacea*, could not be rooted *in vitro*. Dekkers (1989) cultured nodal explants of *Bambusa ventricosa* where sprouting of the auxiliary shoot bud and multiple shoot formation took place but continued growth of the shoots and rooting was hindered.

Rooting of tissue cultured bamboo microshoots seems an ever-endless trial that attempts various hormonal combinations and cultural conditions. However, once the right combination and conditions are met, this seems to be the only viable and cheap techniques for achieving mass production of bamboo clonal material.

Conclusion

The study successfully developed a sterilization protocol for *in vitro* propagation of *Dendrocalamus giganteus* (Giant bamboo). The study also developed optimal *in vitro* cultural conditions for microshoot proliferation. However, based on the type of explant used (culm-bud derived microshoots) this study did not optimize *in vitro* cultural conditions for rooting of regenerated microshoots. Further studies are therefore recommended to test more hormonal combinations and cultural conditions and exclusion of cytokinins in the rooting media by using activated charcoal.

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4.0 STUDIES IN DRYLAND FORESTRY

4.1 MANAGEMENT OF INVASIVE SPECIES: THE EXAMPLE OF PROSOPIS SPECIES

By Simon Choge

Introduction

Invasion by Prosopis on Kenya's landscapes continues to generate much interest among the affected communities and the general public owing to adverse media coverage, particularly in the recent years. During the year under review, demonstrations on Prosopis management and utilization were established in four districts, namely Baringo, Garissa, Tana River and Turkana. These demonstrations are part of out scaling efforts for technologies developed through a pilot project that was undertaken in Baringo District in 2004-2006 with support from FAO. The setting of these demonstrations began in 2007, and the local communities are gradually getting the required knowledge to manage and utilize the species as a long-term measure to curb its spread.

Broad objective

The long-term goal of the project was to out scale the tested field methods of managing and controlling the spread of *Prosopis juliflora* tree species.

Methods

a.Community mobilization

In each of the affected districts where demonstrations are being held, Prosopis management Committees has been set up with membership drawn from Kenya Forest Service, Ministry of Agriculture, Ministry of Livestock Development, Ministry of Lands, local active NGOs and CBOs. Local leaders and representatives of locations/sub-locations/villages affected by *Prosopis* have also been included..

b. Coordination of *Prosopis* management and control strategies

In each district, efforts have been made to coordinate all research and development work on Prosopis under KEFRI and KFS

c. Capabilities to manage the natural stands, product harvesting and utilization

Commercialization of Prosopis products has been a common and popular strategy to reduce densities of Prosopis among the local communities and various active groups, NGOs and CBOs. They have been linked to KFS for harvesting and movement permits for various products, mainly charcoal and poles.

Results

Community mobilization and coordination of management and control strategies

a. Community training

During the year under review, an intensive training on management of Prosopis was conducted in all the four districts (Baringo, Tana River, Garissa and Turkana) where a total of 50 community members were trained

b. Field demonstrations

A cumulative area of over 20 ha of heavily invaded sites was put under demonstrations in the four districts during the year under review. These sites were strategically located for ease of learning by the local communities. The target of demonstrations was therefore to show that when *Prosopis* is managed through heavy thinning and pruning, crops can be inter planted alongside few well managed *Prosopis* trees to provide shade, timber and other products without necessarily affecting the horticultural crop(s).

c. Field Days

During the year under review, Field Days were hosted in each of the four districts. The purposes of the Field Days were to share the results of the main findings for the project activities with the public. All the participants were taken through the demonstration sites where the management and charcoal making technologies being tried were explained in detail. Questions asked were responded accordingly. Participants were urged to practice what they learnt in the occasion, and to get in touch with our officers for further consultations.

Capabilities to manage the natural stands, product harvesting and utilization

In all the districts, organized community groups were encouraged and facilitated to be involved in commercial production of Prosopis charcoal, poles and other products. In Baringo District, for example, more than 1000 product movement permits (charcoal and poles) were issued to the groups and individuals to trade in the products.

New proposals

A total of four new proposals on *Prosopis* were drafted during the year under review aimed at the donor community, including the World Bank (KAPP), European Union (EU), UNEP, DFID and others.

Conclusion

Commercial utilization of Prosopis, centered mainly on charcoal production and collection of pods, is now rising. There is therefore need for establishment of proper supervision structures, particularly for charcoal production, to ensure that other trees are not being removed alongside Prosopis. Policy on production and transportation of Prosopis charcoal needs to be formulated as part of management of Prosopis through utilization.

4.2 TAXONOMY, VARIATION, ECOLOGY AND DISTRIBUTION OF *ACACIA SENEGAL* (L.) WILLD. IN KENYA

By Francis N. Gachathi

Introduction

The importance of conserving and utilizing existing genetic variation is recognized as fundamental in most tree species used for commercial purposes. However, very limited information and experience are available on fundamentally important aspects such as taxonomy, variation, ecology and distribution of *Acacia senegal*, the commercial gum

arabic producing species in Kenya. Yet, the species present a number of serious problems in these specific fields. In particular its taxonomy is often confused and a number of varieties are thought to exist, making proper identification difficult and predictability of performance in subsequent generations impossible. Much of the variation is however recognizable in the field and taxonomically significant. In conducting any provenance trials and subsequent establishment of plantations, it is most important that the taxonomic identity of each population is established as closely and accurately as possible and the aim of this study was to facilitate that.

Methodology

Field study with detailed and careful observations of *A. senegal* populations, particularly on habit, bark on main trunk and branches, habitat and gum production were made in gum arabic producing areas of northern Kenya. Herbarium specimens supplemented with photographs of the habit and the habitat of *A. senegal* varieties were collected. DNA sampling material was gathered from all populations. Each population selected was marked using Geographical Positioning System (GPS).

Results

The results presented here are on taxonomy, variation, ecology and distribution of *A. senegal*. Acacia species found in Kenya that are most similar to and likely to be confused with *A. senegal* are also provided. Under each species its local names, distribution and preferred habitat and the principal distinction from *A. Senegal* is given.

Recognition of *A. senegal*

Acacia senegal (L.) Willd. is a woody species varying in habit from a shrub about 2 m to a tree about 15 m high. It is generally recognized by its three hooked prickles, central one curved downwards and the two laterals more or less curved upwards, or singly, the laterals being absent and with the flowers in spikes. These characters are however shared by a number of other Acacia species and *A. senegal* forms part of this complex group of spicate-flowered acacias with prickles in threes or singly (not in pairs). These species are closely related to and are often confused with A. senegal.

Species likely to be confused with *A. senegal*

A. condyloclada Chiov.

Adad Geri (Somali)

Mandera, around Ramu, in Acacia commiphora bushland on limesone slopes, 450-800 m.

The white peeling bark, long internodes, large basal petiolar gland and few pairs of large leaflets per pinna distinguish *A. condyloclada* from *A. senegal*.

***A. hamulosa* Benth.**

Ethad (Somalia); Osatari (Orma)

Found in Eastern and northeastern in dry bushland, 150-1200 m

The presence of a recurved prickle either at or near the apex of the lower surface of each rhachilla distinguishes *A. hamulosa* from *A.* Senegal.

***A. ogadensis* Chiov.**
Adad Geri (Somali)
Found in Mandera, around Ramu, in *Acacia-Commiphora* bushland on limesone slopes and rocky areas, 400-500 m.
The presence of fewer pairs (2-4) of broad (5-15 x 3-9 mm) leaflets per pinna distinguishes *A. ogadensis* from *A. senegal*.

***A. thomasii* Harms**
Ol-derkesi (Maasai)
Found in Kajiado, Taita, Kitui, Meru, Tsavo East. Occurs in small groups in *Acacia-Commiphora* bushland, 350-1200 m.
The distinctive growth form and large flowers distinguish *A. thomasii* from *A. senegal*.

General description of *A. senegal*
A shrub or tree usually 2-15 m tall. Bark on trunk yellowish to grey or grayish-brown, rough or smooth and papery and peeling off. Crown variable, loose and round to dense and flattened, sometimes open with long whippy branches. Young branchlets glabrous to densely pubescent. Prickles 2-8 mm long, in threes, with the central one curved downwards and the two laterals more or less curved upwards, or singly with the laterals absent. Petiole usually glandular. Pinnae 2-6(-12) pairs, with glands on the rhachis between the top 1-5 pairs of pinnae. Leaflets 7-25 pairs per pinna, glabrous to somewhat pubescent, 1-7 mm lon, 0.5-2 mm wide. Flowers whitish or yellow-white, more or less scented, in spikes 2-10 cm long. Pods dehiscent, straight, grey to brown or yellowish-brown, pubescent or puberulous, oblong or elliptic, 3-14(-19) cm long, 1.3-3.4 cm wide. Seeds (2-)4-8 per pod, more or less transverse.

Variation within A. senegal
Within the species, three varieties are currently recognized: typical var. *senegal*, var. *kerensis* and var. *leiorchachis*. In the field the habit of the three varieties are strikingly different and are probably the most essential diagnostic characters by means of which the taxa can be identified (fig. 1).

Typical variety *senegal* is recognized as a tree with a flat or rounded crown and rough non-papery and non-peeling bark commonly growing on sandy alluvial loamy soils in plains or at the foot of hills in semi-humid to semi-arid areas.

Variety *kerensis* grows as a single or several-stemmed shrub with lateral branches form near the base and with smooth yellowish-brown peeling bark on the stem. It is common on rocky hills and ridges or sandy plains in arid to the very arid areas.

Variety *leiorchachis* exhibits two growth forms; either as a straggling slender tree starting with a very branched bushy base then thinning out to 1-4 slender whippy erect tall stems with peeling bark or a well grown tree with open rounded spreading crown and yellowish papery and peeling bark on the main trunk. The whippy form occurs in clusters of small populations on extremely rocky gneiss-derived sandy soils in semi-arid to arid areas in

plains while the tree form occurs on red deep sandy soils along drainage lines and areas with high water table.

Fig. 1: Three varieties of *A. senegal* showing habit and the habitat

var. *senegal* var. *kerensis* var. *leiorhachis* var. *leiorhachis*

4.3 ENHANCEMENT OF EARLY SEEDLING GROWTH OF *OSYRIS LANCEOLATA* (East-african Sandalwood)

By B. M. Kamondo

Introduction

Osyris lanceolata (trade name East African Sandalwood) is an evergreen shrub to small tree (1 – 6 m) in the family Santalaceae. The species has a relatively wide ecological distribution occurring in Eastern and Southern Africa. In Kenya, it grows in Coast, Eastern, Rift valley, Nyanza and Western provinces. The species is normally found in rocky sites and along margins of dry forests, evergreen bushland, grassland, and thickets at altitude of 900 – 2550 m (Maundu and Tengnas, 2005, Beentje, 1994).

The species has been in terms of importance, a fringe species until recently when it captured the limelight due to its overexploitation to meet the international demand for its perfumery and medicinal products. The nature of its exploitation raises concern on its survival in the wild as it involves uprooting of the whole tree. The tree is now locally considered endangered, which threatens not only the survival of the species, but also the sustainability of the trade in the species products. It is therefore prudent that a domestication program for the species be put in place. However, due to the fact that the species has not been a mainstream plantation species, very little is locally known on its ecology, biology, and propagation.

The species has been poorly researched and publications touching on its propagation and cultivation are few. Preliminary research work has indicated that research emphasis should be on promoting early seedling growth at they are stagnated in the nursery. It has been documented that Osyris growing in the field is parasitic through root attachments on other trees like *Dodonea viscosa*, *Rhus natalensis*, and *Carissa edulis (*Mwang'ingo *et al.*

2005). A trial was setup in the glasshouse to establish whether such relationship was necessary at the nursery level.

Materials and methods

The seedlings of Osyris were germinated on sand in the glasshouse and allowed to remain on this media for a period of 6 months. As the germination was going on, the potting material into which to transplant the seedlings were prepared. Tubes of 15 cm (diameter) by 22 cm (length), commonly referred to 6 x 9 tubes when measured in inches were used. The tubes were filled with ordinary nursery soil. Prior to transplanting, the tubes were watered taking care not to waterlog the soil. Host species of *Rhus natalenis*, *Carissa edulis* and *Cajanus cajan* were used in the trial. Host plant seedlings except Cajanus cajan were transplanted together with Osyris seedlings. In the case of Cajanus, its seeds were planted close to the transplanted Osyris seedlings. A control of Osyris seedlings without host was maintained. The transplanted seedlings were kept in the greenhouse and watered in subsequent days sparingly just to have the soil wet. Where pigeon pea seeds did not germinate, they were resown as many times as necessary to ensure that an Osyris seedling grew adjacent to at least two pigeon pea seedlings.

Results and discussion

Intercropped Osyris seedling improved in vigour and general seedling health compared to non-intercropped seedlings. Judged on visual appearance (colour of the seedling, number of branchlets and height of the seedlings), the best results were obtained from seedlings intercropped with *Cajanus cajan*, followed by those intercropped with *Rhus natalensis* and finally those intercropped with *Carissa edulis*.

The improvement in the performance of the Osyris seedlings when grown with the nurse crop indicate that the Osyris roots locked to the nurse crop's root from which it was able to absorb nutrients. This was established by a destruction sampling where the roots of Osyris were found to have attached themselves to the host plants. More work is required to improve the success rate of attachment for routine application.

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Mwang'ingo P.L., Teklehaimanot Z., Lulandala L.L., and Mwihomeke, S.T. 2005. Host plants of *Osyris lanceleota* (African sandalwood) and their influence on its early growth performance in Tanzania. South African Forestry Journal No. 203 2005: 55-65.

4.4 SEED STORAGE OF *MELIA VOLKENSII*

By B.M. Kamondo

Introduction

Melia volkensii (Mukau) is a high valued multi-purpose tree species endemic to arid and semi arid lands of eastern Africa. In the natural stands, it has been heavily exploited for timber and most trees are now to be found on farms. However, despite the high demand for Mukau seedlings by farmers in the ASALs, especially in the southern drylands of Kenya, there are no large-scale plantings of the species, which could be attributed to the

difficulties of seedling production. A major challenge in seedling production remains the difficulties experienced in getting consistently high seed germination rates. Seed germination rates fluctuate widely from place to place and season to season. Moreover, the appropriate storage conditions for maintaining viability of the seeds is not understood. Studies were therefore undertaken with the objectives of determining germination capacity and storability of *Melia volkensii* seeds collected at different maturity stages. In the year 2006 – 2007, initial germination obtained was 49%, which was disappointing. This despite dealing with fruits from recommended maturity level and provenance. The results of the experiment are shown in the fig 1. We suspected that the art of seed extraction is important in the germination obtained. It is quite confounding that the germination trend dropped after 1 month and then started to rise thereafter.

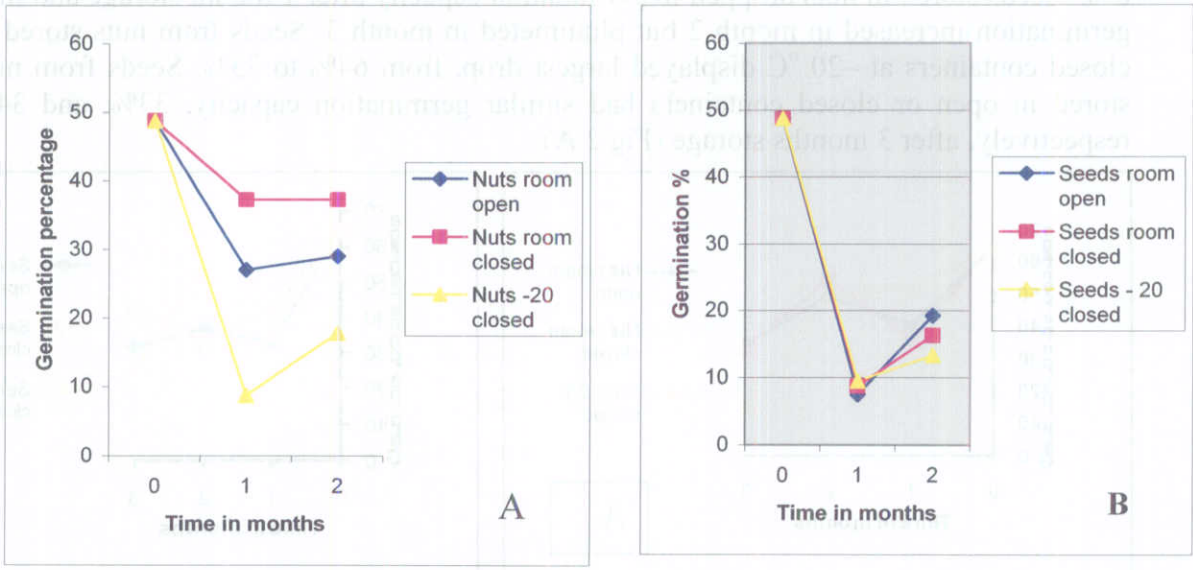

Fig 1. Trend in germination of *Melia volcanism* seeds stored in nut (**A**) and as extracted seeds (**B**) at different ambient conditions

The storage experiment indicated that seeds in nuts stored in sealed containers under room condition maintained highest germination capacity of about 40% even after 2 months of storage. However, the low initial germination meant that germination trends could not be tracked for appreciable length of time. With the foregoing, it was proposed that the experiments be repeated.

Study method

Fruits with yellow tinge as a marker for maturity were collected from trees that were healthy in Kibwezi, Voi and Mwatate. All the fruits were bulked to get a composite working sample. The fruits were depulped using a mortar and pestle. A portion of the depulped fruits had their seed extracted. Germination experiment was set up with the following treatments:

- Extracted seeds stored in open container in the room
- Extracted seeds stored in closed container in the room
- Seeds from nuts that were stored in open containers in the room
- Seeds from nuts that were stored in closed containers in the room
- Extracted seeds that were stored at –20 °C in closed containers
- Seeds from nuts that were stored at –20 °C in closed containers

Germination tests were conducted at months 0, 1, 2 and 3. Moisture content determination was also done on the seed at the time of setting the initial germination.

Results

The initial seed germination was 64% while the moisture content of the seeds was about 6%. Seeds stored in nuts dropped in germination capacity after 1 month storage and then germination increased in month 2 but plummeted in month 3. Seeds from nuts stored in closed containers at –20 °C displayed largest drop, from 64% to 33%. Seeds from nuts stored in open or closed containers had similar germination capacity, 33%, and 34% respectively, after 3 months storage (Fig 2 A).

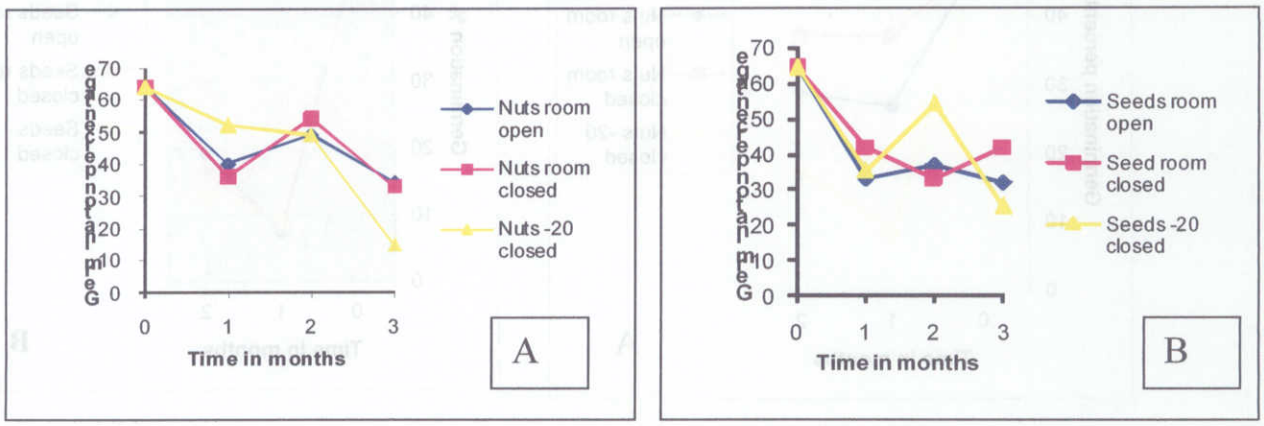

Fig 2. Trend in germination of Melia volcanism seeds stored in nut (**A**) and as extracted seeds (**B**) at different ambient conditions

Extracted seeds also showed initial drop in germination then resurgence and then a drop. The fall and rise happened after the first month for seeds stored in open containers in the room and those stored at –20 °C in closed containers. However, there was a lag in this trend for seeds stored in closed containers in the room, which continued to drop in their germination up to month 2 but subsequently had their resurgence. At month 3, this seed lot had the highest germination of 44 % (Fig 2 B).

Discussion

The results are similar to those obtained from the first experiment. As in the first experiment the resurgence phenomenon is difficult to explain. Although the data obtained cannot answer the question of whether or not seeds of Melia are recalcitrant, results from the two experiments suggest that Melia seeds whether stored in nuts or extracted do not tolerate freezing. The results from the experiments also suggest that Melia seeds rapidly

loose viability. Nevertheless, the experiment should be continued to test the trends over a longer period of time. In absolute values of the germination results, extracted seeds in closed containers stored better than seeds in nuts when both are stored in the room. Future tests should test for significance in terms of results for these storage methods and test for at least one year to answer the question of whether or not the current practice of storing melia seeds in fruits under room temperature should be changed to storing extracted seeds in closed containers under room temperature.

4.5 VEGETATIVE PROPAGATION OF *OSYRIS LANCEOLATA*

By J Machua

Introduction

Domestication of *Osyris lanceolata* has been hampered by low seed production, poor germination which at times can take upto an year (Mwangingo et al, 2006) and high variability between individual trees. Seeds are available in small quantities and there is unreliable supply. Alternative means of propagation were therefore being developed to complement the seeds. Vegetative propagation through cutting and air layering have not yet yielded optimal success and therefore this study was conducted to initiate experiment on tissue culture to complement other propagation techniques.

Materials and methods

Harvesting of explants

Explant material were harvested from sprouts on trees growing in relic forests around Muguga.

Surface Sterilization1

The sprouts were transported to the laboratory for sterilization in a cool box to avoid desiccation. Initially two sterilizing agents were tested each at five concentrations over varying exposure durations (Table 1) based on experiences in previous bamboo sterilization experiments. All the explants were cultured on MS (Murashige *et al.*, 1962) agar basal media and survival of explants material scored.

Table 1: Surface sterilization protocol for field and glasshouse collected materials of *Osyris lanceolata*

Sterilizing agent	% Concentrations (V/V)	Time (min)
Sodium hypochlorite	10, 15, 20, 25 and 30	10, 20, 30
Formaldehyde	10, 15, 20, 25 and 30	10, 20, 30

Surface sterilization 2

Based on the results obtained in the first surface sterilization experiment a further sterilization matrix was designed by using both Sodium hypochlorite and Formaldehyde at varying concentrations and exposure times as shown in Table 3.

Table 3: Surface sterilization protocol for field and glasshouse collected explant materials of *Osyris lanceolata*

Sterilizing agent	% Concentrations (V/V)	Time (min)	Samples
Sodium hypochlorite	3, 5, 7 and 10	6	80
Formaldehyde	4, 6 and 10	4, 6 and 10	36

Surface sterilization 3

As a result of the two sterilization experiments, a further experiment was carried out using sodium hypochlorite at a concentration of 8% and an exposure time of 10 minutes. A total of 76 replicates were tested.

Results and discussion

Results from surface sterilization 1 experiment revealed that both sterilizing agents did not have any significant effect on the bacterial infection of the explants nor dying from necrosis (Plate 1). However, results indicated that there was a significant fungal attack ($P< 0.001$) on the explant cultures and especially when sodium hypochlorite was used as a sterilizing agent. There was neither interaction of sterilizing agent and their exposure times on necrosis, bacterial and fungal infections.

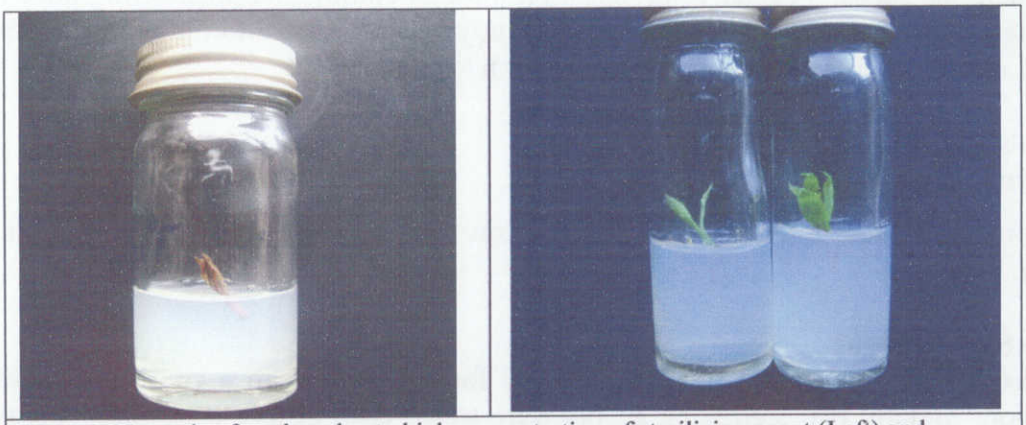

Plate 1: Necrosis of explant due to high concentration of sterilizing agent (Left) and healthy explants after sterilization (Right

Results from the second surface sterilization experiment with sodium hypochlorite indicated that sterilizing the explants for 6 minutes at varying concentrations had a significant ($P< 0.001$) reduction on bacterial attack but neither for fungal nor dying from necrosis.

Results from the second surface sterilization experiment with formadehyde indicated that sterilizing the explants at varying concentrations (4%, 6% and 10%) over varying exposure times (4, 6 and 10 minutes) resulted with no infection from bacteria, fungi or died from necrosis. Results also revealed that there were no treatment significant differences on bacterial, fungal or necrosis. Finally, when sodium hypochlorite was used in (experiment 3) at a concentration of 8% and an exposure time of 10 minutes, 93% of the explants were healthy.

Conclusion and recommendations

This study succeeded in coming up with a protocol for surface sterilization of field-collected explant materials of *Osyris lanceolata.* The study further showed that Formadehyde was not effective in the surface sterilization of field-collected *Osyris lanceolata* explant materials.

References

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4.6 EFFECT OF DESICCATION ON VIABILITY AND STORABILITY OF *COCCINIA GRANDIS*

By John K. Kiamba

Introduction

Coccina grandis, a cucurbitaceae is an almost hairless perennial from a tuberous rootstock, the stems soon developing corky bark; leaves 3-5 lobed, nearly as wide as long, warty below, with glands at midrib base; male flowers 1-2,20-35mm long, yellow to orange; fruit mostly egg-shaped, red, to 6cm long, edible.

It is very common in riverine and alluvial areas in hot districts, 250-1650m. a.s.l. The species is also found in Mau highlands, Mumias, Kisii, Kisumu, Baringo, Magadi, Nanyuki, Nairobi and Kajiado.

The Cucurbitaceae are mostly prostrate or climbing annuals comprising about 90 genera and 700 species that are further characterized by commonly having 5-angled stems and coiled tendrils. The leaves are simple and usually 5-lobed or divided; stipules are absent. They are actinomorphic and nearly always unisexual with fruit type usually refered to as a pepo. This family has a wide range of economic potential from edible fruits to medicinal while some are regarded as weeds. *Coccinia grandis* (L.) Voigt, is a dioecious perennial herbaceous vine with stems mostly glabrous, produced annually from a tuberous rootstock with simple, axillary tendrils. The leaves are alternate and simple. Inflorescence is usually of solitary, axillary flowers. Fruit is smooth, bright red; ovoid to ellipsoid berry 2.5-6 cm long. The fruits are edible while young stems are eaten as vegetable. There is no information on the desiccation tolerance behaviour of this species. There is need to know at what moisture content levels, the species remain viable.

This study was carried out to investigate the effect of desiccation on viability and storability of *Coccinia grandis.*

Materials and methods

Seed source and collection

Mature fruits of *Coccinia grandis* (L.) Voigt, were collected from farmlands and wild sources in Makueni district of Kenya. The fruits were collected directly from the crown, as these plants are ground creepers sometimes climbing onto other vegetation. After collection the fruits were sorted to remove those that were infected and those that showed defective morphological traits and immature. All collections were transported temporarily stored in paper bags to KEFRI Muguga laboratory.

Seed processing and extraction method

Seeds were extracted from the fruits by cutting longitudinally and scooping the fresh seeds using a spoon transferring into a bucket containing water. Fresh seeds were separated from the pulp and mucilage by washing under running tap water on a wire mesh. The seeds were then spread on blotter paper under shade to remove excess water.

Initial quality tests

Seed moisture content tests

Five seeds of *C. grandis* were taken for moisture content analysis. The weight (g) of the un-dried seeds was determined before oven drying them at 103° C for 17 hours. After drying, the seed moisture content (SMC) was determined and expressed on dry weight basis as a percentage of the dry seeds as follows (ISTA,2000). Refer to Table 2.

$$SMC\ (\%) = \frac{\text{Wet weight} - \text{dry weight}}{\text{Dry weight}} \times 100$$

2.2.2 Germination tests

60 seeds of *Coccinia grandis* were disinfected in 10% chlorinated water (Jik) for 10 minutes before sowing on 1% water agar in plastic boxes. The boxes were placed in a germination cabinet set at alternating (day/night) temperatures of 25/30° C (according to Sacandé *et al.*, 1998). Germination was assessed daily by recording radicles protrusion (2 cm; ISTA, 1993) and recorded on prescribed forms.

Equilibrium relative humidity

For storage purpose the remaining seed lot was divided into three potions and suspended on 15%, 47% and 70% Lithium chloride salt solution in an electronic box and incubated at 25°C for 10 days to establish an equilibrium relative humidity. The seeds were removed and sampled for moisture content and germination test, while the remaining was divided into four by three portions and packed into laminated aluminium foil packets that were hermetically sealed, and marked 1 month, 3 months, 6 months and 12 months before storing at +5, +20 and -20 °C at the Genebank/KARI. (Table 1).

Results and Discussion
Results

Table 1. Germination (%) of *Coccinia grandis* seeds equilibrated at different rH's and stored at different temperatures.

	Storage Temp. +5 C			Storage Temp. +20 °C			Storage Temp. -20C		
Storage period(Months)	rH 15	Rh 47	rH 70	rH 15	rH 47	rH 70	rH 15	rH 47	rH 70
Fresh	0	0	0	0	0	0	0	0	0
After rh	0	4	5	0	4	5	0	4	5
1	12	5	12	12	10	20	3	8	8
3	5	2	3	5	15	5	9	5	7
6	15	10	8	0	25	33	8	12	7

Table 2. Moisture content (%) of *Coccinia grandis* seeds equilibrated at different rH's and stored at different temperatures

	STORAGE TEMP +5 °C			STORAGE TEMP +20 °C			STORAGE TEMP -20 °C		
STORAGE PERIOD	RH 15	RH 47	RH 70	RH 15	RH 47	RH 70	RH 15	RH 47	RH 70
FRESH	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3
AFTER RH	5.4	7.2	15	5.4	7.2	15	5.4	7.2	15
I MONTH	6.9	8.8	11.8	6	8.4	9.9	6.7	9.9	10.1
3 MONTHS	6.6	8.4	10.9	5.7	8.4	9.9	6.7	9.9	10.2
6 MONTHS	5.5	7.8	10.3	5.8	7.8	10.3	5.8	8.6	10.9

3.2 Discussion
Coccinia grandis exhibited high fresh moisture content Mc (60.3%) with low initial germination of 0%, while after subjecting to Lithium chloride salt solution to attain three levels of relative humidity (15%, 47%, 70%) there was significant fall in mc 5.4%, 7.2%, 15% respectively with corresponding rise in germination 4%, 5% at relative humidity of 47% and 70% respectively. After one month storage there a significant increase in percent germination for seeds stored at 5°C,20°C and –20°C reaching the highest level after 6 months at a relative humidity of 47% and 70% at a storage temperature of 20 °C.

Conclusion(s) and Recommendations
Coccinia grandis should be stored at ambient temperatures(+5° C and 20°C) within optimal rH(47% or 70%) for suitable viability. Storage duration of 6 months does not affect viability of *Coccinia grandis.* The seeds of this species can be stored at low temperatures without loss of viability within the three levels of relative humidity of 15%,47% and 70%.

Further study on the storability duration should be stepped up to 12 months or more to know the effect of desiccation on viability and storability of *Coccinia grandis.*

4.7 A STUDY ON POPULATION DENSITY AND MAPPING OF *ACACIA SENEGAL* VARIETIES FOR POTENTIAL GUM PRODUCTION IN ISIOLO DISTRICT, KENYA

By Joseph K. Lelon and Chemuku Wekesa

1.0 Background Information

Acacia senegal (L.) Willd is an important multipurpose tree species which grows in the dry woodlands of northern Kenya, over a wide ecological range that differs in rainfall, soil and altitude (Cossalter 1991). It produces gum arabic, stabilizes sand dunes and fixes atmospheric nitrogen and also used for fencing, building poles, firewood and fodder (Katende *et al* 2000). Over exploitation of *Acacia senegal* has reduced the density of natural stands over the past years because of the increasing demands for charcoal making, fuel wood and fencing materials (Lelon, 2008).

In Kenya, *Acacia* tree resources can contribute to the improvement and sustenance of the quality of life of rural pastoral communities in the arid and semiarid lands of Isiolo district. However, the current stocking density and sizes of the *Acacia* trees have not been comprehensively surveyed. Little is known about the current population status of the gum producing Acacias in the district. The aim of this study was to determine the population structure of *A. senegal* in four study sites (Ngare Ndare, Kulamawe, Ntumburi and Daaba) in Isiolo district and establish the potential for gum production.

2.0 Materials and Methods

2.1 Study Area

The area of Isiolo District is approximate 25,605 Km^2. It is located between Longitude 36°60' East and 39°50' East and Latitudes 0°5 North and 2° North. The district is hot and dry and basically arid because the average annual rainfall of 580.2 mm received is scarce and unreliable for most of the year. It has two rainfall seasons; the short rains in October and November, and the long rains which fall between March and May. Since the rainfall is erratic and unreliable, it cannot support perennial agricultural crops. High temperatures are recorded in the District throughout the year, but there are slight variations in some places due to differences in altitude. The mean annual temperature for Isiolo station, at an altitude of 1,104m above sea level is 26.6°C while in Merti, with 300m above sea level is 27°C. The District has a combination of metamorphic rocks and other superficial rock deposits in central division. Tertiary rocks (olive basalt) are found in the northern part of the District. The soils are characterized by lithic sandy clay to gravelly clay, well drained, shallow, stony and rocky, reddish, grey and brownish in color, though pockets of black cotton and red soils that can sustain agriculture exist in Central and Kina divisions. The soils are poor over most places, but supports vegetation that remains green for long after the rain.

A study was carried out to determine the population structure of *A. senegal* and to map the density of *A. senegal* and other vegetation in Ngare Ndare, Kulamawe, Ntumburi and Daaba in Isiolo District, Kenya.

2.2 Mapping of *A. senegal* and other vegetation in the plots

Four sample plots each measuring 100 x 100 m^2 (1 ha), were selected and established in study sites (Ngare Ndare, Kulamawe, Ntumburi and Daaba). Within each sample plot, all individual trees in the sample plots were identified, counted and diameter at breast height (DBH) measured. They were classified into three different DBH classes as follows: 3.0-6.0, 6.1-9.0 and > 9.0 cm.

3.0 Results and discussion

The density of *A. senegal* was higher in Daaba (259 trees per Ha) than in Ngare ndare (196 trees per Ha), Ntumburi (170 trees per Ha) and Kulamawe (123 trees per Ha), respectively (Figure 3.1).

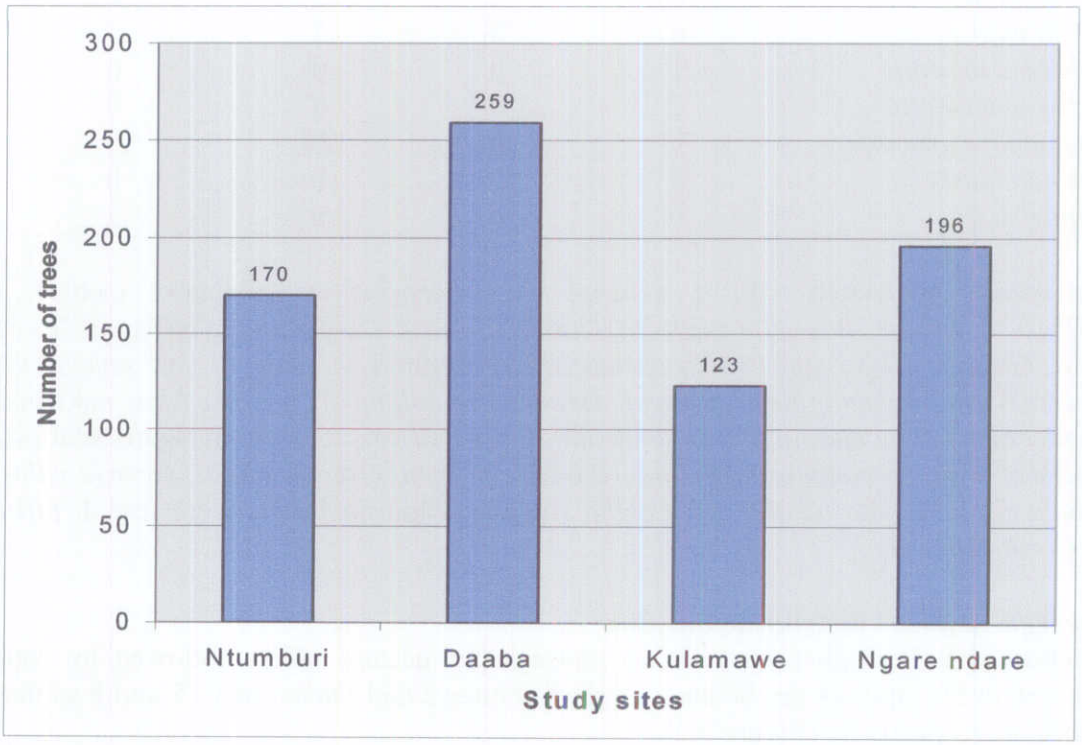

Figure 3.1: Density of *A. senegal* per site in Isiolo District.

Other tree species in the sites

All the varieties of *A. senegal* in the natural stands were found to be mixed with other tree species (Table 3.1).

Table 3.1: Tree species associated with *A. senegal* varieties in sites

Tree species	Number of trees/plot in study sites			
	Ntumburi	**Daaba**	**Kulamawe**	**Ngare Ndare**
Acacia tortilis	27	28	44	12
Acacia mellifera	0	0	11	0
Balanite aegyptiaca	14	0	0	0
Cordia sinensis	0	31	6	14
Boswelia neglecta	0	0	1	0
Boscia coriacea	0	2	7	3
Grewia tenaxi	0	0	5	7
Grewia villosa	0	0	2	11
Euphorpia tirucalli	1	0	0	0
Osyriss lanceolata	2	0	0	0
Commiphora africana	30	0	24	24
Rhus natalensis	3	0	0	0
Delonix elata	0	0	0	2

Tree species associated with *A. senegal* var. *leiorachis* at Kulamawe include; *A. mellifera, A. tortilis, Boswelia neglecta, Cordia sinensis, Commiphora africana, Grewia tenaxi, Grewia villosa* and *Boscia coriacea*. In Ntumburi, *A. senegal* var. *senegal* was associated with *Commiphora africana, Osyriss lanceolata, A. tortilis, Rhus natalensis, Balanite aegyptiaca* and *Euphorpia tirucalli*. *A. senegal* var. *kerensis* in Ngare Ndare was associated with *Commiphora africana, Boscia coriacea, Grewia tenaxi, Grewia villosa, Delonix elata, Acacia tortilis* and *Cordia sinensis*, while in Daaba were few *A. tortilis* and *Cordia sinensis*.

***A. senegal* saplings distribution in sites**

Ntumburi had the highest number of saplings per hectare (133), followed by Ngare Ndare, with 90 saplings per hectare, while Kulamawe and Daaba had 15 and 8 saplings per hectare respectively (Figure 3.2).

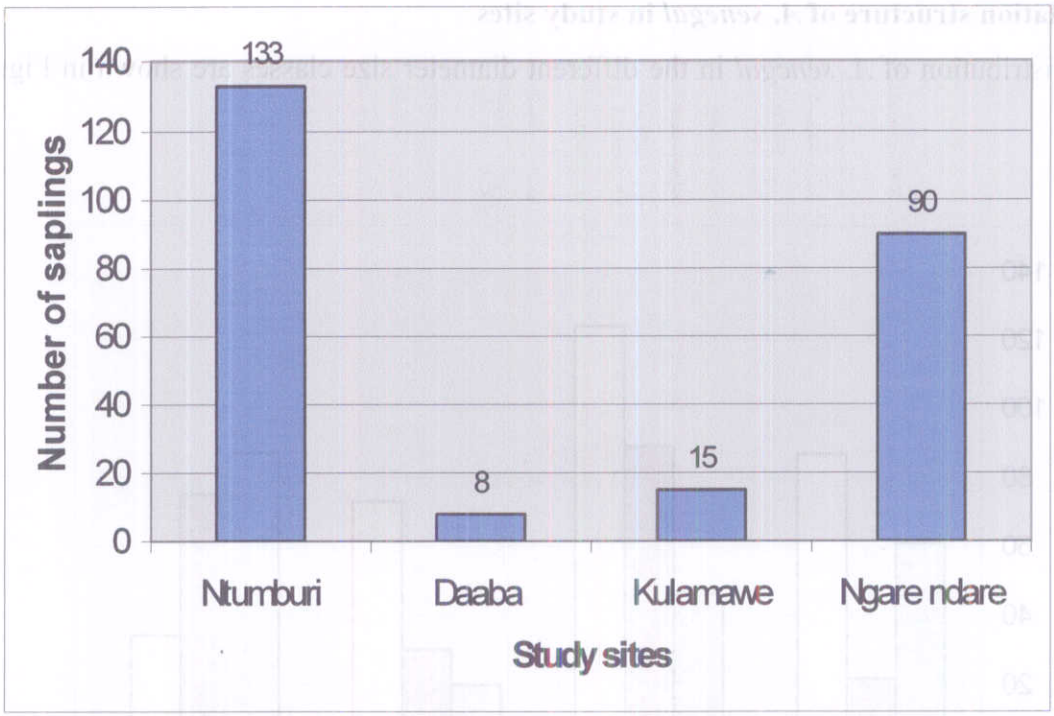

Figure 3.2: Density of *A. senegal* saplings per site in Isiolo.

The rate of natural regeneration was therefore very high in Ntumburi and Ngare Ndare but extremely low in Kulamawe and Daaba.

Population structure of *A. senegal* in study sites

The distribution of *A. senegal* in the different diameter size classes are shown in Figure 3.3.

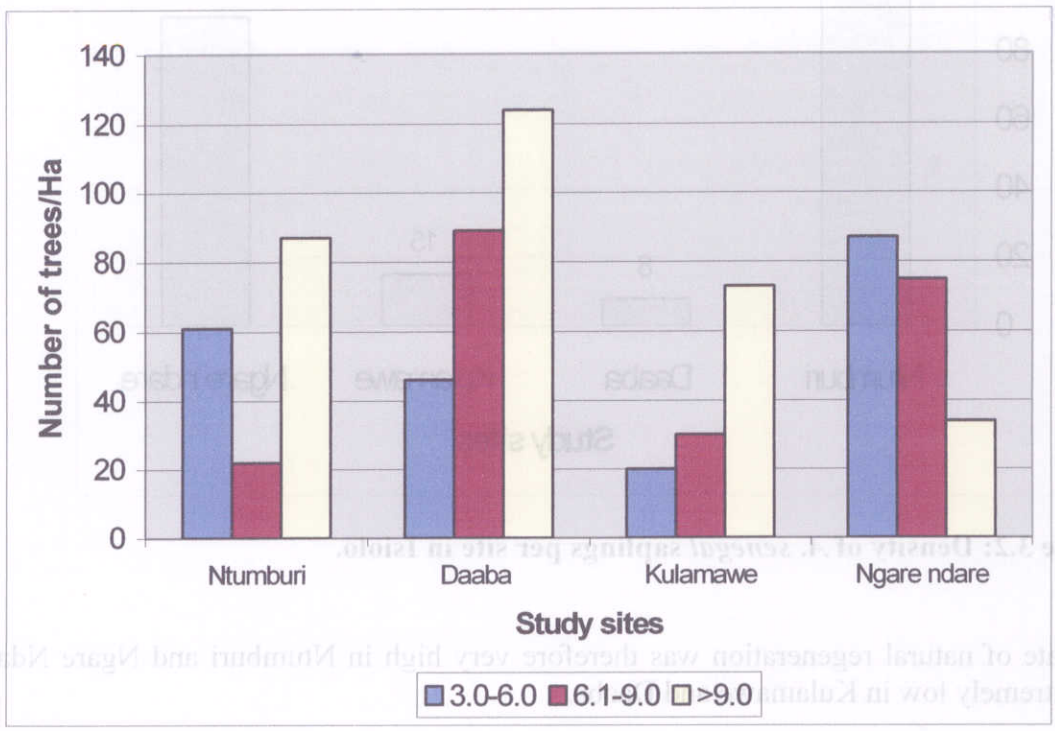

Figure 3.3: Population structure of *A. senegal* in study sites, Isiolo District

Generally, the density increased with increase in diameter size classes for the two sites i.e. Daaba and Kulamawe. However, in Ngare Ndare, it decreased with increase in diameter size classes. Ntumburi on the other hand showed a different pattern whereby trees with the largest DBH class were the highest in number followed by those in smallest DBH class. Class 6.1-9.0 had the least number of trees. In the > 9.0cm DBH, the density was highest in Daaba. There was a high density of trees with DBH of 3.0-6.in Ngare Ndare.

4.0 Conclusion

Overgrazing, deforestation and destruction of the gum trees by wildlife remains alarming problems in the management of *A. senegal* in the ASALs hindering their regeneration and affect the population structure hence reduced quantity of gum yields. The population structure revealed that most of the younger trees produce more gum than mature (old trees). The growth of *A. senegal* seems to be linked to the variety and soil type. The tree density was higher in Daaba and Ngare Ndare than in Ntumburi and Kulamawe. There were more trees in the larger diameter size (>9.0 cm) class than classes 3.0-6.0 and 6.1-

9.0 indicating poor regeneration. Further, undisturbed land had higher densities of *A. senegal* because it is rarely accessed by local people to gather tree products. Grazed and cultivated areas had low densities of the varieties due to constant damage by livestock.

References

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4.8 EFFECT OF DESICCATION ON VIABILITY AND STORABILITYOF CUCUMIS ACULEATUS

By John K. Kiamba

Introduction

Cucumis aculeatus, a Cucurbitaceae is a perennial herb with spiny yellow-hooked hairs on stem and ridges and major veins underneath the leaves; leaves ovate, not circular, deeply or shallowly 3-lobbed; male flowers solitary, yellow, about 11mm long; fruit green to yellow, to 7cm long, with scattered bristle-tipped projections. *Cucumis aculeatus* Cogn.is a trailing herb or climber 2-3m. Fruits occur on a stout long stork turning yellow on maturity.

It is common in grassland and bushland, 1000-2400m elevations. The species is found in Loita highlands, Aberdare highlands, Narok, Baringo, Rift Valley, Machakos, Nairobi and Kajiado.

The Cucurbitaceae are mostly prostrate or climbing annuals comprising about 90 genera and 700 species that are further characterized by commonly having 5-angled stems and coiled tendrils. The leaves are simple and usually 5-lobed or divided; stipules are absent. They are actinomorphic and nearly always unisexual with fruit type usually refered to as a pepo. This family has a wide range of economic potential from edible fruits to medicinal while some are regarded as weeds. In the tropics the usually grow wildly hence the need to study storage behavior for accurate prediction of longevity which is necessary to understand and quantify the population dynamics of weeds and which will helps the farmer to optimize control measures such as solarization.There is no information on the desiccation tolerance behaviour of this species. There is need to know at what moisture content levels, the species remain viable.

This study was carried out to investigate the effect of desiccation on viability and storability of *Cuccumis aculeatus.*

Materials and methods

Seed source and collection

Mature fruits of *Cuccumis aculeatus* Cogn. were collected from farmlands and wild sources around Makueni district of Kenya. The fruits were collected directly from the crown, as these plants are ground creepers sometimes climbing onto other vegetation. After collection the fruits were sorted to remove those that were infected and those that showed defective morphological traits and immature. All collections were transported temporarily stored in paper bags to KEFRI Muguga laboratory.

Seed processing and extraction method

Seeds were extracted from the fruits by cutting longitudinally and scooping the fresh seeds using a spoon transferring into a bucket containing water. Fresh seeds were separated from the pulp and mucilage by washing under running tap water on a wire mesh. The seeds were then spread on blotter paper under shade to remove excess water.

Initial quality tests

Seed moisture content tests

Ten of *C. aculeatus* were taken for moisture content analysis. The weight (in grams) of the un-dried seeds was determined before oven drying them at 103° C for 17 hours. After drying, the seed moisture content (SMC) was determined and expressed on dry weight basis as a percentage of the dry seeds as follows (ISTA,2000). (Table 2)

$$SMC\ (\%) = \frac{\text{Wet weight} - \text{dry weight}}{\text{Dry weight}} \times 100$$

Germination tests

100 seeds of *Cucumis aculeatus* were disinfected in 10% chlorinated water (Jik) for 10 minutes before sowing on 1% water agar in plastic boxes. The boxes were placed in a germination cabinet set at alternating (day / night) temperatures of 25/30° C (according to Sacandé *et al.*, 1998). Germination was assessed daily by recording radicles protrusion (2 cm; ISTA, 1993) and recorded on prescribed forms.

Equilibrium relative humidity

For storage purpose the remaining seed lot was divided into three portions and suspended on 15%, 47% and 70% Lithium chloride salt solution in an electronic box and incubated at 25°C for 10 days to establish an equilibrium relative humidity.This was done following the Kew protocol of desiccation.The seeds were removed and sampled for moisture content and germination test, while the remaining was divided into four by three portions and packed into laminated aluminium foil packets that were hermetically sealed, and marked 1 month, 3 months, 6 months and 12 months before storing at +5, +20 and -20 °C at the Genebank/KARI. (Table 1)

Results and Discussion

Results

Table 1. Germination (%) of *Cucumis aculeatus* seeds equilibrated at different rH's and stored at different temperatures

	Storage Temp. +5°C			Storage Temp. +20 °C			Storage Temp. -20 °C		
Storage period (Months)	rH 15	rH 47	rH 70	rH 15	rH 47	rH 70	rH 15	rH 47	rH 70
0	69	44	12	69	44	12	69	44	12
1	46	46	33	41	31	41	43	45	30
3	32	33	33	38	53	72	23	14	13
6	14	11	8	12	23	17	5	7	2
12	41	61	73	86	80	84	49	37	43

Table 2. Moisture content (%) of *Cucumis aculeatus* seeds equilibrated at different rH's and stored at different temperatures

	STORAGE TEMP +5 °C			STORAGE TEMP +20 °C			STORAGE TEMP -20 °C		
STORAGE PERIOD	RH 15	RH 47	RH 70	RH 15	RH 47	RH 70	RH 15	RH 47	RH 70
FRESH	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
AFTER RH	4.6	9	11.3	4.6	9	11.3	4.6	9	11.3
I MONTH	6.9	10.1	11	10.1	11.6	11	9.6	11.2	11.2
3 MONTHS	6.9	10.1	11	11.9	11.2	11.2	10	11.6	11.2
6 MONTHS	5.3	7.8	10.2	5.8	8.6	10.2	4.9	8.6	10.4
12 MONTHS	7.2	7.8	10.4	7	8.8	11.2	5.7	8.6	11.7

Discussion

Cucumis aculeatus exhibited high fresh moisture content Mc (53.3%) with low initial germination of 3%, while after subjecting to Lithium chloride salt solution to attain three levels of relative humidity (15%, 47%, 70%) there was significant fall in mc 4.6, 9.0, 11.3 respectively with corresponding rise in germination 69%, 44% and 12%. After one month storage there a drop in percent germination for seeds stored at +5° C and –20°C reaching the lowest level after 6 months and rising to a maximum level almost equal to that attained after equilibration.

Conclusion(s) and Recommendations

Cucumis aculeatus should be stored at ambient temperatures (+5° C and 20°C) within optimal rH(47% or 70%) for suitable viability .Storage duration of 12 months does not affect viability of *Cucumis aculeatus.*Low temperatures are likely to result to embryonic injury.

Further study on the storability duration should be stepped up to 24 months or more to know the effect of desiccation on viability and storability of *Cucumis aculeatus.*

5.0 STAFF

SCIENTIFIC STAFF

Name	Qualification	Designation	Research Area
Ely J.M. Mwanza	BEd Sc., M For Sc.	Chief Research Officer (Centre Director)	Forest Pathology
C.K. Kiriinya	Bsc. For, Msc.	Principal Research Officer (Deputy Centre Director)	Forest Silviculture
William Omondi	Bsc. Msc.	Principal Research Officer	Seed Science
Linus Mwangi	Bsc. Msc	Principal Research Officer	Forest Pathology
Francis Gachathi	Bsc. Msc.	Senior Research Officer	Plant Taxonomy
Jane Njuguna	Bsc. Msc.	Senior Research Officer	Forest Pathology
Joram Kagombe	Bsc. For, Msc.	Senior Research Officer	Socio-economics
Simon Choge	Bsc. For, Msc.	Senior Research Officer	Dryland Silviculture
Eston Mutitu	Bsc. Msc.	Senior Research Officer	Entomology
Gordon Sigu	Bsc. For, Msc.	Senior Research Officer	Forest Ecology
Tom Omenda	Bsc. Msc.	Senior Research Officer	Forest Ecology
Jayne Mugwe	Bsc. For, M.Phil, PhD	Senior Research Officer	Agroforestry
Jacinta Kimiti	Bsc. Msc.	Senior Research Officer	Soil Science
Evelyn Kiptot	Bsc. For, Msc., PhD	Senior Research Officer	Agroforestry
Gitehi Giathi	Bsc. For, Msc.	Senior Research Officer	Tree improvement
Bernard Kamondo	Bsc. For, Msc.	Senior Research Officer	Seed Science
Joseph Lelon	Bsc. Msc.	Senior Research Officer	Soil Science
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James K. Ndufa	Bsc. Msc. Phd	Senior Research Officer	Agroforestry

FORESTERS

Name	Designation
Gideon K Mwaura	Senior Forester
William Mucheke	Forester I
Nicholas Riako	Forester II

TECHNICAL STAFF

Name	Designation
Luke A. Gibera	Technologist I
Simon N. Wakaba	Technologist I
George N. Mbuthia	Technologist I
Agnes Ng'ang'a	Technologist I
Anne Wekesa	Technologist I
John G. Mungai	Technologist I
Emmanuel Makatiani	Technologist I
Jared Ogembo	Technologist I
Francis N. Mwaura	Technologist II
Stephen Ndungu	Technologist II
Thomas O. Nyairo	Technologist II
Margaret N. Kuria	Technologist II
Mary Gathara	Technologist II
Mwangi wa Gathura	Technologist II
James Kamau Nyingi	Technologist II
James M. Gitu	Technologist II
Peter K. Kungu	Technologist II
John O. Obango	Technologist II
Jane Njehu	Technologist II
Michael M. Meso	Technologist II
Beatrice Ndakwe	Technologist II
Shadrack O. Aluoch	Technologist II
Allan Wafula	Snr. Lab. Technician
David Meroka	Snr. Lab. Technician
Eliud Waweru	Snr. Lab. Technician
Luke Buyu Owegi	Snr. Lab. Technician

Name	Designation
Lucy M. Kagunyu	Snr. Lab. Technician
Gorret J. Kigen	Snr. Lab. Technician
Esther W. Mutonya	Snr. Lab. Technician
Mary W. Mwangi	Snr. Lab. Technician
Jackline Kinyua	Snr. Lab. Technician
George A. Omollo	Technician II
Hannah Chege	Technician II
Benson Kimani	Technician II
Antony K. Macharia	Technician II
Ruth W. Njuguna	Technician II
Beth W. Ngugi	Technician II
John K. Nganga	Technician II
Peter M. Kmau	Technician II
Paul Kibera	Technician II
Grace Njeri Ngigi	Technician II
Patrick K. Maina	Technician II
Samuel kamonde	Technician II
Samuel Wakori Kubai	Technician II
John O. Ochieng	Technician II
Rachael W. Kariuki	Technician II
Emily C. Yobterik	Technician II
George Opondo	Technician II
Elijah Amolo	Technician II
James M. Mwaura	Technician II
Anne M. Kamau	Technician II

ADMINISTRATION AND FINANCE

Name	Designation
John K. Njoroge	Accountant II
Peter I. Njoroge	Assistant Administrator/Accounts
Rhodah I. Gibera	Personal Secretary I
Joyce Chege	Senior Copy Typist
Miriam Mwai	Senior Copy Typist
Alice Muroki	Senior Copy Typist
Jane N. Mwangi	Senior Copy Typist
Margaret Kimondo	Copy Typist
Anne Wachira	Copy Typist
Rahab Nderitu	Copy Typist

Jossy J. Wekesa	Senior Clerical Officer
Hannah W. Kariuki	Senior Clerical Officer
Christopher K. Chesire	Senior Clerical Officer
George S. Mmasi	Senior Clerical Officer
Malusi Makau	Clerical Officer
Enock Akali	Administrative Officer
Godrick M. Kisingo	Storeman II
John Nyandiko	Storeman II

6.0 ALLOCATED GoK FUNDS FOR FINANCIAL YEAR 2007-2008

VOTE HEAD	PARTICULARS	AMOUNT
2210203	Postal Courier & Telegram Expenses	5,000
2210201	Telephone Exp., Telex and Mobilephone Services	90,000
2210300	Domestic Travel and Transport Costs	770,000
2210502	Printing & Publishing	140,000
2210503	Subscription to Newspapers and Magazines	50,000
2211004	Purchase of fungicides Insecticides & Sprays	80,000
2211005	Chemicals & Industrial Gases	300,000
2211008	Lab Materials, Supplies & Small Equipment	350,000
2211015	Food and Rations	60,000
2211016	Uniforms & Clothings	200,000
2211023	Purchase of Supplies for Production	360,000
2211101	G.O.S. (Paper, Pencils & Small Office Equipment)	550,000
2211102	Supplies & Accessories for Computers & Printers	680,000
2211103	Sanitary & Cleaning Materials	100,000
2211201	Transport Operating Exp. – Fuel & Lubricants	1,900,000
2211301	Bank Charges & Commission	15,000
2211310	Contracted Professional Services – Others	50,000
2220101	Maintenance of Motor Vehicles	1,800,000
2220201	Maintenance of Plant & Equipment	470,000
2220205	Maintenance of Buildings	150,000
2220210	Maintenance of Computer Software & Networks	100,000
2210504	Advert. Awareness & Publicity Campaign	650,000
2210505	Trade Shows & Exhibition	150,000
3111001	Purchase of Office Furniture	100,000
3111002	Purchase of Computers, Printers & Other IT	400,000
3111004	Purchase of Exchange & Other Comm. Equip.	100,000
3111107	Purchase of Lab Equipment	1,850,000
3110701	Purchase of Motor Vehicles	10,800,000
TOTAL		**22,270,000**