A Guide to On-Farm *Melia volkensii* Growing in the Dryland Areas of Kenya

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Nairobi,
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Ministry of Environment and Forestry

(CADEP-SFM is implemented by Ministry of Environment and Forestry, Kenya Forest Service, Kenya Forestry Research Institute and Japan International Cooperation Agency.)

Cover captions:
Top: *Melia volkensii* plantation
Clockwise: flower and fruits of *Melia volkensii* in Kitui, young seedlings in nursery of Better Globe Forestry in Kiambere, mature tree of Melia in Kitui and Stylish furniture made by Rampel Designs Ltd. Of Melia timber with a mahogany finish.

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FOREWORD

Kenya is a low forest country with a forest cover of about 7.2%. This is below the internationally acceptable minimum forest cover of 10%. The Constitution of Kenya and Kenya's Vision 2030 emphasise the need to realise this target forest cover. Opportunities for increasing the land area under protected areas are limited in the public forests, leaving future expansion and growing of trees to the farmlands and drylands. This will be achieved through introducing appropriate multipurpose commercial tree species in Arid and Semi-Arid Lands(ASALs) in order to mitigate against desertification and/or extreme drought conditions while improving local community livelihoods.

Melia volkensii (Mukau) is a multipurpose, fast growing tree species that produce high value timber in rotations of between 10 and18 years. It is therefore a candidate species for investment in the drylands.

Kenya Forest Service (KFS) and Kenya Forestry Research Institute (KEFRI) in collaboration with Japan International Cooperation Agency (JICA) through Capacity Development project for Sustainable Forest Management (CADEP-SFM) have developed Melia silviculture guidelines and Melia woodlot investment model. These guidelines provide practical procedures to farmers and other stakeholders on collection and processing of seeds, raising and management of seedlings in the nursery, pests and diseases management both in the nursery and in the field, silvicultural treatment and management of plantations and/or woodlots including harvesting.

The cost and benefit analysis of growing melia as a commercial investment has been included in the guidelines. This analysis shows the invest and the income a farmer can expect depending on the choice of spacing, silvicultural treatments and the intermediate agricultural crop. The guideline has particularly laid emphasis on spacing, planting, tending, pruning and the thinning operations of Melia, information hitherto unavailable to the growers.

The target beneficiaries of this guidelines include; farmers, extension agents, producers of melia tree seed and seedlings, National and County Governments, NGOs/ CBOs /FBOs, private companies, schools and learning institutions involved in natural resource management activities.

EMILIO N. MUGO
CHIEF CONSERVATOR OF FORESTS
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ACKNOWLEDGEMENTS

Melia silviculture guidelines and melia woodlot investment model are a product of concerted efforts by the CADEP-SFM technical team and other stakeholder. I acknowledge their efforts that have ensured that we have guidelines to guide the on-farm growing of *Melia volkensii*.

Special appreciation to Chief Conservator of Forests(KFS) Mr. Emilio N. Mugo and Deputy Chief Conservator of Forests (Farm and Dryland Forestry), Mr. Patrick Kariuki for steering and providing guidance and advice throughout the process of writing these guidelines.

Special mention of the core technical team Mr. Kenichi Takano, Ms. Naomi Matsue, Dr. Clement Ngoriareng, Ms. Jane Ndeti, Dr. James Kimondo(KEFRI) and Mr. Joseph Njigoya, Ms Diana Kishiki, who put in long hours in drafting, reviewing, revising and editing this document. Dr. Kamiri Ndufa (KEFRI, Kitui) also offered invaluable support during the preparation of this work.

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ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi-Arid Land
BGF	Better Globe Forestry
CADEP -SFM	Capacity Development Project for Sustainable Forest Management in Kenya
CBO	Community-Based Organisation
DBH	Diameter at Breast Height
FAO	Food and Agriculture Organization of the United Nations
FBO	Forest-Based Organisation
JICA	Japan International Cooperation Agency
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
NGO	Non-governmental Organisation

CHAPTER 1: INTRODUCTION

1.1 *Melia volkensii* and its natural distribution

Melia volkensii is a multipurpose deciduous tree that is endemic to drylands of Eastern Africa with natural distribution range in Ethiopia, Kenya, Somalia and Tanzania (Figure 1). It grows in sandy-clay and shallow stony soils but prefers sandy soils with good drainage from 0-1700mabove sea levelin areas with mean annual rainfall of between 300 – 800 mm and temperature range of 26-38^{o}C. The species belongs to the Meliaceae family and is locally known as Mukau (Kamba, Tharaka, Mbeere), Tile (Boran), Bamba (Oromo), Maramarui (Samburu), Boba (Somali) and Kirumbutu (Taita).

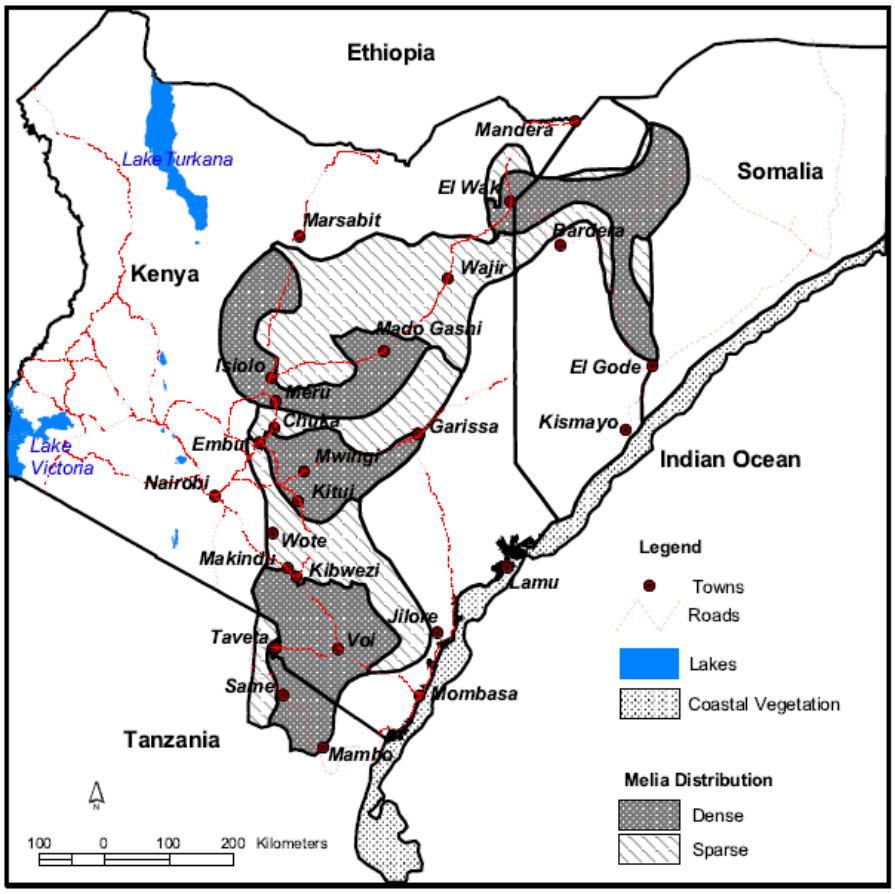

Figure 1: Distribution of *Melia volkensii* in Eastern Africa (source of KEFRI/JICA)

1.2 Importance of *Melia volkensii*

Melia volkensii is a fast-growing tree attaining a height of up to 20m and 40cm diameter in 10 to 18 years, depending on site conditions. It is highly preferred in the drylands because of its drought tolerance, high quality and termite resistant timber. Other products of Melia include poles, posts, fodder, medicine, firewood and bee forage. However, supply of these products has declined over the years because of over-reliance on natural Melia populations, over-exploitation, and conversion of woodlands into farms.

Initial attempts to promote planting of Melia on-farm were constrained by propagation challenges. However, with breakthroughs inbreaking of its seed dormancy, development of technologies for raising seedlings and tree establishment, and promising Melia enterprises, the species is increasingly being adopted as a plantation species in semi-arid areas of Kenya.

Plate 1*: Melia volkensii* **plantation, 10 years old with spacing 4x4m at the shores of Kiambere dam in Kitui** (photo of BGF)

1.3 Objectives of the Guide

Forestry expansion is more feasible in the semi-arid areas of Kenya because of the availability of land due to low population. This is unlike high potential areas where there is intense competition for land between forestry and crop production. This guide will be continuously updated as new research findings emerge.

The guide outlines the entire process of *Melia volkensii* growing including: seed collection, seed processing and handling for production of healthy seedlings. More emphasis is laid on the field management aspects of site selection, land preparation, planting, tending to harvesting (Figure 2). The guide also provides a cost-benefit analysis of growing *Melia volkensii* for income generation to facilitate the individual farmers or tree growers to make informed decision.

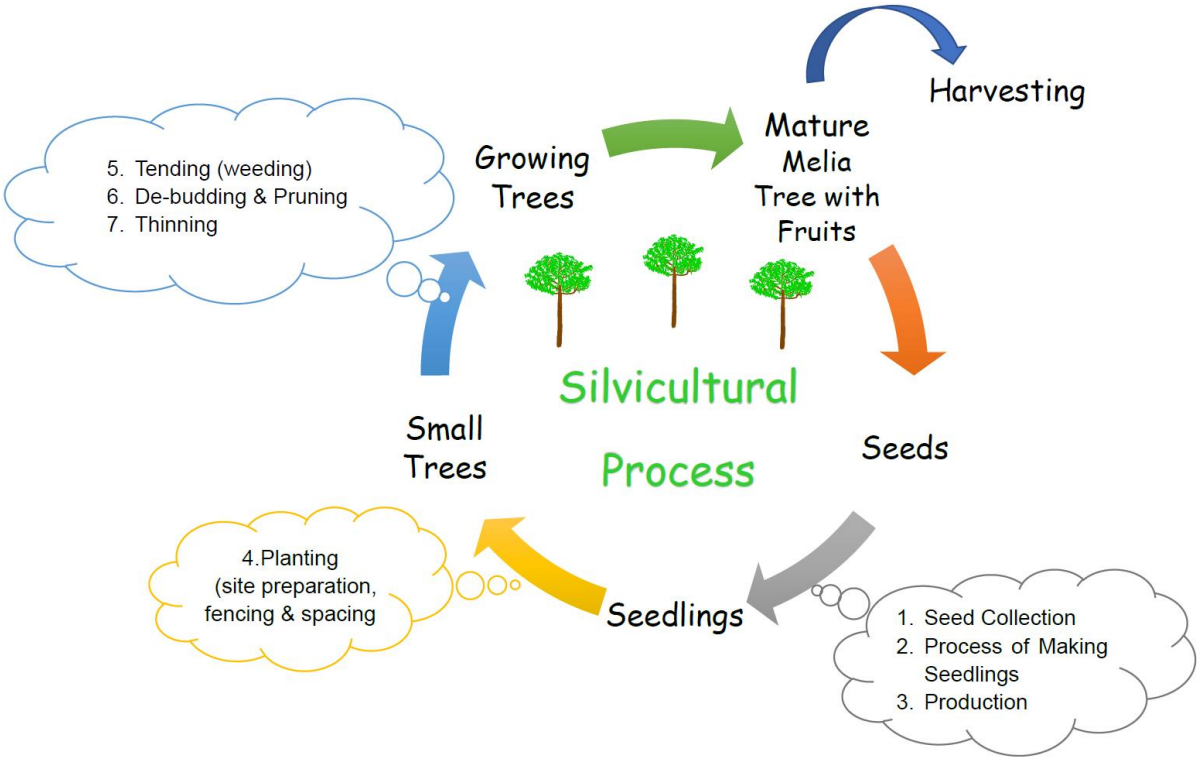

Figure 2: Silvicultural process of growing *Melia volkensii*

CHAPTER 2: COLLECTION AND PROCESSING OF MELIA SEED

2.1 Collection of *Melia volkensii* fruits

Melia fruits should be collected from the tree crown when they are ripe. While yellowish in colour, fruits may be mature but not ready for collection until they have developed brown patches (Plate 2*a*and*b*). Collection is done from the crown by either hand-picking, use of looping shears to cut branchlets bearing ripe fruits or shaking with a Y-forked stick. Fruits that fall on shaking should be sorted to remove: over-mature fruits that are blackish; immature fruits that are dark green; undersize fruit; and fruits that show sign of rotting (Plate 2*c*). Naturally fallen Melia fruits should be avoided as they are either immature or infested. During fruit collection, they should be put in bags which are not air-tight to avoid damaging the seeds. The fruits are temporarily stored under shade before being transported for processing.

Plate 2: *Melia volkensii* fruits at different stages of maturity (a) Mature but not ripe, (b) Ripe and ready for collection (c) Over ripe (photo of KEFRI/JICA)

2.2 Seed Processing

2.2.1 De-pulping

Immediately after harvesting, Melia fruits are de-pulped using a mortar and pestle (Plate 3*a*). Alternatively, de-pulping can be done by placing an individual fruit on a piece of timber or stone and hitting with a plank of wood (Plate3*b*). The nuts are then washed thoroughly, and sun dried for at least two days. Seven kilograms of fruits yield about one kilogram of clean nuts.

2.2.2Seed extraction and packaging

Melia seeds are extracted from nuts using either a Melia nut cracker (Plate 4*a*) or a knife and wooden plank (Plate 4*b*). Melia nut cracker is a tool developed by KEFRI and has adjustable mechanism for cracking nuts of different sizes. When a knife and wooden plank are used in extracting seed, the nut is placed in a groove carved out on of the plank of wood. Different sizes of grooves may be made on one plank of wood to accommodate nuts of different sizes. The nut is placed in the groove and a cut is made at right angle i.e. perpendicular to the nut length, slightly off centre near the blunt end of the nut. Seeds extracted from freshly de-pulped ripe fruits are brown while those extracted from old de-pulped nuts are black (Plate 5).

Plate 3: **De-pulping of *Melia volkensii*fruits using: (a) Mortar and pestle (b) A wooden plank and a stone**(photos of (a) KEFRI/JICA, (b) CADEP-SFM/JICA)

Plate 4*:* Extraction of Melia seeds from nuts using: (a) Melia nut-cracker and (b) wood plank and knife (photos of (a) KEFRI/JICA, (b) CADEP-SFM/JICA)

Plate 5*: Melia volkensii* seeds after 4(a) & (b)(photo of CADEP-SFM/JICA)

It is recommended that extracted seeds are sown immediately. It is therefore advisable to extract seeds only by order so that any extracted seeds are packed and dispatched without delay. The seed should be used within one month to avoid loss of viability.

CHAPTER 3: RAISING OF MELIASEEDLINGS

Activities involved in raising of Melia seedlings include: locating and preparation of a nursery; seed pre-treatment and sowing; potting and pricking out; and management of the seedlings in the nursery including protecting the seedlings from pests and diseases.

3.1 Nursery location

The size of the nursery will depend on number of Melia seedlings being raised. It is important that the site selected for the nursery has adequate land to raise the number of Melia seedlings required and for future expansion. Generally, the nursery should be sited in an accessible open space that is well protected and secure from animals. A reliable water supply is a prerequisite. The topography should preferably slope gently to allow for drainage since Melia cannot withstand water-logging conditions.

3.2 Nursery seedbeds

Melia seed should be sown in a seedbed filled with sterilised river sand. The sand can be sterilised by drenching it using 450 ml of *JIK* in20 litres of water and sprayed with a fungicide. Melia is best sown in raised seedbeds covered by clear polythene sheet. A non-mist propagator can also serve as a suitable substitute. A non-mist propagator consists of a simple frame of timber covered with clear polythene sheet (Plate 6).

Plate 6*:* Non-mist propagators for Melia seed sowing (photo of CADEP-SFM/JICA)

The propagator is filled with the clean river sand to a depth of 15-20 cm and its lid closed to avoid contamination. Small propagators can also be improvised using perforated washing basins covered with polyethylene sheet and tightly wrapped with rubber-band to hold the sheet in place. Tunnels can also be used (Plate 7)

Plate 7: Seeds sown in tunnel under plastic sheet
(photo of BGF)

3.3 Seed pre-treatment

To break dormancy and improve germination (Figure 3), *Melia volkensii* seeds are pre-treated as follows (Figure 4):

Step 1: Nipping the seeds by breaking the sharp tip of the seed between the fingers

Step 2: Soaking the seeds in cold water for 12 to 24 hours

Step 3: Slitting the seeds coat longitudinally

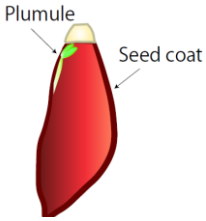

Figure 3: Seed of *Melia volkensii*

As Melia seeds are very sensitive to fungal attack, it is important to maintain a clean sterile environment during the pre-treatment process. Slitting is achieved by cutting the seed coat longitudinally from the tip that was nipped downward to the other end with a clean sterile sharp blade taking care not to injure the radicle and endosperm.

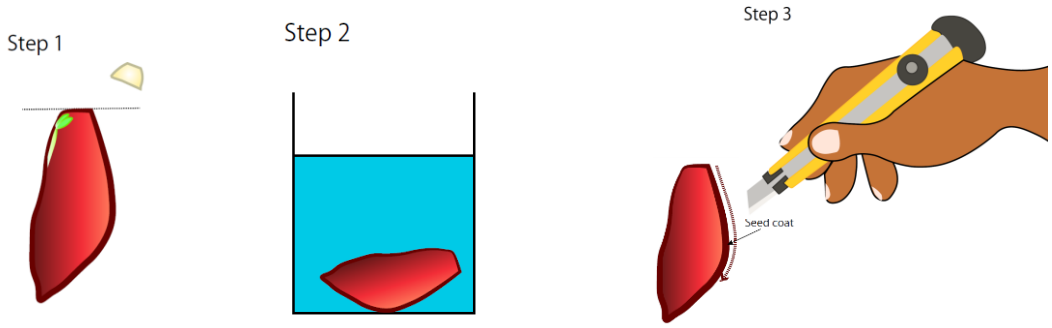

Figure 4: Steps of Seed pre-treatment of *Melia volkensii*

3.4 Seed sowing

Sowing in the seed-bed is done immediately after slitting the seed coat. The pre-treated seeds are spread on clean river sand that has been thoroughly watered and covered with a layer of sand equal to double the thickness of the seed. After sowing, the seedbed is drenched with suitable fungicide. The propagator is closed tightly to ensure that the chamber inside the seed-bed remains humid. The months of June, July and the rainy seasons are not favourable for Melia germination due to low temperatures. Germination of Melia seeds occurs within 3 - 6 days (Plate 8).

Plate 8*: Melia volkensii* seedlings germinated in non-mist propagator(photo of KEFRI)

3.5 Potting and pricking out

Suitable potting media consists of a well-drained mixture of soil, sand and manure in the ratio of 3:1:1. The media is filled into seedlings containers and watered thoroughly. The recommended pricking out (transfer of germinated seedlings to the planting containers) time is 1-3 days after germination. Delayed pricking out of seedlings may cause high mortality and deformed seedlings.

Plate 9: **Young Melia seedling from natural gemination in discarded sand** (right)(photo of BGF).

3.6 Management of *Melia volkensii* seedlings in the nursery

3.6.1 Shading young seedlings

At the time of removing the young seedlings from the seedbed, they are tender and may suffer desiccation and mortality if exposed to direct sunlight. They should be shaded with a shade net or any other suitable material. Initially, a heavy shade (70%) is recommended within the first two weeks. This shall be reduced for 4 weeks after which the seedlings shade should be removed completely. During the rainy season, seedlings should be covered to avoid water-logging that could lead to fungal attack.

Seedlings can also be put in a tunnel during the first 2-3 weeks to protect them against cold spells at night (Plate 10). Tunnels are opened during the day and closed at night to observe right temperature and moisture levels.

Plate 10: Seedlings in their first stages after pricking out, protected by plastic tunnels and also shade-netting (photos of BGF)

3.6.2 Watering

Melia seedlings are sensitive to water-logging and therefore, they should be watered only when the potting media is dry. It is good to water seedlings using a watering can or something with small watering holes to reduce the power of water drops which may cause soil erosion and damage the young tender seedlings. The soil should be maintained moist by giving adequate amount of water. Watering of seedlings should be done either early morning or late afternoon. (Figure 5)

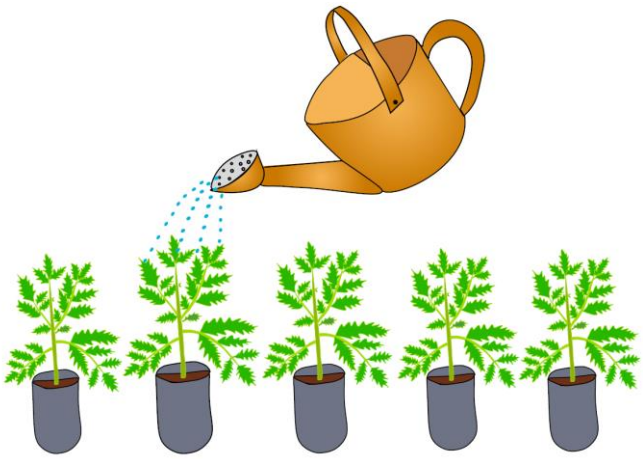

Figure 5: Watering seedlings

3.6.3 Root pruning and hardening-off

Root pruning refers to cutting of roots that extend from the potting container to the ground which is confirmed by seedlings sticking on the ground. Root pruning can be achieved either by lifting them off the ground, systematic transfer of seedlings, or cutting any roots that have penetrated the ground with a clean sharp knife (Figure 6).

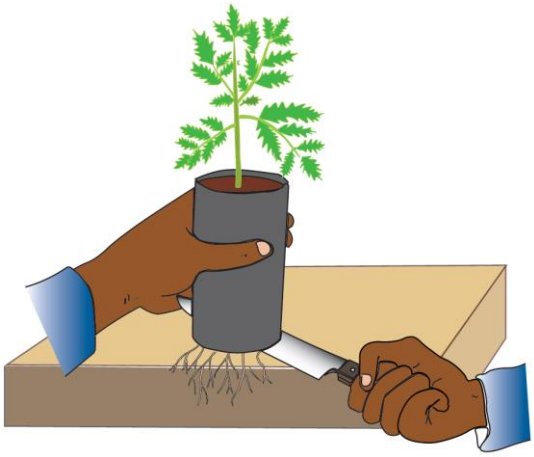

Figure 6: Root pruning using a clean knife

Melia seedlings develop a carrot-like root which is full of nutrients and oils to allow them to survive dry circumstances (Plate 11).

Hardening-off is the gradual exposure of seedlings to field conditions just before out-planting. This is achieved by reducing the watering frequency and exposing the seedlings to full sunlight. Seedlings are ready for field planting when they are at least 30 cm tall.

Plate 11: Melia's carrot-like root, in this case deformed because of hitting the bottom of the polybag (photos of BGF)

Plate 12: Hardening-off of seedlings in full sunlight, and areal root pruning (open ended poly-bags or sleeves)
(photo of BGF)

CHAPTER 4: DISEASES AND PEST MANAGEMENT IN THE NURSERY

Early and prompt monitoring of diseases and pests is important to avoid their spread in the nurseries and in the field.

4.1 Diseases of *Melia volkensii* seedlings

Diseases of *Melia volkensii* seedlings in the nursery are caused by fungi mainly *Fusarium* spp(Plate 13a). Fungal attack causes seed rot(Plate12*b*), root rot (Plate 13*c*) and eventually no germination or death. Depending on severity of the attack, impacts vary from losses of just a few seedlings to 100% seedling loss. Melia seedlings are also affected by powdery mildews which attack the surface of leaves and interfere with photosynthesis resulting in yellowing and stunted growth of seedlings.

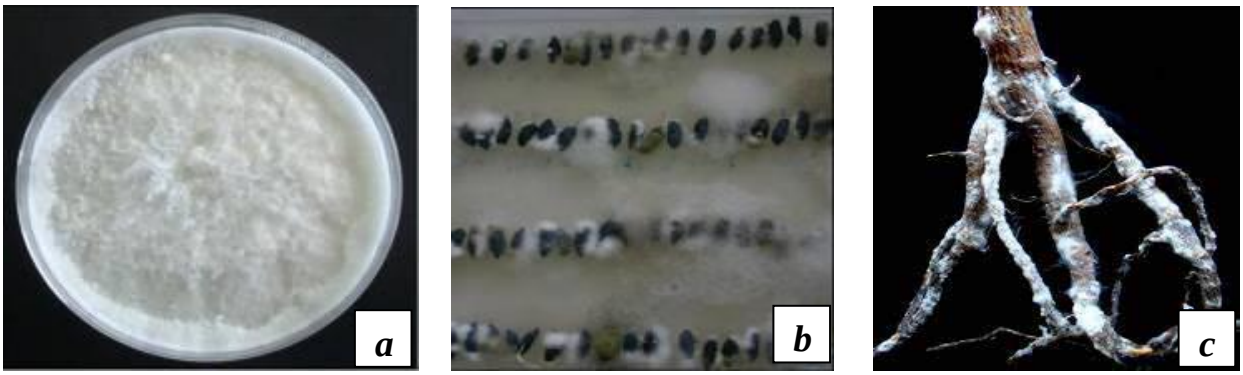

Plate 13:(a) Fusarium spp, (b) Seed rot and (c) root rot

4.2 Pest problems associated with Melia *volkensii* seedlings

Nematode attack in Melia nurseries is often characterized by soft rot of roots and root-collar rot, yellowing and death of seedlings mainly due to over-watering. Other pests that attack Melia seedlings are spider mites(Plate14). Mites suck sap from the leaves of Melia seedlings which turn yellowish grey or whitish grey and sometimes cause death. Mite infections are favoured by hot and dry weather.

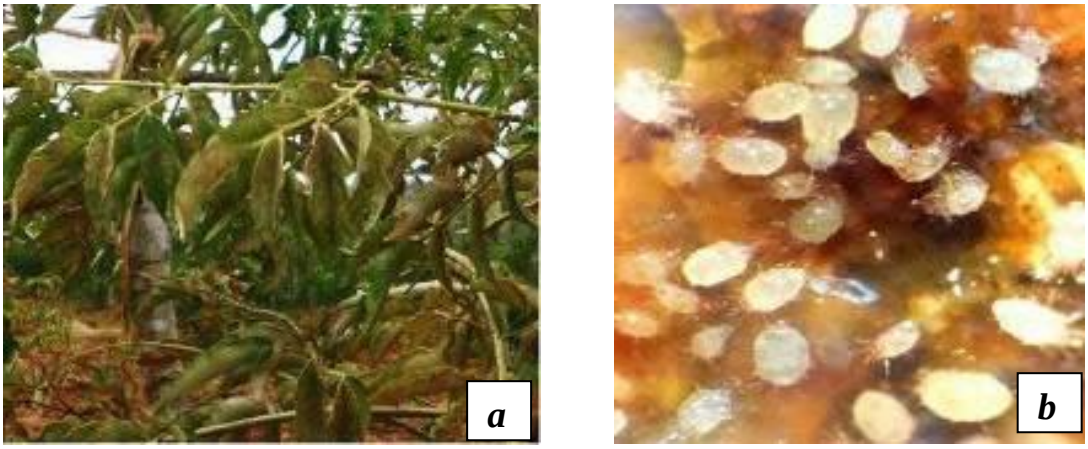

Plate 14:Red spider mite infection on: (a) *Melia volkensii* leaves and (b) rotten *Melia* seedling

4.3 Managing nematodes in the Melia nursery

In the nursery, the following steps should be undertaken to reduce or prevent serious incidences of attack;

- Sterilize nursery media by subjecting it to high temperatures (over 70^{o}C). Allow the soil to cool before it is used for sowing of seeds
- Fumigate soils infected by nematodes by covering it with black polythene and leave it undisturbed for 2 months. Alternatively, drench the soils with nematicides twice or thrice before planting
- Add nematicide powder such as *Nemacur* or *Mocap* to nursery pots during the transplanting of seedlings
- Avoid over-watering of *Melia volkensii* seedlings

4.4 Managing spider mites on Melia seedlings

In managing spider mites the following steps can be undertaken;

- Spray seedlings with termiticide or acaricide at 10 to 14-day intervals until thermite population goes down
- Spray a solution of wettable Sulphur (cheap and non-toxic to humans)
- Change the chemicals used after about 4 sprays to avoid the mite developing resistance

4.5 General management of pests and diseases in *Melia volkensii* seedlings production

The following steps can be used in order to reduce incidence of pests and diseases;

- Pre-soak Melia seed in fungicide solutions for 12 - 24 hours before sowing using fungicides
- Pre-treat the nipped seeds first with dilute *JIK* before sowing and thereafter spray them every 14 days during the first month.
- Spray with systemic fungicide Ridomil (active ingredient Mancozeb and Metalaxyl) against blights.
- Control mildews by spraying with Copperoxychloride or Agrocop 50 wp (Copper based fungicides)45g/20L of water at intervals of 21 days until the mildew clears
- As a rule of thumb, plant only healthy seedlings and avoid seedlings from areas of infestation

CHAPTER 5: Management of Melia plantations

5.1 Selection of planting site

An appropriate site for *Melia volkensii* planting should be gently sloping such that no water logging can take place. The species requires well drained soils that are either sandy, sandy loam or sandy clay. The tree is fast growing and therefore requires soils with high plant nutrients. Rocky and poor sites should be avoided. For the purpose of management, the sites should be accessible to facilitate the implementation of the various silvicultural operations such as the site preparation, delivery of seedlings, planting, weeding, de-budding, pruning, thinning and harvesting of the trees.

5.2 Preparation of planting site

Most sites in the dry lands are normally underlain by a hardpan that may interfere with the survival and growth of out-planted seedlings. For Melia, the hardpan limitation is mitigated by deep-ripping the site to break the hardpan. Deep ripping is also effective as an integral part of complete weeding of the site before out planting the seedlings, as it improves water infiltration and reduces early root growth resistance. The uprooted shrubs and bushes may be used as dead fence to protect young seedlings.

5.3 Methods of site preparation

Site preparation can be done in patches (spot hoeing), strips or through complete cultivation. Strip cultivation is practiced where some natural vegetation is to be conserved especially on sloping ground to prevent soil movement; it involves clearing strips 1-3m wide along the contours and spaced at 10 to 30 m depending on the objective of the management. Bushes are cleared along strips followed by ploughing depending on the site conditions. In areas where complete or strip cultivation is not possible, spot hoeing should be done.

The site preparation can be carried out manually or mechanically. The manual preparation involves use of machetes to clear the bushes and shrubs, and hoes to dig out their stumps. After bush clearing, the site is tilled manually by hoe to loosen the soil ready for planting. However, this is time consuming and is only possible for a small-scale planting program. Alternatively, it may be done mechanically using oxen ploughs, tractors and earth moving equipment (bulldozers, excavators). The latter require heavy capital outlay and are applicable in large-scale plantings though they are more appropriate than the others because they enhance the breaking of the hardpan and deep sub-soiling which greatly improves survival and growth of seedlings.

5.4 Fencing

The selected site should therefore be fenced to protect the young seedlings from browsing animals. Donkeys, goats and cows are known to de-bark melia trees and hence it is recommended that the fence should be maintained throughout the life of the plantation/woodlot (Plate 15).

Plate 15: A 10-year-old Melia plantation in Tiva with dead dry branches fence in the background

Plate 16: Young Melia seedling (the white stick in the middle) protected by a fence. But it is still completely debarked by goats.(photo of BGF)

5.5 Spacing

Tentatively, *Melia volkensii* should be planted at a spacing of 5m by 5m thus giving a stock density of 400 trees per hectare (Figure 7*a*). However, at this density canopy closes at around 6-7 years necessitating thinning operation to commence.

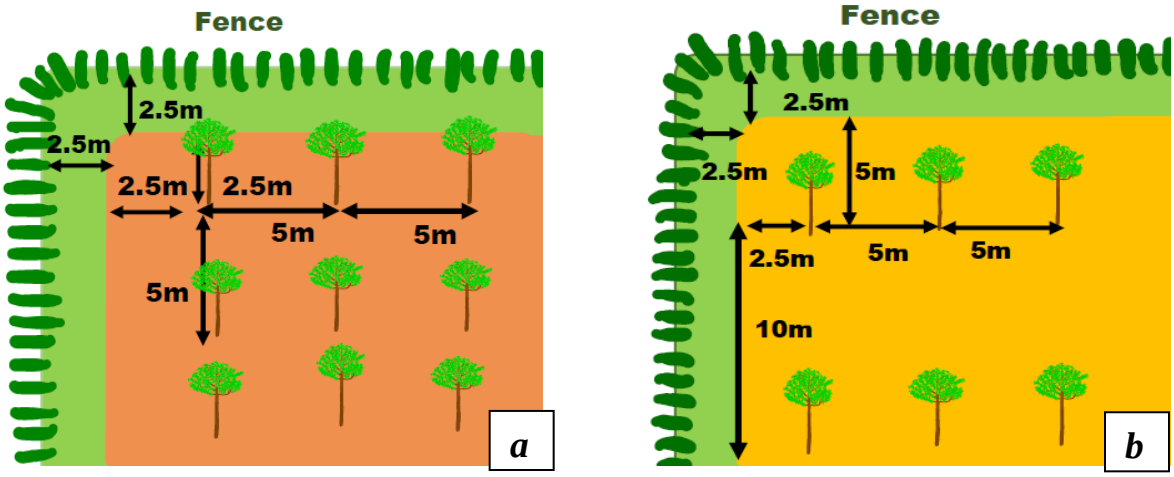

Figure 7: Diagrammatic spacing of Melia plantation at *(a)* 5m by 5m and *(b)* 10m by 5m

Farmers interested in intercropping Melia with legumes or short period crops such as the green gram and cow peas, a spacing of 10m between rows and 5m between trees can be adopted resulting in 200 trees per hectare (this is 80t trees per acre) (Figure 7*b*). The intercropping is beneficial to trees for they are clean-weeded until harvesting.

Spacing can also be influenced by lopping off branches to provide dry season fodder for livestock, as repeatedly lopped trees tend to grow a narrow canopy of columnar shape, which is more conducive to smaller spacings and hence more trees per hectare (Plate 17). In such case, a density of 200 trees/ha will not negatively influence the formation of a DBH of 40-45cm at maturity.

Plate 17: Melia tree where branches have been regularly lopped off. It provides dry season fodder to livestock, resulting in a narrow canopy with more columnar shape, with a diameter of about 4m, hence requiring a growing spacing of about 13m^2.(photo of BGF)

Plate 18: Melia tree with free growing canopy.It reaches a diameter of at least 9m, hence requiring a growing space of about 64m^2.(photo of BGF)

5.6 Planting

The process of planting starts with staking out the prepared site at the selected spacing and digging out the holes. The purpose of digging the planting hole is to make the soil softer so that the roots of melia can easily penetrate into the soil and the loose soil can hold and retain more moisture. These planting holes should be prepared during the dry season and be at least 45cm by45cm by 45cm in size. Larger pits are however advantageous during the initial stages of tree growth as they collect and store more rain water and make it available to the growing seedling for a longer period. During the digging of the pit, the top soil should be put on one side, and the subsoil on the opposite side (Plate 19*a*).

After attaining the required depth of the pit, the top soil should be used to refill it first and top it up with the subsoil (Plate 19*b*) to the ground level. If manure is available, this should be mixed with subsoil and used to refill the pit. This enhances the amount of plant nutrients available to the seedling directly to the roots. Once the hole has been refilled, the stake should be returned at the centre of the pit.

Plate 19:The pitting process: (*a*) Digging up the pit and (*b*) refilling the pit

The above process is shown diagrammatically in Figure 11;

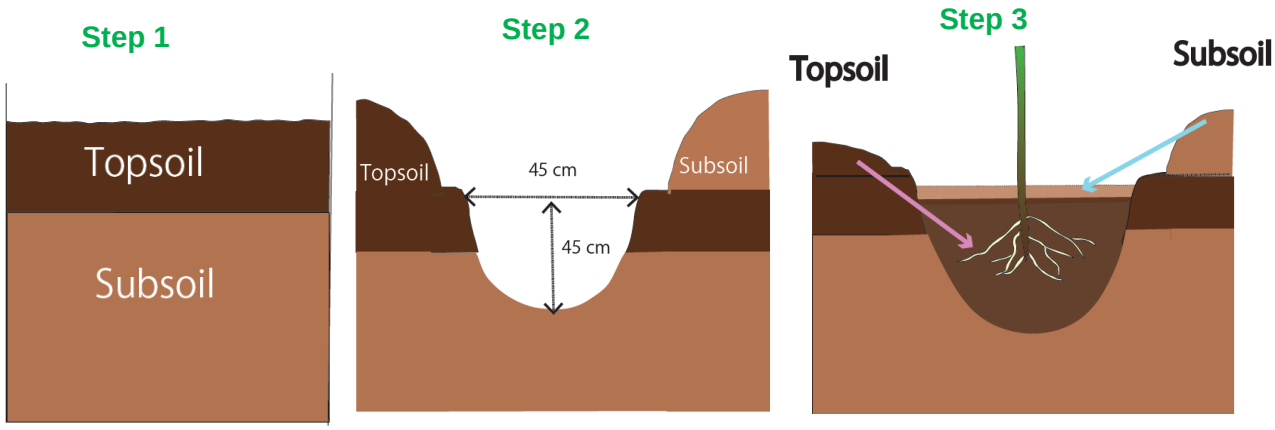

Figure 8. Demonstration of the preparation of the planting holes

Transplanting of the seedlings in the field should be as early in the rains as possible, but not before adequate moisture build-up has taken place (this is determined by squeezing the soil into clumps without disintegrating one day after a rain incidence). Early planting ensures the seedlings experience a prolonged wet season for proper establishment and initial growth.

During planting, the seedling container is removed at the pit by slitting one side from the top to the bottom. The root plug (the mass of roots and the soil) should not be broken during the removal of the container. However, once the seedling is placed in the pit, the root plug should be gently

squeezed to loosen the soil and to ensure water moves freely into the root plug of the planted seedling.

Root collar of the seedling should be maintained at the ground level while the roots are maintained in a downward position without bending them. The top soil is returned into the small pit and squeezed firmly by hand initially and then by foot while holding the seedling in an upright position. The firm contact of the soil particles and the root hairs enhances the uptake of nutrients and moisture from the soil.

Figure9: After firming soil by hand, squeeze it more by foot

In the dry areas, water is the major limiting factor. It may therefore be necessary to construct water harvesting structures to enhance survival and rapid early growth following cessation of the rains. Due to the sensitivity of melia seedlings to even temporary water logging conditions, seedlings can only be planted on the downward side of the structure, approximately 15 to 20cm outside the barrier (Plate 20).

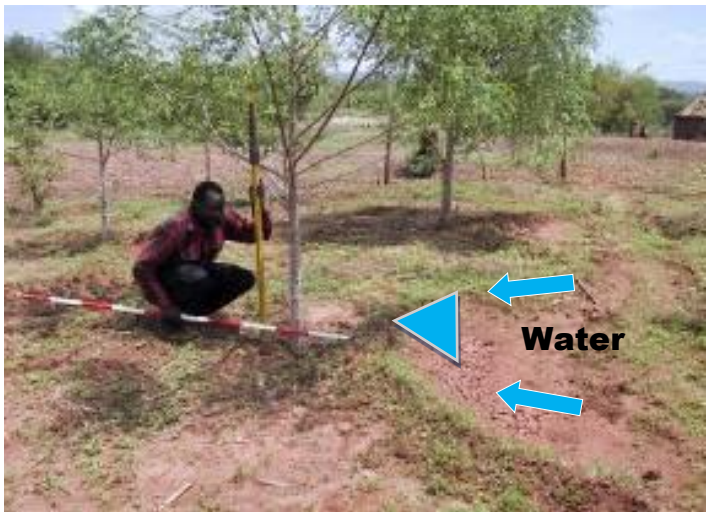

Plate 20:Water micro-catchment with the tree behind the pit

Melia seedlings should not be planted inside the water harvesting structures, including in those areas receiving very limited amount of rainfall. On sloping ground, farmers are encouraged to make soil conservation structures ("fanya-chini" terraces) along the contours spaced appropriately.

If possible, the soil to fill the pit can be mixed with manure (fertilizer), ashes (lots of Potassium for drought resistance) or charcoal dust (fixing humidity), in a ratio of soil: manure: ashes: charcoal dust of 6:2:1:1.

Plate 21: Melia seedlings planted at the coast (Lamu County). Some 6 months old. Spacing 3x3m. Having been sprayed with glyphosate before planting, grass and weeds are sprouting back. (photo of BGF)

5.7 Tending

Melia is sensitive to both vegetative competition and water logging conditions, especially during the early stages of its development. It is therefore recommended that the planted seedlings be clean weeded as this encourages fast growth. However, the weeding requirements vary with the site conditions, age of the trees as well as existing weed species in a given area. The annual weeding requirement shall be high if the spacing between planted seedlings is large enough to allow sufficient light to penetrate and facilitate the rapid growth of weeds.

However, in the areas where intercropping is practiced, trees are weeded alongside the food crops. In the other systems where intercropping is not practiced, seedlings should be clean weeded at least twice during the first two years; where the operations shall be carried out immediately after the short and long rains. Use of oxen ploughs to cultivate is recommended before onset of rains to create furrows that enhance infiltration. Oxen should however not plough within 0.5m of the stem to avoid damage to superficial roots. The subsequent weeding should be done towards the end of the rains to remove developing weeds. Great care should be taken to avoid breakage and injury to the young trees.

Apart from mechanical weeding, chemical weeding is possible by use of a weed killer (e.g. glyphosate) (Plate 22). Care has to be taken to avoid any spray on low hanging leaves, as they will also absorb the chemical and get affected.

Plate 22:Seven-years-old Melia plantation in Kitui County, showing the result of regular spraying with glyphosate in a 2m wide strip alongside the tree lines. At this stage, the trees do not need the spraying anymore, because of canopy closure that naturally suppresses the weeds and grasses. (photo of BGF)

If there is low survival of the planted seedlings due to unreliable weather conditions or any other cause, it is important to carry out beating-up (replanting of the dead seedlings) in the next rainy season.

5.8 De-budding

De-budding of *Melia volkensii* should only be done during the first year of planting. The tiny developing buds (Plate 23(*a)*) should be removed by hand while preserving the branchlets up to half height of the tree (Plate 23(*b)* and *(c*)). This exercise should be repeated three times during the first year, after which de-budding should be stopped. Whenever it becomes difficult to remove the buds by hand, use of secateurs is recommended.

Plate23: De-budding process: *a)* Before de-budding *b)* de-budding, and *c)* de-budded stem

Another school of thought however maintains that de-budding should not be done because the young seedling needs all the branches & leaves it can grow, to achieve high levels of photosynthesis and hence growth.

5.9 Pruning

Pruning of *Melia volkensii* should be from the second year and should be carried out after considering three factors; trees with double leaders, possession of large branches (relative to stem diameter and height, say bigger than 1") and presence of whorls. If double leaders are observed, it is recommended to remove one of them as early as possible. This is to ensure that the tree has only one main leader. Removal of branches is applied selectively, by considering their size in relation to the main stem. If the branches are of large diameter and appear to be competing with the main stem, they should be pruned irrespective of their location on the tree. Smaller branches should be left as they have little effect on the main stem.

Reduction of branches at the whorls is encouraged to leave an appropriate number that leaves the tree balanced on all sides. The branches that develop from the same position on the tree should be gradually removed. Selective pruning to remove all branches with diameters above 2.5 cm should be undertaken as appropriate until the trees attains a clear bole of at least 8m or up to age 5 years (Plate 24). Selective pruning of individual trees should be up to a maximum of two thirds of their total height.

Plate24: Properly pruned Melia to 2/3 height

Plate 25: A home-made wooden ladder fixed with ropes to the stem of a Melia tree, to help in pruning. (photo of BGF)

Pruning should be carried out just before the onset of the rains to enhance growth and healing of the wound. Pruning tools should be disinfected by use of disinfectants e.g. hydrogen peroxide every time a tree is pruned. The operation should start by making an under-side cut (Plate 26*a*) and finish with an upper side cut (Plate 26*b*) to ensure there is no tearing of the bark.

Plate 26*a*: Appropriate pruning method-start with an underside cut

Plate 26*b*: Appropriate pruning method-finish off with an upper cut

Pruning should be carried out just before the onset of the rains to enhance growth and healing of the wound. Pruning tools should be disinfected by use of disinfectants e.g. hydrogen peroxide every time a tree is pruned. The operation should start by making an under-side cut (Plate25*a*) and finish with an upper side cut (Plate25*b*) to ensure there is no tearing of the bark.

Over pruning a tree will result in production of epicormics shoots that have to be removed again and will stimulate the tree to grow more branches higher up the stem, where less pruning takes

place because it is more difficult to attain. Lots of times this results in trees with a clean bole of 3m high and a dense canopy, while the potential length of the clean bole could be 5-6m. This results in a serious financial loss for the grower. In particularly good sites, a clean bole of 7-8m length can be achieved. Most pruning is achieved by year 4, and it is important to prune high up the stem, using a ladder.

Plate 27: Support to over-pruned *Melia* trees

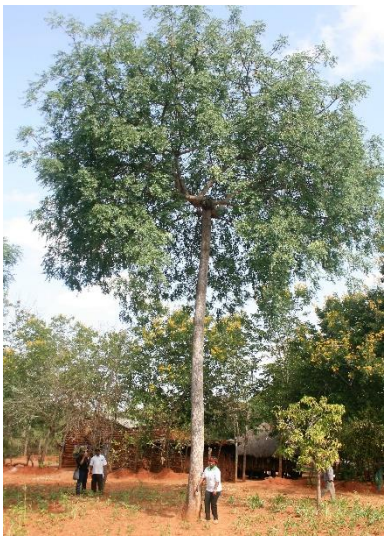

Plate 28: The potential of Melia tree: a 12-years-old tree with a DBH of 30cm and a clean straight bole of 8.2m long (Kitui County). This is because of proper tending & pruning (and good genetic quality). (photo of BGF)

Plate 29: Agroforestry lay-out: no thinning required (photo of Jan Vandenabeele)

Plate 30: Plantation: thinning required. Clean bole up to 5m (photos of BGF)

5.10 Thinning

The main objective of thinning is to enhance the growth of the remaining trees for optimum production of timber. The first thinning should be carried out at 6-7 years by removing 25% of the original planting density of 400 to leave 300 stems/ha in relatively good sites. The 2nd thinning should be carried out when canopy closes, approximately three (3) years after the first thinning. The second thinning thus reduces the tree density from 300 to 200 stems per hectare. During the thinning operation, the dead, weak, diseased, deformed or crooked trees should be removed. If the target number of trees to be removed is not met, then remove the small sized and heavily branched trees. In relatively poor sites, the thinning operation may be delayed as the trees grow slowly before canopy closure.

Plate 31:A *Melia volkensii* woodlot showing canopy closure due for thinning

In situations where the criterion applied above does not attain the required density, the remaining trees should be removed in such a way that the trees left are uniformly distributed in the plantation. The removed materials can be utilized as poles and firewood or timber depending on their size.

The best season for thinning operation is the dry seasons when the trees are not growing actively. This period is also the off-farm season and easy to get human resources for the operation.

5.10.1 Types of thinning

There are several types of thinning operations that could be employed during the operation. These include:

a). Qualitative thinning

During this thinning operation, trees with unfavorable characteristics such as the dead, weak, diseased, deformed or crooked trees are removed; this is the first option to be taken in thinning operation. It is recommended to classify the standing trees according to a criterion such as good, fair and inferior before starting the thinning operation and mark those trees to be removed(Figure 10). The thinning operation becomes easy to implement for the operators. In case the tree spacing after the theoretical removal of the marked trees is considered as very large, some marked trees can be left standing even though their characteristics are not very good. In many situations, the desired numbers of trees cannot be achieved with this eliminative operation. After qualitative thinning operation, the stocking density should be assessed and if the number of trees is too high to create sufficient spaces for remaining trees, some good trees should be removed in order to achieve the target stocking density in such a way that the trees left are uniformly distributed in the plantation.

Figure 10: Example of tree classification in thinning (G=good, F=fair, I=inferior, D=deformed, S=substituted tree for proper spacing)

b). Quantitative thinning

In quantitative thinning, the operation will be conducted based on the pre-determined standing density or the number of trees to be left. In many cases, selection of the trees to be removed will be done mechanically without considering the quality of trees. Some inferior trees might be retained (Figure 11a). Alternatively, thinning may involve the removal of every other row of trees (Figure 11b). However, this will not require expertise during tree selection and will reduce the cost for the survey in tree selection. Marking of trees might still be necessary so as to ease the cutting operation.

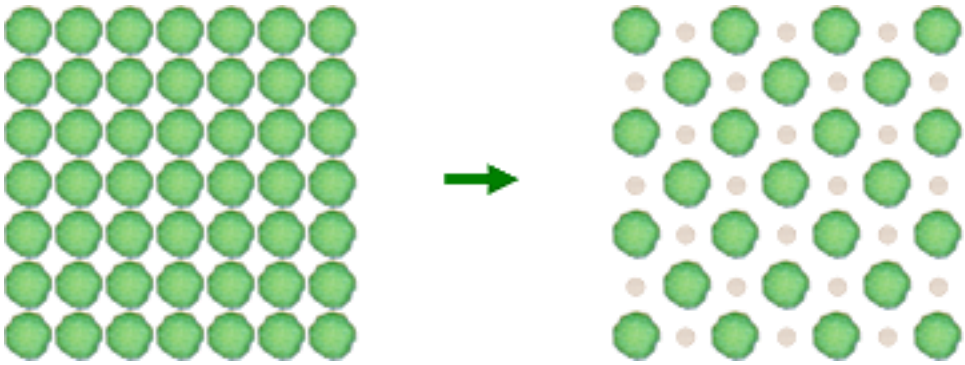

Figure 11:(a) Reducing stock density by removing intermediate trees

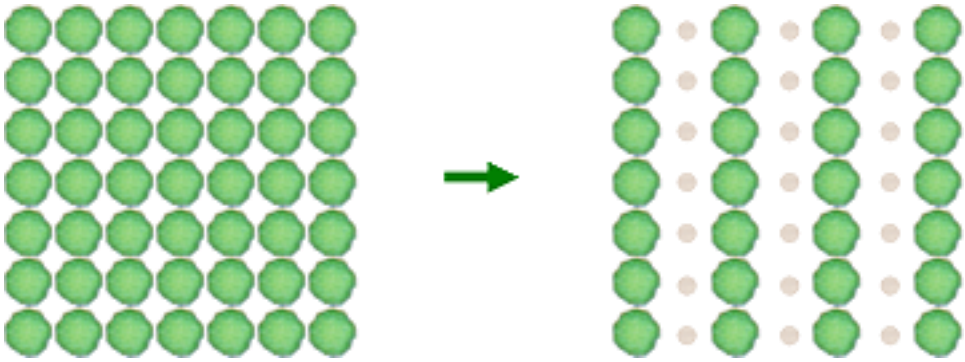

Figure 11:(b) Reducing stock density by removing alternate rows of trees

Under no circumstance should the contractor buying the thinned material be allowed to carry out thinning without proper supervision. This can only be done where trees to be thinned are clearly marked and these are the only trees to be cut.

5.11 Harvesting

It is advisable that when the planted trees attain a diameter at breast height (DBH) of at least 30 cm, the trees can be harvested and sold at a competitive price. In sites with moderately poor soil conditions and very low rainfall, it may take around 18 years to reach such diameters. However, the same diameters can be attained earlier in sites that have more favourable conditions and with better management practices. Generally, it is recommended to harvest *Melia volkensii*trees from the age of twelve (12) years because wood properties for timber do not change significantly with age after this.

From a sawmilling point of view, bigger diameters like 40-50cm are more advantageous, and will produce planks of bigger sizes, that command a premium price. On a good site, these diameters will be achieved after 15-20 years.

5.12 Pests and diseases of mature *Melia volkensii*

Melia volkensii trees have few significant pest and diseases in the plantations. However, there are reported cases of cankers, mites and fungal attack on the main stems. Cases of root rot have also been observed in the field, and they seem to be stimulated by stress conditions (extended periods of drought, unfertile soils). While there may be no known remedies to these cases, any cases of pests and diseases should immediately be reported to the nearest forest office. Old trees of 20 years and above are susceptible to the disease which affects heart wood and hence the quality of timber. Unfortunately, there is no economically feasible fungicide to use on a heart rot hosting tree. The best way to prevent heart rot is to keep your tree healthy using proper management techniques such as:

1. Minimize pruning wounds that expose large areas of wood.
2. Prune trees at an early age such that no major branch will be removed later.
3. Remove broken branch stubs immediately they are noticed.
4. Have trees in a plantation checked regularly by a forester to ensure infected trees are removed early when they still have sound timber that can be utilised.

Chapter 6 Cost and Benefit Analysis of Growing Melia

6.1 Cost and benefit of growing *Melia volkensii*

After the maturity of the plantation, the tree grower has the option of selling the trees as round wood or converts it to timber for domestic use or sale; the option taken by the tree grower will depend largely on the capability to saw timber at the farm level. This guideline proposes intercropping the trees with various agricultural crops (mainly cow peas) to enhance growth performance of the trees, and also to enhance profitability of the tree enterprise.

The management objective is to manage *Melia volkensii* plantation with an aim of attaining a DBH of 30 cm per tree with a top height of 20 cm and a clear bole of 9 m long. For this to be attained, the plantation shall be subjected to weeding, pruning and thinning as described in these guidelines for a grower to obtain maximum benefit. The final crop is expected to be of better quality and will consequently fetch better prices than the current *Melia volkensii* logs in the market. The current farm gate price per tree is Ksh. 5,000 as compared to the expected Ksh. **8,000** from a well-managed plantation with a rotation age of 18 years. However, if the tree grower opts for the sawn timber option each tree is expected to fetch Ksh. **9,300** after deducting sawing cost. Tree growers are advised whenever possible to sell the final product as sawn timber as this wood fetch better returns. The expected revenue for the various Melia enterprise options are shown in the table below:

Plate 32: Melia timber stacked in a workshop (photo of BGF)

Table 1: Summary of revenue returns for various *Melia volkensii* enterprise options

Item/Activity	**Round wood 10x5 m**	**Timber 10x5 m**	**Round wood 5x5 m**	**Timber 5x5 m**
	Amount (ksh)	**Amount (ksh)**	**Amount (ksh)**	**Amount (ksh)**
Final crop proceeds (approx. DBH of 30 cm) -sawn timber	1,600,000	2,403,000	1,600,000	2,403,000
Gross Income	3,520,000	4,603,000	2,670,000	3,753,000
Net Income (18 years)	2,801,800	3,884,800	2,145,400	3,228,400

Table 2: Revenue calculations for a *Melia volkensii* tree

Timber Measurements	Timber pieces	Running Feet	Unit cost (Ksh)	Total (Ksh)
4”x2”x15’	2	30	75	2250.00
3”x2”x15’	10	150	50	7500.00
2”x1”x 15’	6	90	25	2250.00
Total		270		12,000.00
Cost of sawing	270 ft x Ksh. 10 per ft			2,700.00
Profit				9,300.00
Cost of *Melia volkensii* tree after deducting transport and profit for the buyer				8,000.00

Table3: *Melia volkensii* enterprise cost and benefits comparisons for different options

Item/Activity	Round wood 10x5 m	Timber 10x5 m	Round wood 5x5 m	Timber 5x5 m
	Amount (ksh)	Amount (ksh)	Amount (ksh)	Amount (ksh)
(a) Inputs -cost				
Seedling	12,000	12,000	240,00	24,000
Cow peas seeds	21,600	21,600	10,800	10,800
Pesticides (Act force, cyper force or cyper diforc)	54,000	54,000	27,000	27,000
Fertilizer (DAP)	54,000	54,000	27,000	27,000
Total cost	**141,600**	**141,600**	**88,800**	**88,800**
(b) Labour for *Melia volkensii* cost	-	-	-	-
Cutting stakes	400	400	400	400
Staking out (marking planting points)	400	400	400	400
Pitting (45cmx45cmx45cm)	1,600	1,600	3,200	3,200
Planting (Fill the planting hole to the top to ensure no water settles at the base)	400	400	400	400
Beating up (20%)	400	400	400	400
De-budding (4 times in a year for 1 years	1,600	1,600	1,600	1,600
Pruning for up to 5 years (Remove all branches with more than 1 inch diameter. Also heavy branching at the nodes should be reduced)	7,200	7,200	16,000	16,000
Slashing (year 4 to year 7)	-	-	32,000	32,000

Item/Activity	Round wood 10x5 m	Timber 10x5 m	Round wood 5x5 m	Timber 5x5 m
	Amount (ksh)	Amount (ksh)	Amount (ksh)	Amount (ksh)
1st thinning (at age 6-7 yrs)	-	-	800	800
2nd thinning (3 yrs after 1st thin)	-	-	400	400
Clear fell (Cost of Harvesting final crop at age 18 yrs)	-	-	-	-
Cost of sawing timber	-	540,000	-	540,000
Total	**12,000**	**12,000**	**55,600**	**55,600**
(c) Labour for Food crops (Cow peas) cost	-	-	-	-
Land preparation (Clearing and harrowing)	25,000	25,000	13,000	13,000
Planting	7,200	7,200	1,200	1,200
Weeding (4 times)	192,000	192,000	96,000	96,000
Grain harvesting and threshing	48,000	48,000	24,000	24,000
Total	**502,600**	**502,600**	**318,200**	**318,200**
(d) Other costs	-	-	-	-
Transportation of seedling	2,000	2,000	2,000	2,000
Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	60,000	60,000	60,000	60,000
Total cost	**62,000**	**62,000**	**62,000**	**62,000**
Total expenditure(a+b+c+d)	**718,200**	**718,200**	**524,600**	**524,600**
Benefits	-	-	-	-
Cow peas grains (6 seasons)	1,920,000	1,920,000	960,000	960,000
Sale of off cuts	-	280,000	-	10,000
Proceeds from 1st thinning (firewood or poles)	-	-	100,000	100,000
Proceeds from 2nd thinning (timber)	-	-	280,000	280,000
Final crop proceeds (approx. DBH of 30 cm) -sawn timber	1,600,000	2,403,000	1,600,000	2,403,000
Gross Income	**3,520,000**	**4,603,000**	**2,670,000**	**3,753,000**
Net Income (18 years)	**2,801,800**	**3,884,800**	**2,145,400**	**3,228,400**

**The figures in the table above are not based on any research but were generated through field visits to the Melia growing areas and interviews with timber sawyers and merchants.*

Assumptions:

1. The tree grower shall undertake the silvicultural operations, i.e. weeding, pruning and the thinning in the *Melia volkensii* plantation as per instructions.
2. The cover crop (cow peas) shall be subjected to proper agricultural practices.
3. Rainfall during the growth period, will be moderate and not extremely low.
4. The Melia stand in 10mx5m where thinning operations will not be undertaken, shall grow uniformly to maturity.

Conclusions:

1. Tree growers are advised to saw timber rather sell trees as these would earn them more.
2. The 10mx5m option is recommended for farmers who have limited land as this will allow them grow agricultural crops for a longer period before the canopy closes.
3. For commercial tree growers 5m x5m is recommended as these would give this give assurance of quality and fetch more returns from the enterprise.
4. The quality of timber in 10 m x5m is not assured as no thinning will be undertaken.

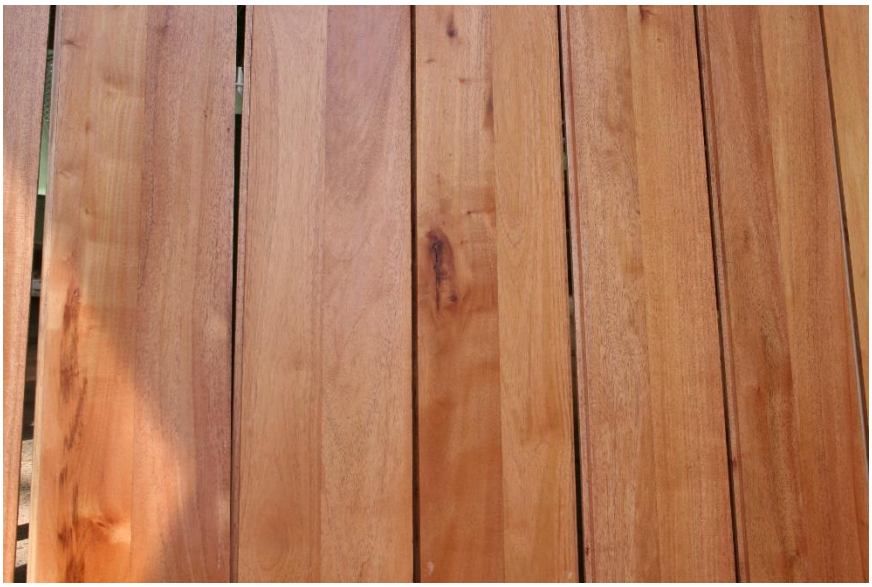

Plate 33:Flooring boards (2cm thick) made out of Melia timber (1 inch thickness), by H-Tes Ltd. Current prices for a mahogany wooden floor are 1200Ksh/m^2 (about 12 US$).(photo of BGF)

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Appendixes

Appendix 1:

(i) Cost and benefit analysis for on-farm *Melia volkensii* enterprise intercropped with cow peas 5mx5m option

Spacing: 5.0 m by 5.0 m					Area: 1 hectare		Rotation Age: 18 years															
Rainfall: >mm 400-800 mm,					Altitude; 300 -1680 m a.s.l.																	
Species: *Melia volkensii* Soil type: sandy, clay and shallow					Working cycle: sawn Timber																	
					Cost(Ksh)																	Amount
No.	Item/Activity	Unit	Qty	Unit price	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	(ksh)
a)	**Inputs**																						
	Seedling	No	480	50	24,000																		**24,000**
	Cow peas seeds	Kg	30	120	3,600	3,600	3,600																**10,800**
	Pesticides (Act force , cyper force or cyper diforc)	Lts	3	3,000	9,000	9,000	9,000																**27,000**
	Fertilizer (DAP)	50 Kg bag	3	3,000	9,000	9,000	9,000																**27,000**
	Total cost				**45,600**	**21,600**	**21,600**																**88,800**
b)	**Labour for Melia volkensii**							`															-
	Cutting stakes	mds	1	400	400																		**400**
	Staking out (marking planting points)	mds	1	400	400																		**400**
	Pitting (45cmx45cmx45cm)	mds	8	400	3,200																		**3,200**
	Planting (Fill the planting hole to the top to ensure no water settles at the base)	mds	1	400	400																		**400**
	Beating up (20%)	mds	1	400	400																		**400**
	De-budding (4 times in a year for 1 years	mds	8	400	1,600																		**1,600**
	Pruning for up to 5 years (Remove all branches with more than 1 inch diameter. Also heavy branching at the nodes should be reduced)	mds	8	400		3,200	3,200	4,800	4,800														**16,000**
	Slashing (year 4 to year 7)	mds	20	400				8,000	8,000	8,000	8,000												**32,000**
	1st thinning (at age 6-7 yrs)	mds	2	400							800												**800**
	2nd thinning (3 yrs after 1st thin)	Mds	1	400										400									**400**
	Clear fell (Harvesting final crop at age 18 yrs)	mds	0	0																			-
	Cost of sawing timber	Feet	54,000	10																		540,000	**540,000**
	Total				**6,400**	**3,200**	**3,200**	**12,800**	**12,800**	**8,000**	**8,800**	**-**	**-**	**400**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**55,600**
c)	**Labour for Food crops (Cow peas)**																						-
	Land preparation (Clearing and hallowing)	mds	1	5,000	5,000	4,000	4,000																**13,000**
	Planting	mds	3	400	1,200																		**1,200**
	Weeding (4 times)	mds	80	400	32,000	32,000	32,000																**96,000**
	Grain harvesting and threshing	mds	20	400	8,000	8,000	8,000																**24,000**
	Total				**46,200**	93,600	93,600	25,600	25,600	16,000	17,600												**318,200**
d)	**Other costs**																						-
	Transportation of seedling	Car hire	1	2,000	2,000																		**2,000**
	Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	no	1	60,000	60,000																		**60,000**
	Total cost				**62,000**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**62,000**
	Total expenditure(a+b+c+d)				**160,200**	**118,400**	**118,400**	**38,400**	**38,400**	**24,000**	**26,400**	**-**	**-**	**400**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**524,600**
e)	**Output/product**																						-
	Cow peas grains (6 seasons)	Kg	4,000	80	320,000	320,000	320,000																**960,000**
	Proceeds from 1st thinning (firewood or poles)	no	100	100							10000												**10,000**
	Proceeds from 2nd thinning (timber)	no	100	1,000										100,000									**100,000**
	Sale of offcuts	no	1,600	150										40,000								240,000	**280,000**
	Final crop proceeds -sawn timber (200 trees)	Feet	54,000	45	-																	2,403,000	**2,403,000**
	Gross Income				**320,000**	**320,000**	**320,000**	-	-	-	**10,000**	**-**	**-**	**140,000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2,643,000**	**3,753,000**
	Net Income (18 years)				**159,800**	**201,600**	**201,600**	**(38,400)**	**(38,400)**	**(24,000)**	**(16,400)**	**-**	**-**	**139,600**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2,643,000**	**3,228,400**

(ii) Cost benefit analysis for on-farm *Melia volkensii* enterprise intercropped with cow peas – 10mx5m option

Spacing: 10.0 m by 5.0 m					Area: 1hactare		Rotation Age: 18 years															
Rainfall: >mm 400-800 mm,					Altitude; 300 -1680 m a.s.l.																	
Species: *Melia volkensii* Soil type: sandy, clay and shallow					Working cycle: sawn Timber																	
					Cost(Ksh)																	
No.	**Item/Activity**	**Unit**	**Qty**	**Unit price**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**	**Y11**	**Y12**	**Y13**	**Y14**	**Y15**	**Y16**	**Y17**	**Y18**	**Amount (ksh)**
a)	**Inputs**																						
	Seedling	No	240	50	12,000																		**12,000**
	Cow peas seeds	Kg	30	120	3,600	3,600	3,600	3,600	3,600	3,600													**21,600**
	Pesticides (Act force , cyper force or cyper diforc)	Lts	3	3,000	9,000	9,000	9,000	9,000	9,000	9,000													**54,000**
	Fertilizer (DAP)	50 Kg bag	3	3,000	9,000	9,000	9,000	9,000	9,000	9,000													**54,000**
	Total cost				**33,600**	**21,600**	**21,600**	**21,600**	**21,600**	**21,600**													**141,600**
b)	**Labour for Melia volkensii**							`															**-**
	Cutting stakes	mds	1	400	400																		**400**
	Staking out (marking planting points)	mds	1	400	400																		**400**
	Pitting (45cmx45cmx45cm)	mds	4	400	1,600																		**1,600**
	Planting (Fill the planting hole to the top to ensure no water settles at the base)	mds	1	400	400																		**400**
	Beating up (20%)	mds	1	400	400																		**400**
	De-budding (4 times in a year for 1 years	mds	8	400	1,600																		**1,600**
	Pruning for up to 5 years (Remove all branches with more than 1 inch diameter. Also heavy branching at the nodes should be reduced)	mds	4	400		1,600	1,600	2,000	2,000														**7,200**
	Slashing (year 4 to year 7)	mds	20	400																			**-**
	1st thinning (at age 6-7 yrs)	mds	2	400																			**-**
	2nd thinning (3 yrs after 1st thin)	Mds	1	400																			**-**
	Clear fell (Cost of Harvesting final crop at age 18 yrs)	mds	0	0																			**-**
	Cost of sawing timber	Feet	54,000	10																		540,000	**540,000**
	Total				**4,800**	**1,600**	**1,600**	**2,000**	**2,000**	-	-	-	-	-	-	-	-	-	-	-	-	-	**12,000**
c)	**Labour for Food crops (Cow peas)**																						**-**
	Land preparation (Clearing and hallowing)	mds	1	5,000	5,000	4,000	4,000	4,000	4,000	4,000													**25,000**
	Planting	mds	3	400	1,200	1,200	1,200	1,200	1,200	1,200													**7,200**
	Weeding (4 times)	mds	80	400	32,000	32,000	32,000	32,000	32,000	32,000													**192,000**
	Grain harvesting and threshing	mds	20	400	8,000	8,000	8,000	8,000	8,000	8,000													**48,000**
	Total				**46,200**	91,600	91,600	92,400	92,400	88,400	-												**502,600**
d	**Other costs**																						**-**
	Transportation of seedling	Car hire	1	2,000	2,000																		**2,000**
	Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	no	1	60,000	60,000																		**60,000**
	Total cost				**62,000**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**62,000**
	Total expenditure(a+b+c+d)				**146,600**	**114,800**	**114,800**	**116,000**	**116,000**	**110,000**	-	-	-	-	-	-	-	-	-	-	-	-	**718,200**
e)	**Output/product**																						**-**
	Cow peas grains (6 seasons)	Kg	4,000	80	320,000	320,000	320,000	320,000	320,000	320,000													**1,920,000**
	Sale of offcuts	no	1,600	150										40,000								240,000	**280,000**
	Final crop proceeds -sawn timber (200 trees)	Feet	54,000	45	-																	2,403,000	**2,403,000**
	Gross Income				**320,000**	**320,000**	**320,000**	**320,000**	**320,000**	**320,000**	-	-	-	**40,000**	-	-	-	-	-	-	-	**2,643,000**	**4,603,000**
	Net Income (18 years)				**173,400**	**205,200**	**205,200**	**204,000**	**204,000**	**210,000**	-	-	-	**40,000**	-	-	-	-	-	-	-	**2,643,000**	**3,884,800**

Appendix 2:

The schedule of various activities involved in raising a *Melia volkensii* plantation

Activity	Year																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Purchase of Seedling																		
Fencing																		
Land preparation (Clearing and hallowing)																		
Staking out (marking planting points)																		
Pitting of planting holes																		
Planting																		
Beating up (20%)																		
Weeding (8 times)																		
De-budding (4 times in year 1)																		
Pruning up to 5 years																		
Slashing (year 4 to year 7)																		
1st thinning (at age 6-7 yrs)																		
2nd thinning (3 yrs after 1st thin)																		
Clear fell (Harvesting final crop 10- 18 yrs)																		

The highlights indicate the timing of the activity. However, considering that harvesting may take place from age 10 years, the marking of ‘the clearfelling from 11 years may or may not take place depending on when the trees are considered mature for harvesting.