TREE BIOTECHNOLOGY PROJECT

ANNUAL REPORT 2003

TBP

TREE BIOTECHNOLOGY PROJECT

A FOREST CLONAL TECHNOLOGY TRANSFER PROJECT

UNDER THE PARTNERSHIP OF

FOREST DEPARTMENT

AND

KENYA FORESTRY RESEARCH INSTITUTE

OF THE MINISTRY OF ENVIRONMENT, NATURAL RESOURCES AND WILD LIFE

WITH

MONDI FOREST A DIVISION OF MONDI LIMITED OF SOUTH AFRICA

ANNUAL REPORT

2003

FINANCIAL SUPPORT BY GATSBY CHARITABLE FOUNDATION THROUGH KENYA GATSBY TRUST

FACILITATED BY ISAAA, *AFRICENTRE*, NAIROBI

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Executive Summary

The major milestones of the year 2003 includes, production of seedlings and clonal cuttings to meet the target for sale in March – May and October-December 2003planting seasons, awareness creation through distribution of information packages and training of extension staff at community level, in addition to marketing and distribution of seedlings and clonal cuttings to the growers. These activities were well coordinated with over 1.7 million seedlings and clonal cuttings distributed to the field to various organizations, corporates and individual farmers, this translates to over 2,763 acres under new forest cover for the year 2003. The Project management has been able to establish links and network with various corporate clients, organized groups, individual farmers and related ministries such as Ministry of Agriculture whose impact has been realized with high adoption rates of the technology in the year with spill orders to 2004 planting season.

Routine monitoring and evaluation of field trials was carried out in the year and all trials were found to be doing extremely well apart from the Hombe trial, which was previously destroyed by the elephants. Other results received from field assessment have clearly indicated that EGC 796 is not suitable for Coastal trial.

The project continued to receive support from Mondi Forest on seeds and clonal cuttings sourcing and continued offering technical backstopping throughout the period as evidenced by various reciprocal visits made by Mondi teams and Kenyan scientists. In April 2003, two officers from TBP Kenya attended a two weeks training on nursery management and breeding both at Mountain Home and Kwambonambi in South Africa. Errol Duncan (Mondi) and Neville Denison (Rtd) Mondi also visited TBP Kenya in May 2003 and carried a technical evaluation on the clonal trials in the coast and selection of *E camaldulensis* and *E urophylla* in Gede. Other reciprocal visits made were by TBP Technical Committee to Uganda and the Ugandan Board members to Kenya.

1.0 Introduction

Rural communities are often forced by poverty and population pressure to destroy natural forests to for their livelihoods. Such forests provide a wide range of products including industrial and domestic wood supply, fuel wood, fodder, and fruits. They also provide habitat to the country's wildlife and ecological stability, particularly in water catchments and wetland areas. In areas with no forest cover especially Arid and Semi Arid Lands (ASALs), the poverty levels are very high and the communities use crop residues and cattle dropping for energy thus reducing soil fertility and over all productivity.

The current level of exploitation of natural forests is so profound that the wood has become scarce and expensive for the ordinary Kenyan who uses 90% of the wood as source of energy. Additionally, this has led to the confounding chain of events including power rationing and high fuel prices even for those who do not use fuel wood. The rural communities can lessen the impact on the forest by including trees in their farming systems as well as enhancing afforestation of superior trees through adoption of appropriate technologies. Superior trees have desirable characteristics of faster growth and high quality wood products to mention but a few.

Forests in Kenya are important in supporting agriculture and hydro electricity generation through water catchments and water flow regulation while preventing soil erosion and siltation of dams and rivers. To the global economy, forests provide public goods in form of biodiversity values, ecosystem interdependency, linkages and carbon sequestration as well as being a rich reservoir of research material, and medicinal plants.

Kenya's government lands, under forests totals to about 1.384 million hectares, and forms about 1.7% of the total country's land area. This is a small area, which can hardly meet the demand for a fast growing population and below the 10% global threats hold for environmental stability.

Unsustainable exploitation of closed canopy forests has greatly reduced productivity and forest cover in Kenya with a projected wood supply deficit of 3 million m^3 by year 2010. This will mainly be manifested in fuelwood shortage especially for the resource challenged community groups. The only mitigating factor is enhancement of farm forestry using superior plantlets and encourage the establishment of long term commercial forestry plantations and farm woodlots to supply raw materials to rural based cottage industries, and to support rural livelihoods to poverty alleviation.

Against this background the project's mission was to provide superior clonal material to the rural/urban communities in the country to mitigate wood deficiencies especially for woodfuel uses. This will improve the living standards by enhancing forestry through integrating successful proven forestry biotechnologies into the traditional propagation systems. The end results would be higher productivity; use of marginal lands for forestry and higher farm incomes. In addition this will have a multiplier effect of conservation of indigenous natural forests biodiversities by reduction of exploitation pressure and is in line with the government Economic Recovery Strategy for Wealth and Employment Creation through the establishment of woodlots.

The selected species for the project include *Eucalyptus* (both hybrids and pure species), *Grevillea robusta* and *Mellia volkensii*. In Kenya, the local *Eucalyptus* (*E. tereticornis, E. saligna, E. grandis and E. camaldulensis*) are widely used for fuelwood. They burn well and when air-dried leave little ash. A market survey carried out in 2000 reviewed that the species is widely used for furniture production in parts of the country due to the current indigenous wood shortfall. In addition, major companies like Kenya Power & Lighting Company and Telkom use *Eucalyptus* species for power transmission poles and telephone posts. Kenya Tea Development Agency has made a major strategic plan to change from furnace oil to wood energy to fire their boilers for tea drying. This will save small-scale farmers up to

Ksh. 1 billion in addition to other environmental benefits. Currently, the standing stock of the *Eucalyptus* is either from seedlings or stump coppice characterized by low yields and un-uniform stands. A number of companies have established *Eucalyptus* plantations using seedlings but the results are disheartening because of low survival, the trees result in an uneven stand which is difficult to manage, low productivity due to crop variability and poor form characteristics making selection vital. The cost of extraction and limitations in utilization of such wood reduces per capita land productivity and eventually income at household levels.

Clonal forestry and vegetative multiplication are technologies, which offer potential to grow more trees with desirable traits. Propagating them vegetatively (micro and macro propagation) ensures transfer and retention of desirable characteristics. Similarly, choosing species well adapted to environment/ecological conditions of a particular area is of paramount importance, as selecting species to give desired wood products. Clonal technology assist in faster development of genetic gains from breeding programmes as compared to seed orchards.

The GC clones from South Africa are a hybrid cross between *E. grandis* and *E. camaldulensis* a drought tolerant Eucalypt species. This hybrid has characteristics of both *E. grandis* and *E. camaldulensis* coupled with wood of high density and high calorific value. The latter characteristic is particularly important for fuelwood needs of the target rural communities in Kenya. The Project has diversified the clonal base by incorporating other clones such as *E. grandis* x *E. urophylla* (GU), *E. grandis* x *E. nitens* and clones of *E. grandis* under the signed Material Transfer Agreement with Mondi.

Tree Biotechnology Project is a demonstration of successful technology transfer through effective partnership between public and private sectors towards development. These were cardinal recommendations of the World

Summit on Sustainable Development (WSSD) held in September 2002 in Johannesburg South Africa.

2.0 Activities at the Central Clonal Nursery

2.1 Clonal Hedges Management

By end of December 2003, 35,825 ramets had been put on hedges. The clonal hedges are now established in an area 2.4 hectare. The ramets can now produce a total of 3,439, 200 placed cuttings in one year. This will give 1,719,600 rooted cuttings at 50% root strike. Maintenance operations on the hedges involved weeding, pest and disease monitoring.

2.1.2 Pest and Diseases

In general, the year 2003 had minimal pest and disease occurrence except for the following:

Pest

Spider mites and leafhoppers were observed on the clonal hedges. Cultural methods and IPM were used to keep them under control. The pests did not cause any problem.

Diseases

Powdery mildew was persistent during the cold months of June/July/August, this reduced in the warm/hot months. However, fungicides were used to keep the disease low during the cold months. Dumping off was observed at rooting Section, Grow-out and seedling area (*E. nitens*). The disease was managed by regulating the moisture available and giving the plants more space by spacing them out. Samples were also sent to pathologist at KEFRI for further study and identification and further advice on the management if found necessary.

2.2 Watering and Irrigation via Drip Lines

- Drip line irrigation system was extended to two clonal hedge blocks, equivalent to an area of 0.5002 Ha.
- A new storage tank with a capacity of 100,000 litres was installed and this have improved water storage capacity and allowed some rest period to the borehole pump.
- Servicing and checking of the borehole pump under contract with Davis and Shirtliff Ltd. continued successfully throughout the year with four checks and tests being done. The performance of the borehole yield remained constant at 10.5 m^3/hr. During the year, the borehole pump motor failed and was replaced with a new motor. An additional (standby) borehole pump was also purchased.
- During the year, a total of 4,584 m^3 of water was used to irrigate the clonal Hedges.

2.3 Cutting Production and Rooting Section

Production of cuttings continued throughout the year with the polythene bags continuing to supplement the existing trays. Consequently 2,258,287 cuttings were placed in the rooting substrate. This figure has gone up by 1,369,086 from the previous year, thus representing about 153% increase. The increase was due to the following: -

- Improvement on speed of cutters with, the best cutter having achieved 7,200 cuttings per day (8hrs);
- More clonal hedges being brought into production;
- Efficiency in clonal hedges management hence more production of coppices.

Production of cuttings in progress

During the year 2003 three different substrate mixtures were used. Early in the year upto September 2003 coir, vermiculite and styrafoam were used at a ratio of 5.4.1. Styrafoam was found to be very expensive and environmental unfriendly because their non biodegradable nature. Pumice rock pebbles were sourced to replace styrafoam but on experimental basis. The pumice experiment showed that it could be used as a substitute to styrafoam. The source of pumice is Naivasha. While plans are underway to source the pumice and also carry out a large experiment, coir and vermiculite mixture continue to be used as the rooting substrate for the cuttings.

Scaling up of production to meet the demand for clonal cuttings

2.4 Grow–out Section

In the year a total of 926,383 rooted cuttings were transferred to the grow-out section from the rooting section for hardening in preparation for planting. The major activities were watering, cleaning, sorting and fertigation. Six additional benches to place the uni-gro trays and polybags were constructed.

2.4.1 Fertigation

The amount of fertilizer applied at the grow -out was as follows:

Type of Fertilizer	**Rate**	**Quantity Used**
NPK macrosal	E.C. 1.5	60.53 kg
Calmag	E.C. 1.5	9.35 kg
Urea	70 gm/m^3	21.29 kg
Micro Feed	20 gm/m^3	2.8 kg
Foliar Feed	20 gm/m^3	220 mls
D.A.P.	E.C. 1.5	2 kg
N.P.K. 17:17:17	E.C. 1.5	3.4 kg
Total fertilizer used		**99.37 kg** **220 mls**

2.5 Seedling Production

Commercial production of seedlings for the year 2003 planting seasons started in December 2002 and continued throughout the year. Two more species were introduced in the year. These are *E. nitens* and *E. dunii*. Amount of seeds sown per species and number raised was as follows: -

Species	**Quantity of Seeds Sown (kg)**	**Number of Seedlings Raised**
E. grandis	2.257423	1,393,139
E. camaldulensis	0.793775	189,508
E. dunii	0.344598	90,444
E. nitens	0.996683	98,574

E. urophylla	0.254990	58,842
E. tereticornis	Sown in December 2002	67,373
G. robusta	1.700000	24,120
Total	**6.347469**	**1,922,000**

The activities that preceded seedlings production were:

- Digging of fertile forest soil from surrounding indigenous forest and transportation of the same to the nursery.
- Procuring river sand
- Filling of polytubes with rooting substrate and arranging them in seedbeds.
- This was followed by direct sowing using sewing needles and pricking out of seedlings already broadcasted in the germination bed.

2.5.1 Maintenance of Seedlings

Watering, weeding, rooting, pruning, sorting / sizing and packaging were carried out throughout the year to ensure healthy and vigorous transplants.

2.6 Nursery Research

Experiment 1

Effect of Basal Wounding on the Rooting of Cuttings

In an attempt to increase the rooting percentage of poor rooters, an experiment was subsequently set up which involved wounding cuttings, by making vertical cuts simultaneously down each side of the cutting. A locally made device was used, consisting of a two edged blade.

Rooting is encouraged along the margins of the wound. This is because wounded tissues are encouraged to cell division perhaps due to natural accumulation of auxins and carbohydrates in the wounded area. Wounded tissues also produce ethylene known to promote adventitious root formation.

Difficult to root cuttings, GC 167, GC 785, GC 796, and GC 642 were put to test. Below are the results showing the average number of rooted cuttings per GC per treatment, out of the 60 cuttings placed per GC:-

Treatment	GC 785	GC 796	GC 167	GC 642
Wounded	18	12	11	11
Unwounded Control	11	26	22	11

However, no significant differences were found between treatments. This means that wounding did not have an effect on the rooting even for the poor rooters.

Experiment 2

Assess the Effect of Mixing Fungicide and Rooting Hormone on the Incidence of Fungal Infection of GC 15 Cuttings

Fungal disease is mostly characterized by rotting of cuttings. In the nursery it was noticed that GC 15 is most susceptible to the disease at the rooting section. The rotting was observed to initiate from the base of the cuttings. Mixing fungicide with hormone was seen as one of the ways to curb the disease, from the point of initiation. The fungicide and hormone were mixed in different ratios i.e., 1:2, 1:1, 2:1, 0:1 respectively. The 0:1 ratio was the control

Results

Significant differences were found between treatments, with the treatment having fungicide and hormone in a 1:1 ratio, having the highest rooting percentage of 61.5%, followed by 1:2 ratio, having 47.9%, then by 2:1 ratio, 45.8% and lastly by the control 0:1 with 31.3%

It was therefore conclusively demonstrated that adding fungicide to hormone in a 1:1 ratio helps to reduce the incidence of fungal infection on GC 15 cuttings. The mixture has a balanced ratio of hormone and fungicide ideal for rooting and is the current practice at the nursery.

Experiment 3

Effect of covering the green house with different colours of polythene sheet and their effect on the rooting of cuttings

The effect of light has a direct or indirect effect on the rooting and overall growth of cuttings. At the clonal nursery, we have observed different rooting percentages with different colors of polythene sheet, covering the top of green house. An experiment was therefore set up in a tunnel, with all the 12 GC in the clonal nursery, represented i.e., GC 785, 167, 581, 642, 15, 14, 12, 522, 10, 3, 584. The tunnel was fitted with misters and was divided into three compartments, each having a different cover color i.e. black, yellow, and colorless.

Results

Significant differences were found between treatments, with the black compartment having a rooting percentage of 0%, yellow compartment 18.0%, and the colorless compartment, 46.3%.

Cuttings in the yellow compartment had produced healthy looking shoots but little or no root development. All the cuttings in the black compartment died from rotting due to high temperatures. The colorless compartment had healthy looking shoots and roots.

The results of this experiment were adopted in the nursery during fabrication of the new green houses.

3.0 Further Infrastructure Development

3.1 Grow-out Area:

Six more beds were constructed each with a capacity of 16,660 cuttings per bed using 98-way tray or 30,000 cuttings using the poly tubes after spacing out.

3.2 Additional Irrigation System

A 100 m^3 surface tank was installed in the year, to increase storage capacity.

3.3 Production House

Renovation of Production house was carried out in the ear with the plastic film being replaced with iron sheet. This change has helped to counter wind drift and direct sunlight thus minimizing loss of moisture.

3.4 Rooting Section

A half of the rooting section was renovated in the year using material that are long lasting as opposed to the timber. The net shedding was replaced with polythene sheet (plastic film 200 mic). This has helped to raise the relative humidity and counter the strong winds.

- Approximately 8 tonnes of 19mm ballast were used to cover some uneven floor areas of the improved rooting section.
- A total of three 2" solenoid valves were relocated to serve three compartments of the improved metallic compartment.

4.0 Purchase of Equipment

Three computers were purchased in the year, installed in various offices. This has assisted the officers particularly in accounts and Marketing to store and retrieve their data easily. The offices are now networked and information can easily be exchanged from one office to the other thus minimizing time wasted in movement and has also helped reduced paper wastage as a result of draft prints.

5.0 Marketing and Distribution

In the year over 1.7 Million seedlings/clones were distributed to various farmers within the country (see attached appendix).

Analysis of distribution of seedlings and clones to growers from January 1st 2003 to December 31st 2003 is as follows

Category	Number	% Total
Individual farmers	1,358,246	76.8%
Organised groups (NGO's, CBO's)	270,303	15.3%
Corporate	140,000	7.9%
Total	**1,768,549**	**100%**

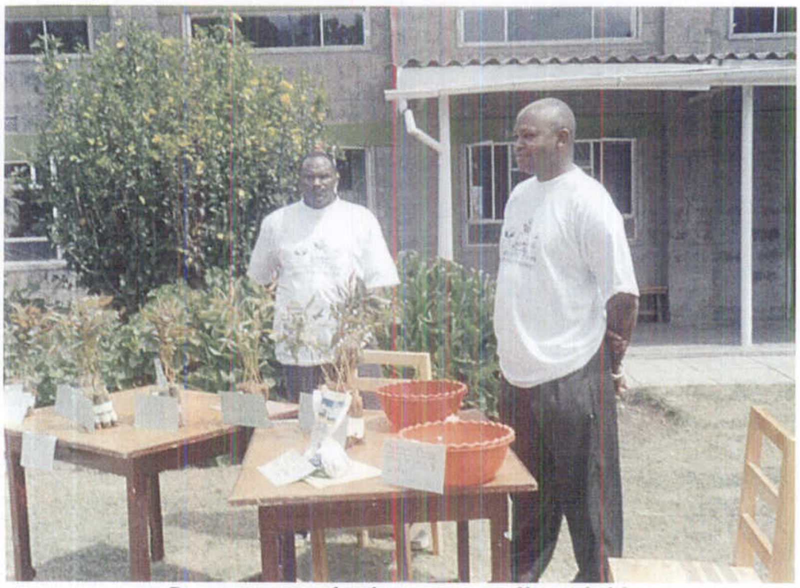
NB: Seedlings/clones procured by organized groups were distributed to small-scale farmers thus 92.1% of seedlings/clones were distributed to individual farmers.

One and half year old farmer's woodlot with GC Hybrid.

5.1 Marketing Strategies

The following strategies were adopted by the project to create more awareness countrywide

- ◊ Release of one set of newsletter. 2000 units were distributed countrywide
- ◊ Continuous distribution of posters and brochures produced in the previous year
- ◊ Training of extension service provider in three regions of the country
- ◊ Participation at the International Trade fair
- ◊ Field participation by the project staff. This has yielded very positively in awareness creation and technology diffusion at the grass root level.
- ◊ Follow up visit for farmers by the project staff and technical advise on seedlings management and monitoring the previous years planting.
- ◊ Deliver of seedlings to the farmlands by the project
- ◊ Visit to farms to offer technical advise on species and site selection
- ◊ Use of forestry officers in the field to offer technical advise and collaborating with NGOs, CBOs, and other extension service providers.

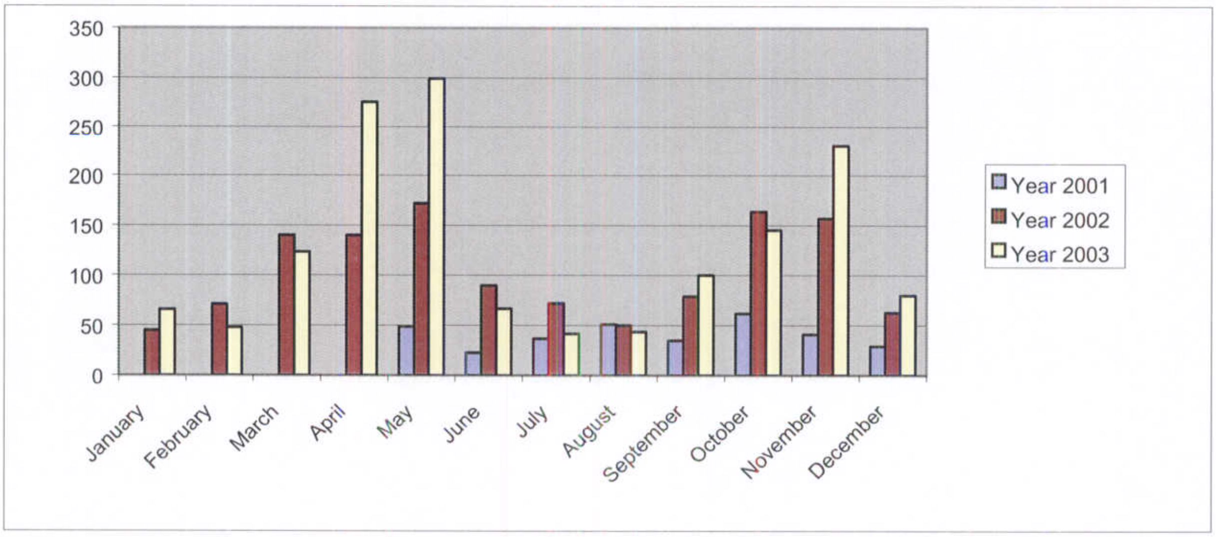


Demonstration by the project staff in a field.

5.2 Achievements

By end of the year over 1.7 million were planted in the year this translates to 2,764 acres land under new forest.

Impact created through awareness creation has been realized with the number of visitors received both from organized groups and individuals at the clonal nursery and office in the year rising in comparison to the other year as reflected in table below:



6.0 Field Trials

6.1 Field Trial Assessment

In the year assessment of field trial was carried out by KEFRI in July thirteen trials established in different parts of the country. The assessment results were as follows:-

6.1.1 Hombe Trial

Generally, the plot was poor as there was a lot of elephant damage on almost all the trees. Those trees that had been damaged were either coppicing or recovering As a result, the trees looked unhealthy with stunted growth. Six clones namely GC14, 642, 15, 522, 10 and 581 were compared for growth performance with four local species. The mean DBH per plot were analyzed and the ANOVA showed significant ($p = 0.003$). Mean annual increment (MAI) at the site was 2.9 cm for DBH and 2.6 m for height.

6.1.2 Embu Trial

Four clones (GC 14, 15, 642 and 581) were compared for growth performance with the four local species. ANOVA for DBH showed significant ($p < 0.001$) clonal differences.

At the age of 3.6 years, most trees had attained an average height of about 10 m and DBH of about 10 cm. The hybrid clones especially GC 642 and GC 581 showed the best growth rate, while the local *E. grandis* and *E. saligna* had some of the trees with comparable growth as the hybrid clones except that there was variation in growth within plots thus reducing the mean.

Survival of *E. saligna* was however poor and *E. tereticornis* had poor growth with average DBH and height of about 6 cm and 8m, respectively.

6.1.3 Machakos Trial

Five clones (GC 10, 14, 581, 642 and 15) were compared for growth performance with four local species. There were missing observations with *E. saligna* having no trees for block I; while in block III, there were no trees for *E. camaldulensis* nor *GC 14*. Estimates were made for the missing values as row and column means of standing trees, which resulted in error degrees of freedom being reduced by 3, and error variance increasing.

With the above adjustments, the mean DBH per plot were analyzed and the ANOVA showed significant ($p<0.01$) clonal differences.

6.1.4 Timboroa Trial

Five clones namely GC 3, 642, 15, 14 and 581 were compared for growth performance with four local species.

This was a generally poor crop, probably due to offsite planting of GCs, *E. camaldulensis* and *E. tereticornis*. The GCs especially GC3 and 581 had poor form and heavy branching, while GC 642 and 15 had double leaders. Some of the trees had broken tops due to strong winds, seedlings that were tall and thin at time of planting could have caused this. Seedlings of the local species were also very small at time of planting compared to the GC's so they may have been suppressed

Table 1: Means for DBH for various clones and species in Timboroa at age 3.9 years

E. cam	*E. tere*	EG	GC 3	GC 642	GC 15	GC 14	*E. sal*	GC 581	Mean
6.15	7.28	9.11	10.87	10.91	11.00	11.22	11.76	13.03	10.15

6.1.5 Karura Trial

Seven clones were compared for growth performance with three local species in three replicates. Twenty-five trees were planted per plot out of which six were randomly selected for assessment (on each occasion). This should have given 6x3x10 = 180 measurements but there were missing trees due to vandalism, which left 131 for analysis.
The mean DBH per plot were analyzed and the ANOVA showed significant ($p<0.001$) clonal differences.

6.1.6 Kitui Trial

The stand was established in October 2002 with the following treatments: GC 15, 167, 514, 540, 584, 784 and 796, *E. camaldulensis*, and *E. tereticornis*. The survival, health and maintenance of the trial was good. Growth rate for the local species (*E. camaldulensis* and *E. tereticornis*) was better than that of GCs. At age 6 months, trees had attained an average height of about 1.7 m compared to the best GC clone that had an average height of about 0.7 m. Clone GC 796 had the lowest growth rate. The trial is due for the first year assessment in November.

6.1.7 Kabage Trial

This was planted in April 2002 under shamba system with the following materials: GU 7, 8, and 21, TAG 5, E. grandis, and GC 514, 540 and 784. General growth rate was good with most trees having attained an average height of about 2m in 11 months. The trial is due for the first year assessment.

6.1.8 Marigat Trial

The trial was established in May 2002 with GC 514, 540 and 784, *E. camaldulensis* and *E. tereticornis*. The trail was irrigated for the first two months as the rains disappeared soon after planting. This would not be the normal practice for plantation establishment. The trial was also established on alluvial soil, which is not representative of the area. The plot is well maintained and the general growth performance is good. Performance of both *E. tereticornis* and *E. camaldulensis* is just as good as the GC clones. The tallest trees for both GCS and local species were about 5 m, and some trees were already seeding. There was some goat damage on some of the trees, especially where there were prosopis trees, which have pods that the goats feed on. The grass under trees also attracted goats.

6.1.9 Kakamega Trial

The trial was planted in April 2002 but survival was very poor with only about 50 seedlings surviving. This was probably due to poor maintenance as the plot was established under shamba system and farmers interfered with the seedlings. At the time of the visit, the plot was bushy as farmers had already harvested their crops and cultivation for the next season had not commenced. The trial is recommended for write off.

6.1.10 Sokoke Trial

This was planted in June 2002 with the following materials: *E. camaldulensis, E. tereticornis, E. urophylla*, GU 21, 7, 8, GC 540, 514, 784, 796, 584, 167, 785, 14 and 581. The trial was growing very well with some clones having attained average height of about 7 m. and DBH about 5 cm at six months but *E. urophylla* had average growth rate. *E. camaldulensis* and *E. urophylla* appeared to be a mixed species, and most of the trees in the *E. camaldulensis* plot, which were grandis/saligna like, were dying. GU 7 and 8 had a problem of falling-over and also appeared stressed probably due to poor root system

6.1.11 Gede Trial

The trial was established in May 2002 using the same materials as those in Sokoke. Performance was not as good as the Sokoke replicate probably due to poor initial maintenance. GC 785 was the fastest growing with average height of about 3½ m. GU 7 and 8 had the same problems as in Sokoke, but most trees for GC 796 had all died probably due to poor adaptation. Performance of *E. urophylla* is generally better than that of GU hybrids with average height of about 1½ m.

Figure 1 Hybrid clone GC 796 dying at the coast

6.1.12 Msambweni Trial

The stand had average growth but most noticeable is the dome palm, which had infested the plot. There was also high variation in growth rate within clones probably due to mode of site preparation, which was a slash and burn and also soil compaction. The site should have been reaped. GC 785 was not the fastest growing as in Gede, and *E. tereticornis* and some of the clones like GC 584 seem to have a disease problem on the leaves.

6.1.13 Muguga Trial

The Trial was established in April 2002. Materials planted were GU7, 8, 21, TAG 5, *E. grandis, E. tereticornis, E. camaldulensis,* GC5, 514, 540 and 784. The performance was very variable even within plots. This had been illustrated by variable tending under shamba system by various farmers. Some treatments show clear signs of off-site planting. Height growth among plots varies from 0.5 m. to 2.5 m.

7.0 Breeding and Selection Programme for Local Germplasm

- KEFRI has selected and marked 182 local Eucalyptus grandis from Kericho, 19 E urophylla from coast and 11 E camaldulensis (6 from Coast and 5 from Baringo) for clonal propagation of local germplasm. Out of this 192 E grandis 103 have already been planted on hedges at Karura clonal nursery for trial. Selection is on going to build up 400 trees per species for breeding population.

E. urophylla selected and marked for breeding.

- **Selection by TBP**

  In the year 2002, about 500 of *E. grandis* and another 500 *E. urophylla* selected (from seedling beds) seedlings were planted on hedge rows. During the year 2003 and after 1½ year of growing selection of plus trees on each species was done. Physical characteristics of importance during the selection and that qualified the tree to be plus trees were: -

  i) Good Height
  ii) Good Diameter
  iii) Free from disease
  iv) Straight stem

24 trees of *E. grandis* and 26 *E. urophylla* qualified and were selected, felled and coppice collected for rooting trials.

Out of this *E. grandis* had 5 trees and *E. urophylla* 11 trees that were selected as good rooters. Subsequently, cuttings were raised from these good rooters and planted on Research Clonal Hedges from which numbers will be built for field trials.

Also planted at RCH are indigenous species of very important values. The reason for putting them on RCH is to enable nursery level selection and rooting ability trials. These are:

	Species	**Use**
i)	*Podocarpus falcatus*	For Timber
ii)	*Warburgia ugandensis*	Medicinal
iii)	*Prunus africanum*	Medicinal
iv)	*Trichiria emetica* (roka)	Medicinal
v)	*Markhamia lutea*	For Timber
vi)	*Grevillea robusta*	Not indigenous but very popular in Agroforestry.

8.0 Rainfall

Rainfall was not adequate in the October-December Season as was expected; this prompted some farmers to postpone their seedlings planting in fear that survival may be low (see attached appendix).

9.0 Project Administration

9.1 Board Meetings

The board members met four times in the year to deliberate on a number of management issues among them were the approval of the year 2003 workplan and budget.

9.2 Project Technical Committee

The Project Technical Committee met nine times in the year to discuss issues related to the Project and share data and information with the consultant Mr. Michael Underwood who was hired by ISAAA to carry out a social economic study on the *Eucalyptus* seedlings/clones already released to the farmers.

10.0 Visits

In the year 2003, the Project was privileged to host the following dignitaries among others: -

Name	Designation	Organization
Hon. Isaac Ruto	Member of Parliament	National Assembly
Hon. Newton Kulundu MP	Minister for Environment	MENR & W
Professor Wangari Mathai MP	Asst. Minister for Environment	MENR & W
Dr. Epilla Otara	Project Manager	TBP - Uganda
Patrick Mwangingo	Research Officer	TAFORI
Hon. Kinyua Mbui	Farmer	Mwea- Kirinyaga District
Bashir Juma	Research Scientist	ICRAF
Ngari Mahihu	Farmer	Dundori-Nakuru
Joseph Ngarira	Secretary CBO	Mt. Kenya Conservation Action Group
J.K. Gichuhi	Chief Finance officer	Ministry of Agriculture
Teonas H. Msangi	Research Officer	TAFORI
Ally Mbwana	Research Officer	TAFORI
Hon. Julius Sunkuli	Secretary General	KANU
E.A Duncan	Tree Breeding Manager	Mondi Forest

N.P Denison	Rtd. Manager	Mondi Forest
Mark Teketay	Scientist	E.AR.O Ethiopia
Demel Teketay	Scientist	E.AR.O Ethiopia
Mark Gush		University of Natal
Jolanda Roux	Pathologist	TPCP, FABI univ. Pretoria South Africa
Michael Underwood	Consultant	South Africa
I. Oluka Akiley	Scientist	Kampala – Uganda
J.F.O. Esegu	Scientist	Forri Naro - Kampala
Nshibemriks	Scientist	Tanzania

A visit to Gede Trial by TBP Ugandan Board, TBP Kenya and KEFRI Gede.

11.0 Future Strategies

1. The project intends to scale up its production of clonal cuttings and seedlings production to meet the growing demand. This will be accomplished through further establishment of clonal hedges to ensure maximum production.

2. Decentralize distribution and delivery channels. Plans are under way to open up holding nurseries in the hot spot areas where the demand is high for easy assess of planting materials to small-scale farmers.

3. The project will lay strong emphasis on extension and marketing for technology diffusion at grass-root level this will be enhanced through continuous regional workshops for extension service providers. Networking and linkage through collaboration will also enhanced through, NGOs, CBOs and Ministries such as Ministry of Agriculture and Environment and Natural Resources and Wildlife.

4. The project is working with its collaborators KEFRI, ISAAA, and Mondi to adapt other species for clonal programme to ensure biodiversity. Already KEFRI has embarked on selection of local *Eucalyptus* germplasm for clonal programme, together with ISAAA they are also working on *Mellia Volkensii* and local indigenous species with germination problem.

5. The project will continue to enhance the mainstreaming of biotechnologies adoption with the forestry in Kenya through sensitization and awareness creation in workshops, field-days participation and interaction with mainstream forestry sector. The project is grateful for the visits to the clonal Nursery, Karura by the Minister of Environment and Natural Resources and wildlife Hon Dr. Newton Kulundu, Assistant Minister Hon. Prof. Wangari Mathai, the Permanent Secretary of the Ministry Mrs. Rachel Arunga and other senior Ministry officials.

6. The Project will continue to offer technical backstopping with the assistance of Mondi and ISAAA to the Tree Project – Uganda and the proposed Tree Project- Tanzania. It is expected mutual sharing of experiences and information will fully entrench the biotechnologies in forestry within the region.

7. The Board has continued to offer guidance to the project and with Mondi's technical support it is hoped that the effective adoption on the clonal forestry technology will continue to be a positive path through impact in forestry especially the farm woodlots in the areas previously without any forest cover such as Semi-arid and arid lands.

8. Forest Department has continued to play a key role in supporting implementation of the project particularly in extension and awareness creation. The Chief Conservator of Forest has continued to offer guidance on policy matters and his personal support has assisted the project to remain focused on its goals towards contributing to afforestation.

9. The Project has continued to enjoy a working rapport from KEFRI through the Project Technical Committee and the full support of the Director KEFRI, Dr. Paul Konuche which has been vital for the adoption of indigenous species to the programme as well as the establishment of the breeding programme for *Eucalyptus* in Kenya in support of the clonal propagation.

10. The Project is fortunate and grateful with GCF's decision to financially support the project for the third phase. This will now provide the opportunity for full sustainability of the project activities and diffusion of the technology downstream to the target groups of the resource challenged rural communities in Kenya.

11. Enhancement of private sector role in afforestation will be through collaboration with the East African Business Summit (EABS) Afforestation sub-committee as per the following recommendations agreed during the meeting on 26th November, 2003:

Background
A meeting of approximately 50 individuals, (list of those invited attached), was held at 10 am Friday 21st. November 2003 at the Tree Biotechnology Project offices at Karura. Three members of the EA Business Summit Environment Committee were present as hosts; Pradeep Paunrana, Hon. Rose Waruhiu and Andrew Enniskillen. The Minister participated throughout until he had to leave at 1 pm. The meeting was rained off, (business completed), by 2.30 pm. Therefore unfortunately participants did not have time to visit the Tree Biotechnology Project who had generously offered to provide facilities for the meeting. Follow up visits by all is highly recommended.

- **Action Points** arising and falling into two categories are as follows; firstly 'newsletter' type items and then legislative and related issues for the Minister to follow up

- **Newsletter Action Points**

Newsletter, which should contain the full text of the communiqué to Heads of State should go to all Committee Members, all invited participants, the Nation Group, the FKE, KAM, KEPSA, KARA and KFWG Chief Executives

- Full details of the Tree Biotechnology Project and what they can offer
- Appeal to all to start nurseries, provide a lead, (don't wait to be asked), and spread the word to business colleagues
- Communique to be given to the Minister/Hon. Waruhiu to hand to HE The President/ follow up in Arusha
- List those who volunteered to join the Committee + e-mails
- Follow up with Del Monte and Safaricom - both ready to start
- Encourage everyone to plant/interplant with indigenous trees especially along streams, dry river water courses, rivers, old quarry and mining sites, spring sources etc.
- Publicize the idea of matching those with money and those with land - tax breaks requested below
- Lead by example and thus encourage others
- Sensitize the entire private sector through, e.g. FKE/KAM
- Develop the technology and motivate communities to focus on ASAL regions

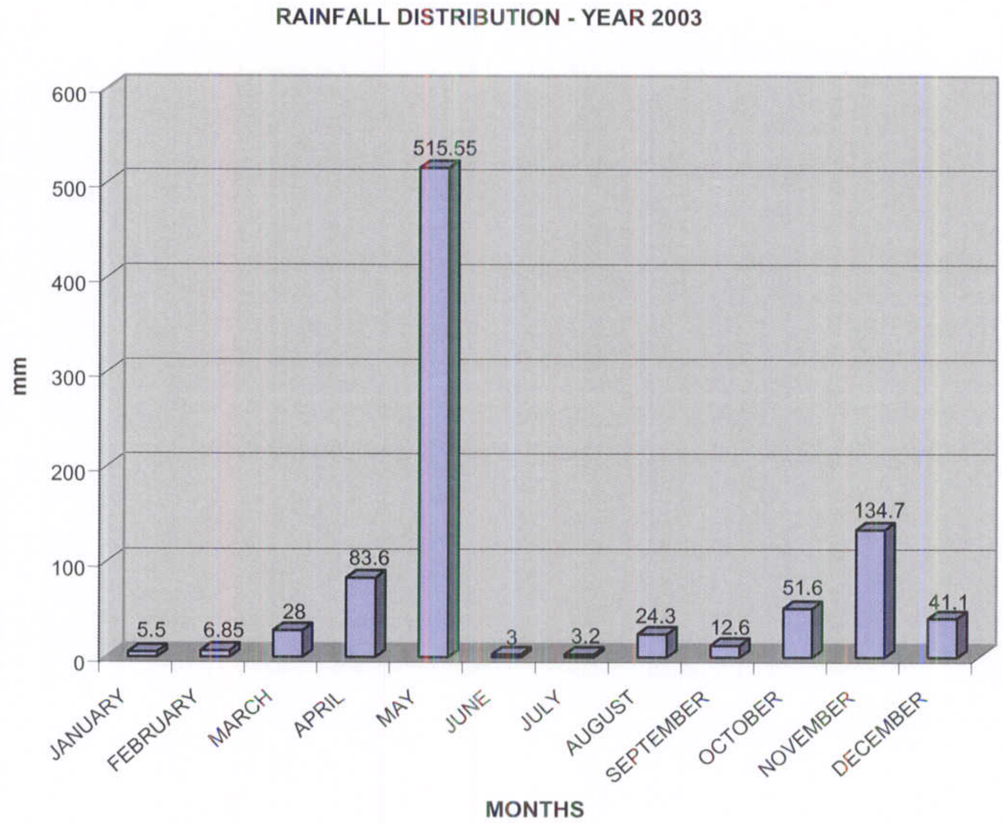
- Special emphasis - using NEMA if necessary - on rehabilitating mining and quarry sites
- Facilitate and partner NEMA - especially in the EIA process
- Establish a data bank into which all participants can feed details of their projects, record of planting and periodic audit of survival rate

If enough businesses embrace the above, 20 m. new and growing trees can without doubt be achieved by Nov. 2004 as Kenya's contribution to the EA Business initiative.

APPENDICES

Appendix I

RAINFALL DISTRIBUTION – JANUARY TO DECEMBER 2003



No. of Rainy Days	-	**73 days**
Total Rainfall to-date	-	**909 mm**
No. of days	-	**365 days**
Average Rainfall	-	**2.49 mm**
Year	-	**2003**

Appendix II

DENSITY AND MECHANICAL PROPERTIES OF SEVEN KENYAN GROWN EUCALYPTUS HYBRIDS AND THREE PROGENIES.

By

Muga, M.O.

Research Scientist,
KEFRI Forest Products Resource Centre.

A technical report submitted to the Manager Tree Biotechnology Project, Karura, Kenya.

Abstract

The study reported here evaluates and compares the nominal density and mechanical properties of wood derived from seven Kenyan grown *Eucalyptus grandis x E. camuldulensis* clones and three local progenies of *E.grandis, E.tereticornis* and *E. saligna*. These had been grown in 1998 at an experimental site established by Tree Biotechnology Project at Karura Forest in Kenya. The experiment had been established to test the adaptability of the clones and to compare their performance with the local progenies.

At *4-½* years, 3 trees from each clone/progeny were randomly selected and wood samples were obtained from their butt logs and used for this study. Small clear specimens of wood were used to determine the nominal density, MOE, MOR, surface hardness, crushing strength and shear strength values as per British Standard (BS 373) (Lavers, 1969).

The results show that the clones studied have significantly ($P< 0.05$) higher values in all the wood properties tested except for the MOE. It is further evident that all the tested mechanical properties of wood from the clones except MOE compare favorably with those of mature trees from the same species.

It is concluded that at 4-½ years, Eucalyptus grandis x E.camaldulensis clones can produce wood that is significantly superior to that from the local progenies in density, MOR, crushing strength, hardness and shear strength and similar in the Modulus of elasticity. It is recommended that further comparisons on MOE for all the clones and progenies and all mechanical properties for the clones and E.tereticornis be done at the rotation age to establish if there may be any significant differences then. Evaluation of other important wood properties is also recommended.

Key words: *E. saligna*, *E.grandis*, *E. camaldulensis*, *E.tereticornis* clones, progenies, Kenya, South Africa, mechanical properties and density.

1.0 Introduction

Eucalypts constitute about 10 % of plantation grown timber species in Kenya (MENR, 1994). A number of eucalyptus trees are also grown on farms. *Eucalyptus grandis* Maid, *E. camaldulensis* Dehn. *E. tereticornis* Sm *and E. saligna* Smith, are among the ten most important eucalyptus species around the world in terms of the current annual increment of wood (Hillis, 2000). The first three species and their hybrids are the most important in this group and much genetic and clonal selection has been done, particularly using *E. grandis* (e.g. Malan, 1993). In Kenya, most eucalyptus species are grown in high potential areas and are used for fuel wood, charcoal, poles, posts and furniture production. Some species are also used for pulp and paper production.

With decreasing availability of forestland in high potential areas in Kenya, there is need for suitable species, provenances and hybrids to meet the inferior environmental conditions in the marginal areas, where unused land is abundant. Studies in South Africa by Mondi, ICFR and CSIR have recommended *Eucalyptus grandis* x *Eucalyptus camuldulensis* clones for marginal areas as they are drought resistant (Kanyi, 2003). It is for this reason that seven *Eucalyptus grandis* x *Eucalyptus camuldulensis* clones obtained from trees growing in South Africa were planted in an experimental plot at Karura Forest in 1998. A long side with these, three local progenies, *E.grandis, E. saligna* and *E. tereticornis* were planted. The main objective of the experiment was to test the adaptability of the clones and to compare their growth performance and wood properties with those of the local progenies.

The study reported here was concerned with the evaluation and comparison of the nominal density and mechanical properties of wood derived from the seven *Eucalyptus grandis x E. camuldulensis* clones and local progenies of *E.grandis, E.tereticornis* and *E. saligna*. Wood density being a natural characteristic can be influenced by tree improvement through cloning and other such techniques. It is also known to have a positive influence on most wood properties including mechanical properties. Mechanical properties of wood, which refer to its resistance to imposed loads or forces, are most important when wood and wood products are used for structural building applications. Structural uses of wood and wood products include floor joists and rafters in wood-frame housing, power line transmission poles, plywood roof sheathing and sub-flooring and glue laminated beams in commercial buildings (Haygreen &

Bowyer, 1989). The structural purposes for which the Kenyan grown Eucalyptus is employed include: poles (used as studs, roof trusses and scaffolding in the building industry and to support power and telegraphic transmission lines), posts (for fencing) and sawn timber for furniture making.

Some of the basic and important mechanical properties of wood that are determined include: modulus of elasticity (MOE), modulus of rupture (MOR) in bending; maximum stress in compression parallel to grain, compressive stress perpendicular to grain, shear strength parallel to grain and hardness (Green *et al.*, 1999). The objectives of the study were therefore to establish the nominal density and basic mechanical properties of *E. grandis* x *E.camaldulensis* clones and compare these with those of the local progenies of the same age and grown under similar conditions.

2.0 Materials and Methods

Wood samples used in this study were obtained from 4 ½ year old clones of *E. gradis* x *E. camaldulensis* and progenies of *E.grandis, E.tereticornis* and *E. saligna* grown at an experimental site established by Tree Biotechnology Project at Karura Forest in Kenya. The clones were obtained from trees growing in Mondi in South Africa and the seeds for the local progenies were obtained from the Kenya Forestry seed center, at Muguga. The trees were established in April 1998 using the experimental design shown below Table 1. A spacing of 2.5 x 2.5 m was used. A total of 3 trees per clone/progeny were sampled, one tree being randomly selected from each compartment. The growth performance of the trees used in the study is as shown in Table 2. A butt log, 2 m in length, was obtained from each tree and used for the production of the samples used in the tests.

Table 2- 1. Experimental design

3^{rd} Rep				2^{nd} Rep		1^{ST} Rep			
GC 15	GC 10	GC 522	E. saligna	GC 522	E. Tereticornis	GC 12	GC 15	*E.grandis*	GC 581
GC 14	*E.grandis*	GC 12	GC 642	GC 12	GC 14	E. saligna	E. tereticornis	GC 14	GC 522
GC 642	*E. tereticornis*	GC 581	*E.grandis*	GC 581	GC 15	GC 10	*E. saligna*	GC 642	GC 10

Key: GC- grandis x camaldulensis

Table 2-2. Growth performance of the trees sampled

Clone/Progeny	Mean total Height (m)	Mean DBH (cm)
GC10	14.4	13.2
GC522	14.8	13.5
GC581	14.8	13.5
GC14	14.7	13.2
GC642	14.9	13.6
GC15	14.8	13.3
GC12	14.5	13.2
E. grandis	15.3	14.5
E. saligna	14.9	14.3
E. tereticornis	14.0	13.0

Evaluation of the properties

Small clear specimens of air dry wood from the butt logs of the three trees from each clone/ progeny were used to determine the MOE, MOR, surface hardness, crushing strength and shear strength values. The specimen sizes and test procedures used were as per British Standard (BS 373) (Lavers, 1969).

The tests were carried out at the KEFRI Forest Products Resource Centre, Karura, using a Universal strength-testing machine with a capacity of 500 KN supplied by Avery Kenya Limited. The load was applied to all the test samples until failure, indicating that a maximum load had been reached. Prior to testing, the dimensions of each specimen were recorded for the computation of the density and some of the mechanical properties. The oven drying method was used to determine the moisture content and density of the specimens, at the time of testing.

Statistical analysis

Plot means were used for the analysis of variance using Statistical Programme for Social Scientists (SPSS)(Norris, 1998).

Comparison of the properties of the clones/progenies

Tukey's pair wise comparison method was used.

3.0 Results and Discussions

3.1 Results

The means for the mechanical properties and density of the clones/progenies are shown in Figures 3-1 to 3-6. The standard deviations and coefficient of variations are summarized in the Appendix (Tables A1- A4). Results of one-way analysis of variance (ANOVA) for the effect of clone/progeny on the mechanical and physical properties are also shown in Table 3-

1. The results show that progenies/clones studied had significant differences in all the wood properties tested except for the MOE and moisture content (at the time of the tests).

Multiple comparisons (Table 3-2) show that all the 7 clones have hardness, density and shear strength values that are significantly ($P<0.05$) higher than those for E.grandis progenies. It is also evident that at least 4 of the clones have significantly ($P<0.05$) higher crushing strength values than E. grandis while the remaining 3 have higher values that are statistically not different from those of E. grandis. In the case of E.saligna, the density value is lower than that for all the seven clones, the crushing strength value is lower than those of six clones, hardness and shear strength values are lower than those of 2 clones. Comparison of the clones with E. tereticornis reveal that, the clones have higher values of crushing strength, shear strength, hardness and density than E. tereticornis progenies, however, these differences are statistically insignificant except for the density values of GC 10 and GC 642.

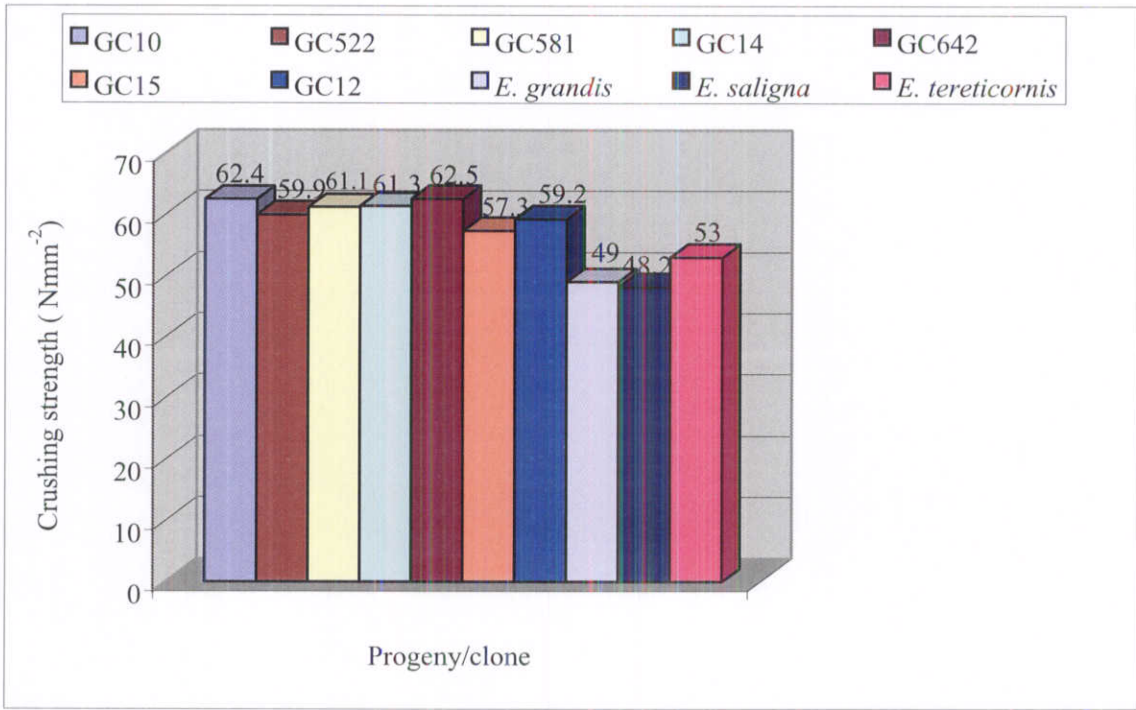


Figure 3-1. Crushing strength of wood from Eucalyptus progenies/ clones.

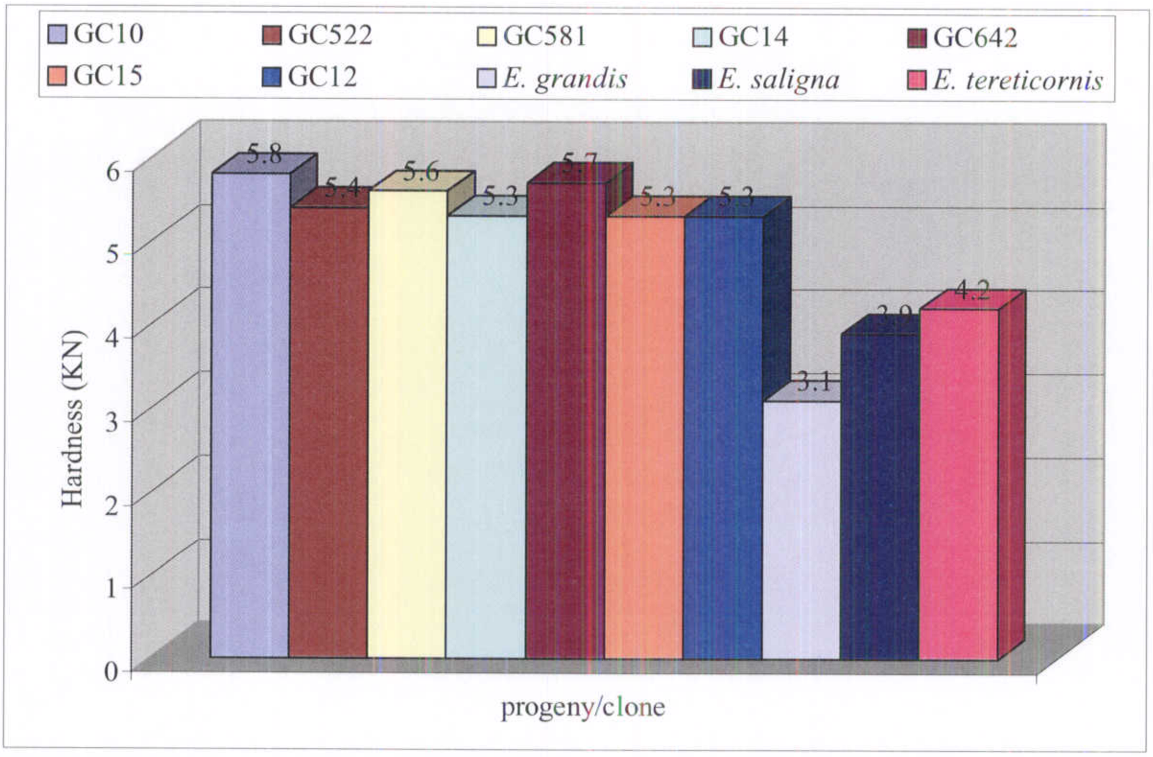


Figure 3-2. Surface hardness of wood from Eucalyptus progenies/ clones.

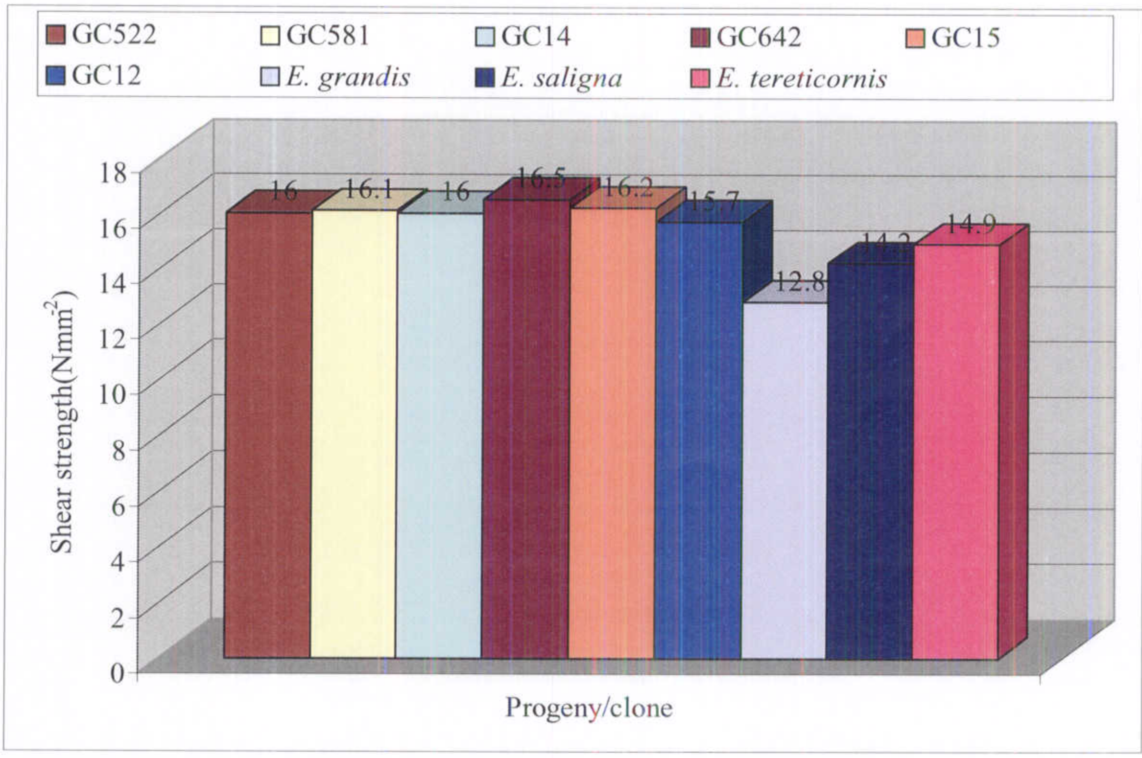


Figure 3-3. Shear strength of wood from Eucalyptus progenies/ clones.

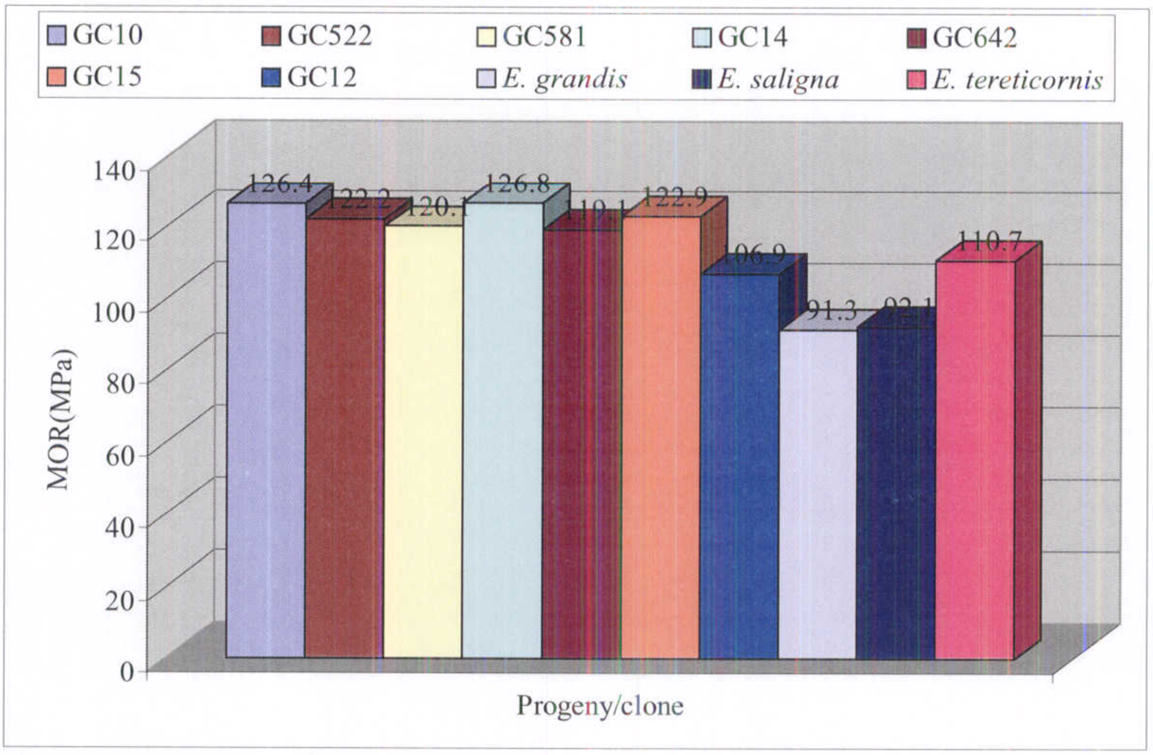


Figure 3-4. MOR of wood from Eucalyptus progenies/ clones.

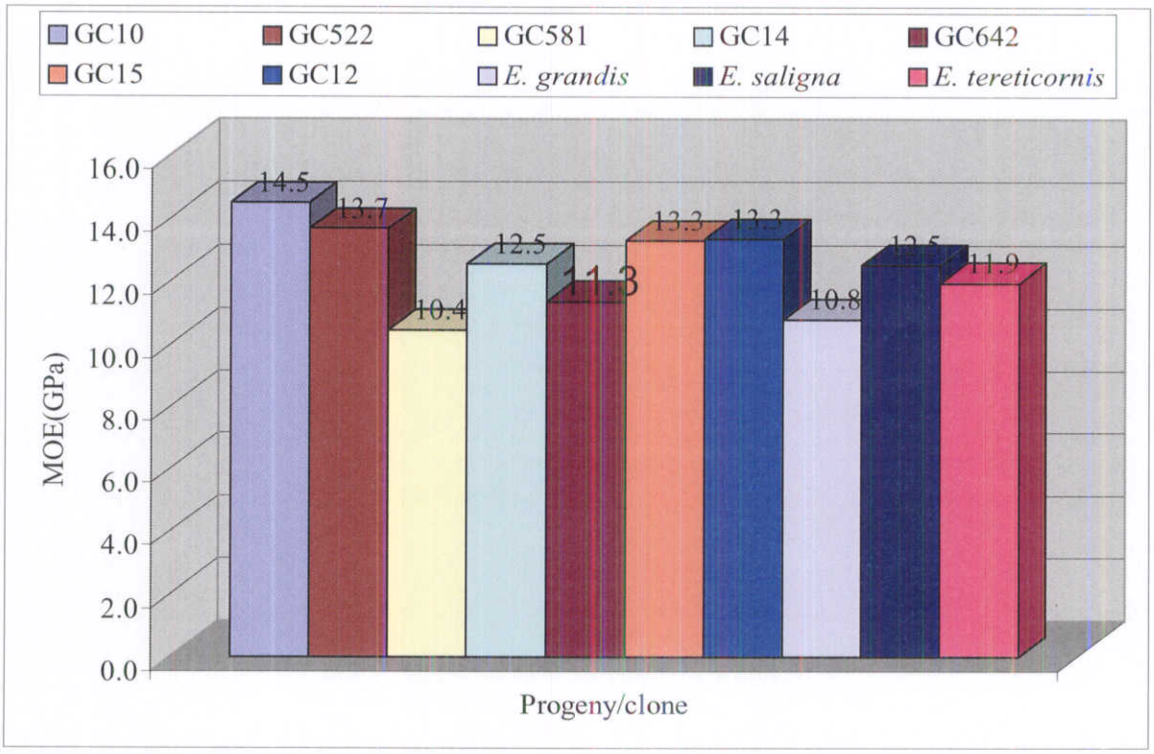


Figure 3-5. MOE of wood from Eucalyptus progenies/ clones.

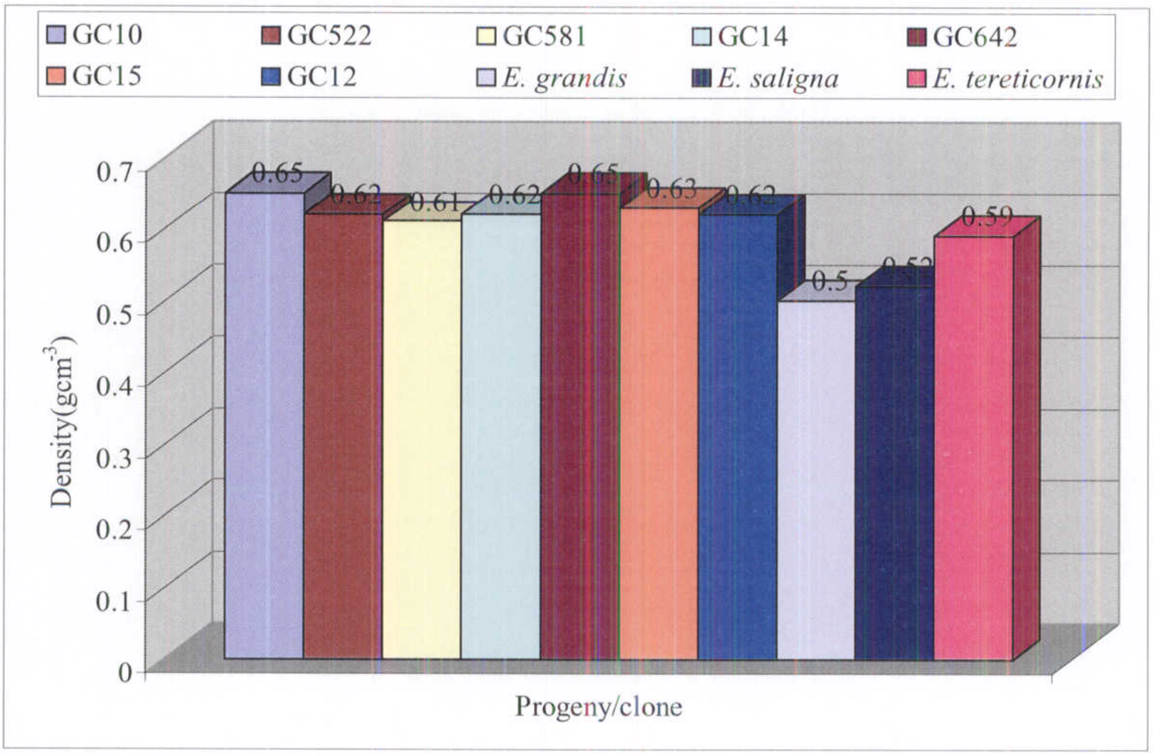


Figure 3-6. Wood density of Eucalyptus progenies/ clones.

Table 3-1. Results of Analysis of Variance

Property	$F_{(9,27)}$ - value	P-value	Statistical Significance of difference
Crushing strength (MPa)	6.8	0.000	s
Hardness (KN)	5.3	0.001	s
MOE (GPa)	1.7	0.158	n.s
MOR (MPa)	3.2	0.017	s
Shear strength (MPa)	5.4	0.001	s
Density (gcm^{-3})	10.3	0.000	s
Moisture content (%)	0.99	0.462	n.s

Key s- significant results at 0.05 level: n.s.- non-significant results at the same level.

Table3-2: Results of Tukey's multiple comparisons of the means

Property	Clone/Progeny	GC10	E. grandis	*E. saligna*	*E. tereticornis*
Crushing strength	GC10	-	s	s	n.s
	GC522	n.s	n.s	s	n.s
	GC581	n.s	s	s	n.s
	GC14	n.s	s	s	n.s
	GC642	n.s	s	s	n.s
	GC15	n.s	n.s	s	n.s
	GC12	n.s	n.s	s	n.s
	E. grandis	s	-	n.s	n.s
	E. saligna	s	n.s	-	n.s
	E. tereticornis	n.s	n.s	n.s	n.s
Hardness	GC10	-	s	s	n.s
	GC522	n.s	s	n.s	n.s
	GC581	n.s	s	n.s	n.s
	GC14	n.s	s	n.s	n.s
	GC642	n.s	s	s	n.s
	GC15	n.s	s	n.s	n.s
	GC12	n.s	s	n.s	n.s
	E. grandis	.s	-	n.s	n.s
	E. saligna	s	n.s	-	n.s
	E. tereticornis	n.s	n.s	n.s	-
Shear strength	GC10	-	s	.s	n.s
	GC522	n.s	s	n.s	n.s
	GC581	n.s	s	n.s	n.s
	GC14	n.s	s	n.s	n.s
	GC642	n.s	s	s	n.s
	GC15	n.s	s	n.s	n.s
	GC12	n.s	s	n.s	n.s
	E. grandis	s	-	n.s	.s
	E. saligna	s	n.s	-	n.s
	E. tereticornis	n.s	s	n.s	-
Density	GC10	-	s	s	s
	GC522	n.s	s	s	n.s
	GC581	n.s	s	s	n.s
	GC14	n.s	s	s	n.s
	GC642	n.s	s	s	s
	GC15	n.s	s	s	n.s
	GC12	n.s	s	s	n.s
	E. grandis	n.s	-	n.s	s
	E. saligna	n.s	n.s	-	s
	E. tereticornis	n.s	s	s	-

Key: s- significant results at 0.05 levels & n.s.- non-significant results at the same level.

3.2 Discussions

Density

Wood density is a critical determinant of wood working properties (Bamber, 1978).
It has an appreciable influence on many properties and conversion processes, including cutting, gluing, finishing, rate of drying and papermaking.

At 4 ½ years, the eucalyptus progenies and clones tested have attained a density that is about 55-73 % and 62-80 %, respectively, of that of the mature wood from *E. saligna* and *E. grandis*. As compared to mature *E. camaldulensis*, the progenies and clones tested have attained 50-65.5 % and 68.9 –80 % of its density. It is an established fact that density varies between and within eucalypt species (Hillis. 1984). This explains the significant variations in the density among the clones and progenies. The lower density of the clones and progenies as compared to mature wood from the same species is due to a higher proportion of juvenile wood. Such wood may be problematic with traditional processing and seasoning methods. However, they may be more successfully utilized in processes such as gluing and joining where lower density material is advantageous.

Mechanical properties

The lower mechanical properties in the wood from *E.grandis and E.*saligna progenies as compared to those from *E. tereticornis* and the seven *E.grandis* x *E. camaldulensis* clones could be attributed to the significant differences in their wood densities. Wood density is the most important determinant of the strength properties of wood (Panshin and Carl de Zeeuw, 1980). It provides a good but not always direct indication of the strength, stiffness, toughness etcetra of timber. In general, species with high wood density have correspondingly high strength values.

It is evident from the results that at 4 ½ years, the shear strength of the wood from *E. grandis* and *E. saligna* progenies are in a range comparable to those for mature Eucalyptus trees from the same species (Table 3-3). However, the shear strength of the wood from all the clones is higher than those for wood from mature *E.grandis* and *E. camaldulensis* trees. It is further evident that, the crushing strengths of the wood from the 4 ½ year old local progenies are lower than those for wood from mature trees from the same species while those of the clones are in the same range as those of the mature *E. grandis, E. saligna* and *E. camaldulensis* trees. All the clones except for GC12 have MOR values similar to those from mature *E.grandis* and higher than those of mature *E.camaldulensis* trees. The MOR values are also higher than that for timber from mature cypress (44.6 MPa), the main structural timber in Kenya, (Ngang'a, 1992).

The MOE of all the progenies and the clones are lower than those for mature *E. grandis* and *E. saligna* but higher than those for *E. camaldulensis*. Clones GC10, GC581and GC 642 have hardness values in the same range as those of mature *E. grandis* wood. All the clones and progenies have hardness values much lower than those for mature *E. saligna* and *E. camaldulensis* trees.

The results indicate that that at 4 ½ years the timber from the clones and *E.tereticonis* is strong and that from *E. grandis* and *E. saligna* moderately strong. The clones and *E.tereticonis* can be grouped in the strength category S_2 and can be efficiently used in building construction such as truss rafters, while *E. grandis* and *E. saligna* fall in S_3 category and can be used in furniture manufacturing, door frames and tool handles (Chikamai *et al*, 2001).

Table 3-3. Mechanical properties of mature eucalyptus (Hillis, 1984).

Species	Wood property					
	Shear Strength (MPa)	MOR (MPa)	MOE (GPa)	Crushing strength (MPa)	Hardness (KN)	Density (gcm^{-3})
E. grandis	12.5-13.8	111-124	15.5-17.2	62.2-69.0	5.6-6.3	0.81-0.9
E. saligna	13.9-15.4	125-138	15.5-17.2	62.2-69.0	7.2-8.0	0.81-0.9
E. camaldulensis	15.5-17.2	96.7-110	9.7-11.0	55.3-62.1	10.0-11.0	0.91-1.0

4.0. Conclusions and Recommendations

Conclusions

At 4-½ years *Eucalyptus grandis x E.camaldulensis* clones can produce wood that is significantly superior to that from the local progenies in density, MOR, crushing strength, hardness and shear strength and similar in the Modulus of elasticity. The MOR, crushing strength, hardness and shear strength of wood from the butt log of the clones compare favorably with those of mature trees from the same species. All the clones and progenies have hardness values much lower than those for mature *E. saligna* and *E. camaldulensis* trees.

Recommendations

Further studies should be done at the rotation age to establish if there may be any significant differences in MOE of the clones as compared to the local progenies and if the strength values of the clones would be significantly higher than those of E. tereticornis. There is also need to evaluate the variation in the basic wood density, chemical and morphological properties within trees and among the progenies and the clones, which would be important if they were to be used for pulp and paper. It will also be necessary to establish if there are any significant differences in shrinkage and drying defects, which are the most important problems encountered in the utilization of eucalypts.

Acknowledgements

I am very grateful to the KEFRI Technologists, Mr. Mikile, Mr. Lukibisi and Mr. Mogire for sampling of the trees and carrying out the tests. Further thanks go to Mr. Muraya, TBP technician who assisted the KEFRI technologists in the sampling of the trees. I would also wish to acknowledge the useful comments from Mr. Githiomi, the Centre Director.

APPENDIX

Table A-1: The Crushing Strength of the clones and local progenies

Clone/progeny	Crushing Strength			Moisture Content		
	Mean (MPa)	SD	CV (%)	Mean (%)	SD	CV (%)
GC10	62.4	3.2	5.2	9.8	0.28	2.9
GC522	59.9	3.3	5.5	9.7	0.14	1.4
GC581	61.1	1.9	3.1	9.7	0.17	1.8
GC14	61.3	6.0	9.7	9.7	0.16	1.7
GC642	62.5	6.9	11.0	9.8	0.15	1.6
GC15	57.3	4.6	8.1	9.7	0.24	2.5
GC12	59.2	5.3	8.9	9.9	0.26	2.6
E. grandis	49.0	4.1	8.3	9.5	0.21	2.2
E. saligna	48.2	2.6	5.3	9.6	0.17	1.8
E. tereticornis	53.0	6.4	12.0	9.5	0.12	1.2

Table A-2: The surface hardness of the clones and local progenies.

Clone/progeny	Hardness			Moisture Content		
	Mean (KN)	SD	CV (%)	Mean (%)	SD	CV (%)
GC10	5.8	.82	14.3	9.1	0.98	10.9
GC522	5.4	0.69	12.9	9.4	0.13	1.4
GC581	5.6	0.84	15.0	9.4	0.16	1.7
GC14	5.3	0.86	16.3	9.5	0.21	2.2
GC642	5.7	1.26	22.0	9.6	0.17	1.8
GC15	5.3	0.63	11.9	9.4	0.17	1.8
GC12	5.3	1.04	19.9	9.4	0.15	1.6
E. grandis	3.1	0.39	12.4	9.3	016	1.7
E. saligna	3.9	0.99	25.8	9.4	0.15	1.6
E. tereticornis	4.2	0.36	8.6	9.3	0.10	1.1

Table A-3: The Shear Strength of the clones and local progenies.

Clone/progeny	Shear Strength			Moisture Content			Density		
	Mean (Mean (MPa)	SD	CV (%)	Mean (%)	SD	CV (%)	Mean (gcm^{-3})	SD	CV (%)
GC10	16.8	1.7	10.1	9.3	0.51	5.5	0.65	0.03	5.3
GC522	16.0	1.2	7.7	9.2	0.39	4.2	0.62	0.03	4.8
GC581	16.1	1.4	8.9	9.3	0.37	4.0	0.61	004	6.1
GC14	16.0	1.1	6.9	9.4	0.48	5.1	0.62	0.04	6.5
GC642	16.5	2.1	12.7	9.5	0.55	5.8	0.65	0.03	4.6
GC15	16.2	1.6	9.1	9.4	0.5	5.3	0.63	0.02	3.2
GC12	15.7	2.1	13.4	9.5	0.39	4.1	0.62	0.06	9.7
E. grandis	12.8	1.5	11.7	9.1	0.52	5.7	0.50	0.03	6.0
E. saligna	14.2	1.7	11.6	9.3	0.41	4.4	0.52	0.04	7.7
E. tereticornis	14.9	0.89	6.0	9.2	0.52	5.6	0.59	0.02	3.4

Table A-4: The Bending strength of the clones and local progenies

Clone/progeny	MOR			MOE			Moisture Content		
	Mean MPa)	SD	CV (%)	Mean (MPa)	SD	CV (%)	Mean (%)	SD	CV (%)
GC10	126.4	18.5	14.6	14472.6	1040.7	7.2	9.2	0.16	1.7
GC522	122.2	8.0	6.5	13664.9	2946.5	21.6	9.1	0.20	2.2
GC581	120.1	6.9	5.7	10444.0	1287.5	12.3	9.2	0.46	5.0
GC14	126.8	15.7	12.4	12520.0	2298.3	18.4	8.9	0.31	3.5
GC642	119.1	14.7	12.3	11342.0	1853.2	16.3	9.1	0.52	5.7
GC15	122.9	9.7	7.9	13280.0	2516.4	19.0	8.7	0.22	2.5
GC12	106.9	5.5	5.2	13336.1	2105.8	16.0	8.9	0.35	4.0
E. grandis	91.3	6.4	7.1	10777.8	1855.1	17.2	8.9	0.27	3.0
E. saligna	92.1	3.9	4.2	12486.1	1769.9	14.2	9.1	0.46	5.0
E. tereticornis	110.7	20.0	18.1	11925.8	1451.9	12.2	8.8	0.22	2.5

APPENDIX 111

Insect Pest Management of Introduced *Eucalyptus* Germplasm in Kenya

A paper presented to the participant of Extension Service providers Workshops on 13th-15th April 2003 at KFRI Muguga, Kenya

By K.E. Mutitu, KEFRI Entomologist

Introduction

The genus of *Eucalyptus* contains more than 600 species, almost all of which are endemic to Australia. *Eucalyptus* is now grown in over 80 countries for a variety of purposes and industrial plantations total to about 8 million ha. Of this, approximately 4 million ha are in South East Asia. Plantations and natural stands in both introduced and endemic areas are a potential source of pests of the host tree.

Many species of insects attack *Eucalyptus* in both their natural range and places where they have introduced as exotics. A number of eucalypt-infesting insects are of economic importance and could be moved via transfer of germplasm. The risk of transferring insect pest through germplasm transfer is considered to be lower compared to viral, bacterial, and fungal disease causing organisms. Insect pests which pose the greatest risk of being moved to new locations via germplasm are small insects, especially sap-sucking insects which insert their month parts into the plant tissue for extended periods. These are mostly in the insect order *Hemiptera* and *Homoptera* e.g. aphids, scale insects, psyllids and lacebugs.

It is thus important to note that any introduction of germplasm has a risk of pest introduction. The Tree Biotechnology Project is a technology transfer project. It involves transferring very high quality selected genetic material of *Eucalyptus* species. The material is being transferred from a company called Mondi Forestry Division of South Africa. This germplasm is introduced in form of rooted cuttings that is usually in vitro and high quality seeds. KEFRI plays the role of carrying out pest risk analysis to prevent any possible entry of pest(s) of the host into the country.

The following are some of the measures that the KEFRI Entomology section plays in the management of insects of introduced *Eucalyptus* germplasm.

Phytosanitary Measures

These are measures that are undertaken to all incoming germplasm materials into the country. They must adhere to the international standards before being shipped to Kenya. The standards for the transfer of any germplasm are clearly stated in the Food and Agricultural Organization of the United Nations (FAO). The germplasm must be collected from a source of healthy materials. At the point of entry – Jomo Kenyatta International Airport – Nairobi, the material is inspected for any sign of contamination or any possible foreign insects pest(s) or disease causing agents. The cuttings are packed in insert material e.g. vermiculite instead of other media like soil. From the point of entry the materials are placed in quarantine nursery for a period to allow any expression of pest/disease symptoms. It is only after this that the materials can be moved to multiplication nursery. The materials are planted in different agro-ecological zones for further observations. Due to their narrow genetic base they could be attacked by our local pest fauna.

Field Trial Monitoring for Pests

Trials are set in most agro-ecological zones and a pest outbreak situation is monitored in all these trials. At present KEFRI have more than ten trial sites in certain locations countrywide. The monitoring is carried out twice a year, during the long dry period and immediately after the long heavy rains. The changes in weather patterns allows possible would be pest population to be monitored and detected. The monitoring is also carried out to show the trend of the local natural enemies populations. Most of the natural enemies are generalist and play a great role in stabilizing the pest population below economic injury levels. The natural enemies noted include the pentotomide bugs, ladybirds (Coccinellids), sryphids etc. The table below shows the insects that were collected during the last survey that was carried out by KEFRI scientists.

Establishment of *Eucalyptus* Insect Fauna Database

One of the best ways to determine and identify any new pest is by knowing what you have in the country. Using KEFRI's insect collection reference that was established in the 1940's and preserving over 50,000 insect species a database on insect association with Eucalyptus has been established. The database shows that status of the insect species, its host(s), nature of damage, etc. This thus helps to verify data collected from the various surveys that are being undertaken from the various trial sites. This will give direction on the trend of potential pest populations in the country as new germplasm is being introduced. Further work is being carried out with other organizations with quasi-taxonomic databases like the

Natural Museum of Kenya. This will help to know when we have new pests in our country and thus implement possible control strategies.

Insects collected at different trial sites in Kenya during the assessment: -

Trial Site	Insect Name	Insect Family	Insect Order	Nature of Damage	Insect Status
Naivasha	*Gonipterus Scutellatus* *Psiloptera sp.*	*Curculionidae* *Buprestidae*	*Coleoptera* *Coleoptera*	Defoliator Borer	Pest* Pest*
Hombe		*Saturnidae* *Geometridae*	*Lepidoptera* *Lepidoptera*	Defoliator Defoliator	Pest* Pest*
Embu	Blue gum psyllid	*Psyllidae*	*Hemiptera*	Sap-sucker	Pest*
Machakos	*Sphaerocoris annulus* Blue gum psyllid	*Pentatomidae* *Psyllidae*	*Hemiptera* *Hemiptera*	Predator Sap-sucker	Beneficial insect Pest*
Karura	*Odontotermes sp.* *GonipterusScutellatus* Blue gum psyllid	*Termitidae* *Curculionidae* *Psyllidae*	*Isoptera* *Coleoptera* *Hemiptera*	Borer Defoliator Sap-sucker	Pest* Pest* Pest*

*- The insect pest population is very low to be considered as a threat to the host plants, thus can only be termed as potential pest.

Examples of Potential Pests

- ***Eucalyptus* Snout Beetle – *Gonipterus scutellatus.***

This pest was first reported in Kenya in the 1920's attacking *Eucalyptus* species in the Rift Valley. The pest belongs to the order *Coleoptera*, family *Curculionidae* (weevil family). The adult female of *gonipterus* lay their eggs in blackish brown egg capsules, only on the young tender foliage of *Eucalyptus* species. The eggs hatch into slimy, yellow larvae which devour the epidermis of the leaf and when fully developed drops to the ground, burrow into the soil and pupate. Damage on the trees is caused by the feeding of both adults and larvae.

The preferred feeding place for the adults is long the edges of the leaf. The greatest damage, however, is caused by the feeding of larvae, which devour the entire epidermis of the leaf. Continued destruction of the young soft twigs and leading shoot prevents all height growth, and in the course of a few seasons, the tree becomes on a stunted, stag-horned in appearance with clusters of dead shoots along the framework of the branches.

In 1926 an attempt was made to control the beetle by artificial means. This took the form of dusting plantations with an arsenical poison from aeroplanes. These dusting experiments gave promising results from a control point of view, but proved to be economically unsound and therefore had to be abandoned.

The only likely avenue of management of this pest covering big areas was implementation of a biological control method. This measure entailed a search for biological control agent in Australia. The home range of many *Eucalyptus* pest species and thus areas where the pests are under the control of local natural enemies. A biological control agent, *Anaphes nitens*, an egg parasitoid wasp was introduced in Kenya. It's introduction proved successful with only very few sporadic infestations that slowly crashed with human interventions. It is important that with possible increased in eucalypts planting a pest outbreak situation can arise, and thus the need for continued monitoring.

- **Blue gum pysllid; *Ctenarytania eucalypti***

This pest belongs to the order *Homoptera*, family *Psyllidae*. This insect pest was accidentally introduced into a number countries where it has caused extensive damage to eucalypt plantations. It was first reported in Kenya and Tanzania in 1993 on *E. globules*.

It causes distortion, wilting of foliage, mostly at the tips, followed by leaf drop. Dieback of twigs and branches can occur during heavy infestation and young plants may have reduced growth due to foliage loss. Nymphs and adults excrete honeydew, which provides a medium for growth of sooty mould. Nymphs exude filaments of a white, waxy secretion, which they shelter.

The ages of this pest are laid in masses near the developing buds of host plants. Adults and nymphs feed by sucking plant juices. All life stages may be found throughout the year. Adults are strong fliers and nymphs may be dispersed by air currents. This insect could be transmitted via root cuttings. One method of control is destroying all infested germplasm.

Conclusion

- Implementation of the FAO code of transferring germplasm should be adhered.
- Continued monitoring for pests and there possible outbreak.

It is important to note that good management is the key to healthy forest, and a good healthy forest is a sign of sound forest management practices.

Appendix IV

TERMITE ASSESSMENT AND MANAGEMENT AT KITUI EUCALYPTUS CLONAL TRIAL FROM 31ST JULY-1ST AUGUST 2003.

1.0 Introduction

The trial was established on 26th November 2002 (this is to correct the previous report written by Ebby at el, on July 2003) which stated October 2002 as planting date. The following treatments were planted: GC 15, 167, 514, 540, 584, 784, 785, and 796, *E. camaldulensis,* and *E. tereticornis.* Before planting was done, land was ploughed using a tractor. The size of the plot is 34 rows of 30 trees, each, making a total of 1020 trees. The experiment is surrounded by 3 guard rows all round. There are four blocks in the whole experiment. Block I and IV has 10 plots each while block II and III has 11 plots each. Each plot has 16 trees at a spacing of 2.5 by 2.5 metres. See the layout attached. During planting time, Regent 3 G. was applied at the rate of 33 gm per tree. Stock- absorb was applied in two middle rows of the trial i.e row 17 and 18.It was reported to us by the TBP Manager (Mr. Kanyi) and the soc-economic team led by Mr. Luvanda that the trial in Kitui are heavily attacked by termite. This prompted us to immediately undertake control measures against the pest.

2.0 Field Observations

At the age of 8 months, the trees height can be estimated as between 1.5 – 2.5 metres. Diameter at soil level was estimated as 3 – 4 cm. The field is nicely weeded and clean. Survival percentage of both treatment and guard rows is 80.7 and 77.8 respectively. To assess the termite damage/attack the trees were categorized as follows;

- Healthy trees (H)
- Termite attack-completely ringed and partially ringed at the base of the tree but alive. (R and P)
- Dead due to termite attack. (D)
- Dead due stress associated with climatic factors. (S)
- Unknown deaths. (M)

Two genus of termites were collected. These are *Macrotermes* and *Odontotermes* species. These genus are common and widely distributed. They belong to the family termitidae. This family is subterranean, mould-building and arboreal-nesting termites. *Macrotermes* species are responsible for damage of roots to seedlings and ringbarking transplants.

Table 1 TREES ASSESSMENT STATUS OF THE GUARD ROWS.

Guard Rows	
Composed of E. *camadulensis* and *E. tereticorntis*	
Assessments Results.	
Healthy	229
Termite Damage	44
Missing	69
Termite Death	7
Death due to stress	2
Total	*351*

Table 2 TREES ASSESSMENT STATUS IN EACH OF THE FOUR BLOCKS.

	Healthy	Termite Attack	Termite Deaths	Stress Death	Unknown Death
Block 1	118	8	3	0	31
Block 2	130	12	6	1	27
Block 3	125	18	11	0	22
Block 4	120	11	3	0	26
Total	493	49	23	1	106
Percent	**73.4**	**7.3**	**3.4**	**0.1**	**15.8**

Table 3: TREE ASSESSMENT PER TREATMENT(CLONE).

Clones	Healthy	Termite Attack	Termite Deaths	Stress Deaths	Unknown Deaths
GC15	41	3	3	0	17
GC167	45	3	2	0	14
GC514	51	4	5	0	4
GC540	47	4	6	0	7
GC584	38	10	2	0	14
GC784	50	4	3	0	7
GC785	56	6	0	0	2
GC796	37	4	0	0	23
EC	47	6	2	0	9
ET	55	3	0	0	6
EC/ET	26	2	0	1	3
Total	**493**	**49**	**23**	**1**	**106**

3.0 Termite Management

In each of the 815 surviving trees (79.7% of the planted trees) 33g of fipronil was applied at the base of the tree both in guard rows and treatment. Fipronil belongs to an insecticide family called "phenyl – pyrazoles".Regent 3G, is a broadspectrum granular insecticide recommended for use in maize and forestry for the control of termites. This chemical is very effective in termite control. It can help in improving our tree survival percentage in areas where termites are a problem. The chemical is capable of protecting the trees from termite attack for a period of 12 years.

4.0 Kitale Observation

It has been reported to Entomology section that Crickets have been observed defoliating Eucalyptus species in Kitale (Kuza farm). The tree species affected are *E. grandis.* The site where the trees are planted was previously under maize. The affected parts of the trees are stem and roots. Seedlings have been found dying. The symptoms of attack are nimbling of the bark and root cut. According to Mr. Muraya about 35,000 seedlings are affected. This figure looks unrealistic and scaring thus it warrants control measures to be undertaken immediately. The report by Mr. Muraya is unclear whether the age of the trees is 30 days or 15 days as he had indicated both ages in the data form.

The insects were identified as:

Order : Orthoptera

Family : Gryllidae

Genus & Species : *Liogryllus bimaculatus Deg.*

5.0 Control Measures

Cultural method

This can be achieved through maintenance of hygiene in the field particularly when planting.

Chemical method

It is advisable to spray the seedlings with Cyanox L50 ULV (Cyanophos) at the rate of 500g/1

6.0 Discussion

Table 1 show the total number of trees per category in the guard rows. 229 trees were alive. 44 trees showed termite attack but were healthy. 69 trees were missing. 7 trees were dead due to termite attack while 2 trees were dead due to stress associated with climatic factors.

Table 2 shows assessment per block. The total number of healthy trees were 493 out of 672 representing 73.4%. Trees attacked by termite but alive

(i.e. both Ringed and partially ringed) represented 7.3%. Trees killed by termite represented 3.4%. Dead trees due to stress were 0.1% while 15.8% of the death were due to unknown factors.

Table 3 shows tree assessment per treatment. GC785 has the highest number of healthy trees followed by E. *tereticornis*. GC540 has the highest number of dead trees due to termite attack followed by GC514. Only one tree in the filler had died as a result of stress. GC796 had the highest number of missing trees (unknown deaths) followed by GC15. The clone with the highest number of termite attack (but alive) was GC584 followed by GC785 and E. *camaldulensis*. Figure 1 shows the total number of surviving trees is 80.7% (Healthy and termite attacked). The total number of trees, which were dead represented 19.3%. Figure 2 shows trees status in each of the four Block. The highest number of tree per block were healthy followed by deaths due to unknown causes. Stock-absorb has the ability to retain water in the soil. It is interesting to note that there were no deaths due to termite in the two rows where stock-absorb was applied. More deaths of ring barked trees is expected due to stress associated with the current dry spell. However, this trend can change if the rains come soon than expected in November. Fipronil is expected to protect the trees from further termite attack even when the termite activities increase with the coming rains.

APPENDIX V

SALES/SEEDLING DISTRIBUTION – JANUARY TO DECEMBER 2003

MONTH	SPECIES								
	E. GC	*E. grandis*	*E. urophylla*	*E. tereticornis*	*E. camaldulensis*	*E. dunii*	*E. nitens*	Assorted	Totals
January	1,500	24,409	10	160	2,830	-	-	2,046	30,955
February	39,500	8,011	10	-	1,514	-	-	500	49,535
March	29,740	59,788	3,825	1,665	20,071	-	-	45	115,134
April	47,170	287,410	30,640	10,108	40,992	-	-	897	417,217
May	36,525	237,419	8,909	5,658	59,363	-	-	1,456	349,330
June	31,578	29,578	1,559	104	13,695	-	-	0	76,514
July	10,943	18,807	700	220	310	-	-	1,750	32,730
August	14,530	7,046	300	100	2,760	90	412	60	25,298
September	26,642	25,031	4,422	22	2,380	5,276	642	1,970	66,385
October	50,376	105,179	9,464	11,548	3,725	26,049	375	6,299	213,006
November	44,811	205,123	24,665	4,180	24,288	2,357	8,422	844	314,690
December	15,908	58,563	360	20	2,757	2	100	45	77,755
Total	**349,223**	**1,066,364**	**84,864**	**33,785**	**174,685**	**33,774**	**9,951**	**15,912**	**1,768,549**

Appendix VI

PROJECT MANAGEMENT STRUCTURE