KENYA FORESTRY RESEARCH INSTITUTE
MUGUGA CENTRE

A manual for growing *Eucalyptus grandis* plantation and its benefits

By
Charles Kimathi Kiriinya
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Introduction

In recent, years there has been a lot of interest in growing trees in Kenya mainly by farmers due to ban on timber harvesting from government forests and increased awareness of the importance of trees coupled with realization that trees could be a source of income. Most farmers prefer planting tree species that are fast growing, with available market and that can earn cash in the shortest time possible. One of the popularly sought species is *Eucalyptus grandis* (flooded gum). The species is among the fastest growing with a height growth rate of 3 to 5 m per year. It grows in a wide range of altitudes from 0 to 2000 m above sea level, with annual temperatures ranging from 5°C to 32°C and annual rainfall ranging from 700 mm to 1200 mm. The species grows well in both flooded and well drained soils. It grows best on the highlands west of Rift Valley and Central highlands of Kenya. *Eucalyptus grandis* produce can be sold from 2 years of age as fitos and later as poles, posts and timber. However, the management of *E. grandis* is not well known by farmers.

Eucalyptus grandis can attain a height of 45 to 55 m and usually has an excellent straight trunk and a widespread thin crown (FAO, 1979). The wood is pink to light reddish brown and is usually lighter, softer and more fissile than that of most eucalypts. The wood is likely to warp when seasoned. *Eucalyptus grandis,* grown for income generation requires high quality seedling stock, adequate site

preparation, proper planting techniques, effective weed control and satisfactory soil nutrient status. The planted seedlings should be able to establish rapidly and grow uniformly. This would ensure uniform height and diameter during the seedling through to harvesting stages of the crop and to enable the produce to be harvested and marketed efficiently.

In Kenya, where a local market exists, thinning may be sold for fitos, poles, posts, pulpwood, particleboard, and fuelwood among others. The species may also be managed on longer rotations for sawn timber, plywood or veneer. *Eucalyptus grandis* may be coppiced and harvested at intervals of four to ten years up to 4 times. Uniformity in growth at the seedling stage of a crop intended for coppicing is particularly important because irregularity tends to be progressively pronounced in the first and subsequent coppice crops.

This paper provides guidelines for growing of *E. grandis* plantations by farmers.

Seed Collection

Seed should be collected from superior trees, which are tall with straight bole and little taper. The branches should be small and the crown light. Seeds could be collected cheaply following felling of mature trees. Seed may also be collected from standing trees by climbing and cutting the branchlets using pruners, flexible saws or sharp pangas.

Extraction of *E. grandis* seeds is done by drying the fruit in open sunlight on wire mesh/screen or polyethylene sheet until the capsules open letting out the seed and chaff. It is estimated that 1 kg of *E. grandis* seed contains approximately 630,000 viable seeds (Turnbull 1977). High quality seed can be purchased from Kenya Forestry Seed Centre (KFSC) at the Kenya Forestry Research Institute.

Seed Storage

Seeds should be air-dried and stored in dark sealed containers at 1 to 4°C. Seeds of most eucalyptus can be stored for about 3 years in an air tight container without losing viability as an acceptable germination level of 80 to 90% can be maintained (FAO 1979).

Nursery Management

(a) Nursery site and layout

As for normal practice, a tree nursery should be situated on a gentle sloping land with unimpeded water drainage and near a reliable source of water. It should have regularly laid out Swaziland beds of 1 to 1.2 m width and a maximum length of 10 m. The beds (or bays) for holding container stock should be of a convenient width of 1 to 1.5 m and levelled.

(b) Nursery Soil

Soil mixture used in nursery containers depend on soil that is locally available. In general, the soil should be fertile, with adequate water

holding capacity and good drainage. Addition of manure or fertilizer is common (Kimondo and Kioko, 2000).

(c) Seed Sowing and Germination

The most common and effective way to raise Eucalyptus seedlings is to broadcast the seeds in a tray or seedbed containing sand or a mixture of sand and soil. Due to its small seed size, Eucalyptus seeds should be mixed with fine dry sand 2 to 3 times its volume before broadcasting. Seeds germinate within 7 to 21 days. Viable and mature Eucalyptus seeds germinate satisfactorily at temperatures range of 20 to 28^{0}C (Turnbull 1977).

Pricking Out

Seedlings are ready for pricking out after about 4 weeks of seed sowing. Pricking out should be done when the young seedlings have developed two to four pairs of leaves. To avoid damage, the young seedling should be uprooted by gently holding the upper leaf pair together and at the same time carefully loosening the soil around the seedling using a dibbler. The roots of the seedling should not be exposed to direct sunlight. This is achieved by immersing uprooted seedlings into water in a container before transplanting into Swaziland beds, pots or tubes. Eucalyptus seedlings are normally raised in polyethylene tubes of 10 cm width and 15 cm length.

Raising of Seedlings

After transplanting, seedlings should stay in the nursery under shade for about 7 days. The seedlings grow in the containers or Swaziland beds until they are ready for transplanting in the field. During this time, the seedlings in Swaziland beds should be root pruned every 2 to 3 weeks to reduce the length of the taproot, which might penetrate the soil in the nursery. Seedlings in containers can also be lifted every 2 to 3 weeks so as to disturb and discourage development of taproots outside the containers. Watering may be done up to two times a day depending on the prevailing temperatures.

(d) Size and Quality of Seedlings

The period of stay in the nursery and the average size of seedlings at planting time varies greatly. The recommended time is 3 to 6 months or when the plants attain a height of 25 to 45 cm. Sometimes, exceptionally large seedlings are required for planting in grassy areas. These should be grown for 8 to 9 months in the nursery and large polyethylene tubes of 15 cm width and 25 cm length are required. If planting has to be delayed because of unfavourable conditions, or if sowing is done too early, overgrown plants should be clipped or trimmed from the top so that they can be planted the following season.

Seedling Handling and Hardening Off

Hardening-off is the process of preparing the seedlings for field conditions. This can be achieved by gradually removing the shade and reducing watering for 2 to 4 weeks before planting in the field. Hardening off reduces the shock after planting and increases survival.

Hybrid Clones

Until 1997, *Eucalyptus grandis* plantations in Kenya were established through seeds, except for demonstration plots that were planted from pure clones. Clones of *Eucalyptus grandis* can also be grown as species or hybrids with other *Eucalyptus* species such as E. *camaldulensis*, and *E. urophylla* depending on the climatic conditions of the area to be planted.

In 2001, KEFRI and Forest Department introduced 12 clones of *E. grandis* x *E. camaldulensis* (GC) from South Africa and 7 clones comprising one pure *E. grandis* (TAR), three (GC) hybrids and 3 *E. grandis* x *E. urophylla* (GU) hybrids in different agro-ecological zones. Results from different ecological zones after five years of growth showed significant differences in growth between pure and hybrid clones (Table 1). Cloning can be applied to improve tree growth, disease and pest resistance and timber quality once trees with such traits are identified. Clones of pure *Eucalyptus grandis* and hybrids are available at Karura Forest Biotechnology Project.

Table 1: mean height (m) and standard error of mean (s.e) of eucalyptus clones and local landraces at various ages in different sites in Kenya

	Sokoke (2 (yrs) S.e 1.22	Msamb (2 yrs) Se 0.495	Gede (2 yrs) S.e 1.188	Macha (5 Yrs) (S.e 1.429)	Kar (6yrs) S.e 0.872	Embu (5 yrs) S.e 0.872	Hombe (5yrs) S.e 0.827	Timb (5 yrs) S.e 1.102	Marigat (2yrs) s.e 0.736
EC	7.3b	3.3a	7.3a	9.4b		12.0b	10.6b	6.8b	4.5a
ET	5.3c	4.2a	10.0a	12.0b	8.7c	11.6b	10.5b	7.2b	4.0a
EG				22.6a	17.3a	14.8b	16.3a	10.2a	
ES				19.3a	14.5b	13.6b	14.7a	10.8a	
EU	7.0b	4.4a	8.1a						
GC 3								11.7a	
GC 14	7.9b	5.5a	6.7a	21.3a	18.5	17.2a	13.4a	10.9a	
GC 15				22.5a	16.9a	17.0a	14.8a	11.1a	
GC 10				21.2a	18.8a		14.7a		
GC 12					17.7a				
GC 17					20.3a				
GC167	8.3b	5.1a	8.7a						
GC584	9.3a	4.4a	7.7a						
GC514	11.6a	5.1a	7.0a						4.9a
GC522				20.8a	18.5a		15.2a		
GC540	9.2a	4.8a	7.2a						5.8a
GC796	8.0b		7.6a						
GC581	9.0b	5.2a	7.6a	19.6a	18.5a	16.4a	16.0a	12.0a	
GC784	9.2a	5.0a	7.7a						5.4a
GC785	10.5a	5.0a	6.6a						
GC642				20.2a	16.8a	16.3a	15.0a	10.9a	
GU21	9.4a	4.6a	9.2a						
GU8	8.4b	3.1a	9.7a						
GU7	8.3b	3.3a	9.1a						

NOTE: a, b, c in =order of performance, Macha =Machakos, Timb=Timboroa, Msamb=Msambweni, Kar=Karura
Source: Oballa *et al.*, 2005

(e) Ground Preparation

Land should be ploughed before planting. Planting pits of about 10 cm diameter and 30 cm deep should be prepared. It is preferable that pits be prepared before the actual planting season to enable water percolation for the benefit of the seedlings to be planted.

Initial Spacing

Initial spacing depends on the end product and the fertility of the site. Generally, in poor sites, wider spacing should be adopted while in good sites closer spacing is preferable. Spacing guideline in accordance with the end product is as shown in Table 2.

Table 2. Spacing guideline according to end product

Object of management	Initial spacing (m)	No. of Trees/ha.
Pulpwood, light posts	2 x 2	2500
Pulpwood, light posts	2 x 2.5	2000
Pulpwood, light posts	2.5 x 2.5	1600
Light posts, heavy posts	3 x 2	1670
Light posts, heavy posts	3 x 2.5	1330
Saw logs, light and heavy posts	3 x 3	1110

Planting Procedure

Planting should be done as early as practicable in the wet season, so that the plants can take full advantage of the rains and residual warmth in the soil. The moisture build up should be adequate and can be tested by squeezing a ball of soil and water oozes out. Planting is done by placing the seedling into planting holes, filling the holes with soil up to the root collar and firming the soil against the roots. If the containers are polyethylene pots, they should be removed before planting to avoid rooting deformities. If survival is low, seedlings should be replaced as early as possible in the same year to avoid an uneven crop. Replacing seedlings in the year following the original

planting is not usually successful. Replanting should be done if more than 65% of the seedlings die.

On farms, planting can be done as woodlots, boundary planting or scattered. Since Eucalyptus interferes with crop yields due to competition for water, the recommended pattern of planting is woodlot. Trees should not be planted in catchment areas and should be at least 15 m from running water.

Application of Fertilizer

Young *E. grandis* are known to respond quickly to fertilizer application, both in the nursery and in the field. In the field, it is recommended that fertilizer, at 50 gm per seedling be applied a few weeks to three months after planting. The application should be done in a circle or in two small patches on either side and 15 to 30 cm away from the plant. On some fertile soils, response to fertilizers may be insignificant or uneconomical. On nitrogen deficient soils the best application is 200 kg per ha of NPK fertilizer twice every year until the trees attain 3 years of age (FAO 1979).

Weed Control

Eucalyptus grandis grows well when it is free from weeds. It is most sensitive to competition especially by grass such as *Imperata cylindricum* during the first year. Initial weed control can be achieved by good site preparation. The first year of tree growth is very

important as it determines the vigour of the plants. Weeds should be controlled until canopy closer.

Thinning

Thinning before the first harvesting/felling of the crop is usually not recommended. Only highly defective stems or those damaged by animals or weather should be removed. Such trees should be cut close to the ground to enable vigorous new shoots to develop. In cases where a stand has been severely damaged by fire, animals, or windstorms, clearfelling close to the ground may lead to a more even stand which will grow more quickly than if the stand were replanted.

Pruning

Eucalyptus grandis is self-pruning if recommended spacing is used initially. *Eucalyptus grandis* planted at wider spacing may require pruning, if necessary especially if planted for timber.

Felling and Coppicing

(a) Clear felling

The time of clearfelling of *E. grandis* depends on the end product as shown in Table 3.

Table 3. Maturity period and yield in hectares for various products from *E. grandis*

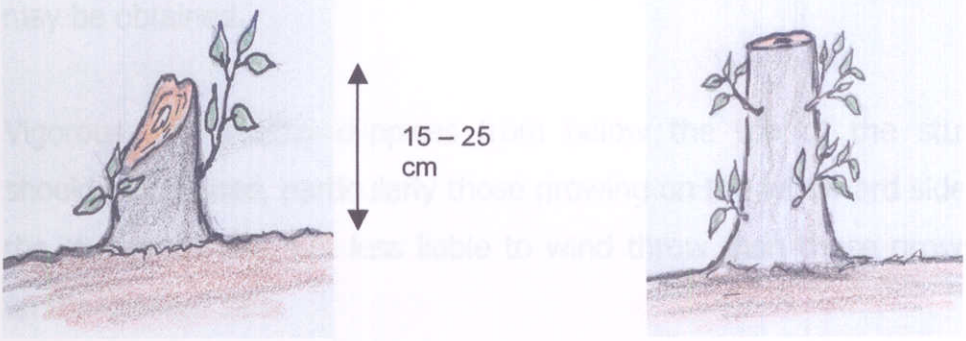
Products	Maturity time Years	Yield /ha.
Fitos	2 to 3	2,000
Poles	7 to 12	1,600
Posts	10 to 15	1,000
Sawn timber	Over 25	300 to 500 trees

(b) Coppicing

The timing and method of harvesting Eucalyptus is important for coppicing. Most plantations for coppicing are felled between ages 7 to 10 years. Products obtained from coppices are mainly poles and posts. To ensure a vigorous growing stock harvesting should be done as follows:

- When there is enough moisture in the ground to encourage sprouting of new shoots,
- At the beginning of the rainy season or during the cold season,
- Using sharp tools that give a clean cut such as power saws, bow saw and two-person crosscut saw. *Pangas* and axes are discouraged as they damage the stump, hence reducing the sprouting capacity of the stump. The tree should be cut at slight angle but not flat to avoid water collecting on the cut surface.
- The cutting height should be between 15 to 25 cm from the ground level (Figure 1). All Eucalyptus trunks have numerous dormant buds on the trunk which develop into shoots when the tree is felled. The upper shoots usually develop more quickly and suppress the lower

ones. Shoots from the trunks are much less stable than shoots from stumps cut to the recommended height of 15 to 25 cm or less. For this reason, felling Eucalyptus trees at a height of more than 25 cm is discouraged.



(a) Recommended cutting height and angle

(b) Wrong cutting height and angle

Figure 1: Cutting height and angle for Eucalyptus

After felling, the stumps should be cleared of branches, twigs and leaves so that young coppices can develop without interference.

(c) Number of Coppice Shoots(Shoot sprouts)

Several shoots sprout after the tree is cut. The shoots should be reduced (singled out) otherwise they bow and produce inferior products. If straight and more valuable stems are required, the coppice should be thinned to two or three stems per stool or even one

single stem. This should be done when the coppices are 18 months old. Coppices should not be removed too early, as the diameter of the stems may be too small to be sold as fitos resulting in loss of revenue. Financial advantage may be considerable if singling is done at age 2 to 3 years after clearfelling, as this still leaves a full coppice return at age 10 years from which many straight poles of high value may be obtained.

Vigorous and healthy coppices from below the top of the stump should be retained, particularly those growing on the windward side of the stumps as they are less liable to wind throw than those growing on the leeward side.

The final number of stems per hectare retained in the singled crop should not be less than the original stock. Should some of the stumps die, adjacent stumps should be left with more than one coppice.

(d) Number of Rotations

In each successive coppice rotation, a percentage of stumps fail to produce another coppice crop after felling. On good sites, it is recommended that *E. grandis* be coppiced two times after the original seedling crop if on short rotations of up to 10 to 12 years. If the rotations are shorter, more than two coppice crops can be obtained. A total of four crops in 22 years with harvesting at 7, 12, 17 and 22 years are recommended (FAO 1979).

Yield

Eucalyptus grandis yields higher volume than many other eucalyptus species. It has an annual mean increment of above 60 m^3 of wood and can grow from 3 to 6 m per year(see the attached volume tables for young *Eucalyptus grandis* in a good site).

Killing of Stumps

If a crop is to be replanted or the land is needed for other purposes, the stumps should be removed or killed. Old stumps which will take many years to decay could also harbour pathogens, which might attack the new crop. If the stumps cannot be physically removed they should be killed by either complete de-barking or use of poison. The poison commonly used is 2, 4, 5 –T chemicals e.g. Tricon, Viroaxe and Molopo.

Income from Eucalyptus grandis

Income derived from *E. grandis* depends on the expected end product as shown in the various scenarios below. On average it costs Ksh. 20,200 to raise 1 ha of *E. grandis* at spacing of 2.5 m x 2.5 m (Table 4).

Table 4. Cost of raising 1 ha of *E. grandis* in Central highlands of Kenya at a spacing of 2.5 m x 2.5 m

Item	Unit Cost (Ksh.)	Total cost (Ksh.)
Land preparation/ha	4, 800	4,800
Seedlings	7	11,200
Planting (8 mandays)	150	1,200
Weeding twice a year	1,500	3,000
Total		20,200

Possible Scenarios

(a) Scenario 1

1. First cutting (thinning) fitos after 3 years. 500 fitos to be removed and sold at Ksh. 10 giving a total income of Ksh. 5,000.
2. Second cutting (thinning) poles at 7 to 8 years. 500 poles to be removed and sold at Ksh. 50 giving a total of Ksh. 25,000 and addition of 15 stacks of fire wood at Ksh. 1,000 each giving a total of Ksh. 15,000.
3. Clearfelling at 12 years for 500 poles (telegraph posts sold at Ksh. 300) giving a total of Ksh. 150,000.

The total Income is Ksh. 195,000 over a period of 12 years with an expenditure of Ksh. 20,200. This gives a net profit of Ksh. 174,800.

(b) Scenario 2

Alternatively the crop can be grown and harvested once at age 12 years for telegraph posts. The income will be Ksh. 450,000. This gives a net profit of Ksh. 429,800.

References

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Table V: Total overbark volume (M^3) of *Eucalyptus grandis* planted at Muguga Kenya

Total Height (m)

Dbh (cm)	6	8	10	12	14	16	18	20	22	24	26	28
8	0.0468	0.0516	0.0558	0.0604	0.0620	0.0662						
10	0.0532	0.582	0.684	0.0684	0.0808	0.0846	0.0904					
12	0.0612	0.0702	0.0802	0.0898	0.0948	0.1024	0.1132					
14	0.0708	0.0848	0.0946	0.1048	0.1109	0.1282	0.1386	0.1496	0.1696			
16	0.0812	0.0986	0.1104	0.1220	0.1388	0.1598	0.1748	0.1896	0.2002	0.2194	0.2232	
18	0.0971	0.1150	0.1280	0.1498	0.1770	0.1904	0.2012	0.2214	0.2508	0.2774	0.2890	0.3108
20	0.1108	0.1280	0.1598	0.1854	0.2004	0.2348	0.2587	0.2800	0.3004	0.3303	0.3492	0.3800
22	0.1240	0.1540	0.1848	0.2109	0.2449	0.2760	0.3058	0.3306	0.3588	0.3869	0.4239	0.4549
24	0.1419	0.1777	0.2134	0.2491	0.2848	0.3205	0.3562	0.3919	0.4276	0.4634	0.4891	0.5348
26	-	0.2020	0.2440	0.2880	0.3280	0.3694	0.4095	0.4525	0.4953	0.5373	0.5691	0.6216
28	-	0.2300	0.2778	0.3273	0.3758	0.4240	0.4730	0.5210	0.5900	0.6189	0.6670	0.7160
30	-	0.2580	0.3148	0.3694	0.4254	0.4832	0.5360	0.5928	0.6506	0.7044	0.7602	0.8160

For trees older than 8 years, bigger than 18 cm diameter and taller than 28 m other tables should be made.

Table V1: Total volume without bark of *Eucalyptus grandis* grown at Muguga Kenya

	Total height (m)											
Dbh (cm)	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**
8	0.0325	0.0351	0.0387	0.0419	0.0450	0.0481						
10	0.0380	0.0428	0.0475	0.0520	0.0573	0.0622	0.0670					
12	0.0422	0.0512	0.0592	0.0622	0.0723	0.0790	0.0864					
14	0.0508	0.0604	0.0699	0.0795	0.0889	0.0986	0.1980	0.1178	0.1273			
16	0.0600	0.0625	0.0850	0.9076	0.1100	0.1225	0.1350	0.1475	0.1600	0.1725	0.1870	
18	0.0700	0.6860	0.1020	0.1180	0.1340	0.1490	0.1650	0.1806	0.1975	0.2120	0.2280	0.2460
20	0.0817	0.1012	0.1207	0.1400	0.1600	0.1787	0.1982	0.2183	0.2378	0.2574	0.2769	0.2960
22	0.0920	0.1156	0.1400	0.1628	0.1764	0.2101	0.2337	0.2593	0.2809	0.3046	0.3282	0.3518
24	0.1064	0.1346	0.1627	0.1908	0.2189	0.2470	0.2751	0.3032	0.3313	0.3594	0.3875	0.4438
26	-	0.1551	0.1881	0.2210	0.2540	0.2870	0.3200	0.3530	0.3860	0.4190	0.4520	0.4850
28	-	0.1752	0.2134	0.2517	0.2900	0.3280	0.3664	0.4047	0.4430	0.4812	0.5195	0.5562
30	-	0.2000	0.2439	0.2878	0.3318	0.3757	0.4196	0.4635	0.5094	0.5514	0.5953	0.6392

For trees older than 8 years, bigger than 18 cm diameter and taller than 28 m other tables should be made.