MANUAL FOR ESTABLISHING AND MANAGING *MELIA VOLKENSII* SEED ORCHARDS IN KENYA

MANUAL FOR ESTABLISHING AND MANAGING OF *MELIA VOLKENSII* SEED ORCHARDS IN KENYA

Jason G. Kariuki[1], Hisaya Miyashita[2] James K. Ndufa[1] and Bernard M. Kamondo[1]

[1]Kenya Forestry Research Institute, P. O. Box 20412 Nairobi 00200,
[2]Forest Tree Breeding Center, Forestry and Forest Products Research Institute,
3809-1 Ishi, Juo, Hitachi, Ibaraki 319-1301, Japan

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Cover Photos;
Clockwise(i) Grafted seedlings sorted for planting; (ii) and (iii) Melia trees fruiting in clonal orchard (iv) Kibwezi *M. volkensii* Clonal Orchard. (Photos by J. Kariuki)

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Foreword

Melia volkensii is a fast growing drought tolerant and termite resistant tree found only in eastern Africa. The species produces high quality timber which can be harvested in 10-15 years. Apart from its highly valuable timber, it is also a good source of fodder, hence it has a high potential for improving livelihoods of dryland rural communities. Melia is readily accepted for planting in eastern drylands of Kenya but can also do well in a number of areas in coast region. Although the acceptance of *M. volkensii* is high, actual planting is still low and its seedlings production has depended on seeds collected from general sources.

In 2012, Kenya Forestry Research Institute (KEFRI) with support from Japanese International Cooperation Agency (JICA) under the project on 'Development of Drought Tolerant Trees for Adaptation to Climate Change in Drylands of Kenya' developed and started implementing a Melia breeding strategy that constituted, among others, selection of candidate plus trees, establishment of seed orchards and progeny trials using the selected material. The breeding objective was production of fast growing trees for timber production that will be drought tolerant and adaptable to the environment that prevails in Melia growing areas and in drier sites. These activities were continued under Capacity Development Project (CADEP) from 2017 to 2021. The Kenya government and some non-governmental organizations and private sector are promoting Melia planting in the drylands.

KEFRI, with support from JICA, as part of the Melia breeding programme, has established two 11 hectare (total 22 ha) of Melia seed orchards in Kitui and Kibwezi for production of improved seed for raising quality Melia plantations in the drylands. The orchards have started yielding improved seed and this is made available to the public. However, the amount of seed required exceeds the current capacity of the orchards. Granted that, it is important that communities planting Melia only utilize improved seed, it is imperative to increase the number of orchards.

The main objective of this Manual is help seed orchard managers to understand the process and rationale of establishing Melia clonal seed orchards and also to assist in management of established seed orchards. The topics covered include plus tree selection, site selection, grafting, planting and management of the orchards. The manual will also be useful in training distributors of improved Melia seeds and seedlings for plantation development and mainstreaming Melia growing as a viable commercial economic enterprise in arid and semi-arid lands of Kenya. The manual will also be useful as a reference in establishing clonal orchards of other similar tree species.

This manual has been developed from the practices and experiences gained by KEFRI and Forestry Tree Breeding Centre (FTBC-Japan) researchers during the two phases of the project.

Joshua K Cheboiwo (PhD)

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Director, KEFRI

Tohru Nakashizuka (Toru Asano)

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Director General of FFPRI

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1. Introduction

Melia volkensii is an indigenous drought tolerant and multipurpose tree species endemic to the Arid and semi-arid areas of eastern Africa. Its common names are Melia, tree of knowledge (English); Mukau (Kamba, Tharaka and Mbeere), Tile (Boran) Boba, Mbamba (Somalia, Oromo) Maramarui (Samburu), and Kirumbutu (Taita). Melia is a deciduous tree that attains a height of 6 to 20 m and an average diameter of about 25 cm. The crown is open while the bark is grey and fairly smooth. Leaves are bright green, up to 35 cm long, compound, with 3-7 deeply lobed leaflets that are densely hairy when young. The flowers are small, white and fragrant, arranged in loose inflorescences. Mature fruits are yellow later developing brownish patches due to the deposit of cork. The fruit is an ovoid drupe 3 to 4 cm long with each fruit containing one to five seeds that are enclosed in a very hard and thick endocarp (nut). The seeds are oval, about 2 cm long and 0.5 cm wide. There are about 200 seeds per kg of nuts, with the average number of seeds per kg of extracted seed ranging from 3000 to 3,500. At the radicle end of the seed is an appendage called the caruncle.

M. volkensii occurs naturally in the semi-arid zone of Ethiopia, Somalia, Kenya and Tanzania (Figure 1) at altitudes between 100 and 1700 m, in areas with mean annual rainfall of 300-1000 mm and temperature range of 26 - 38 °C (Orwa *et al*., 2009). The species is found in deciduous bushlands in association with Acacia-Commiphora vegetation. The species grows well mostly on sandy soils, sandy loams, or sandy clay soils with good drainage.

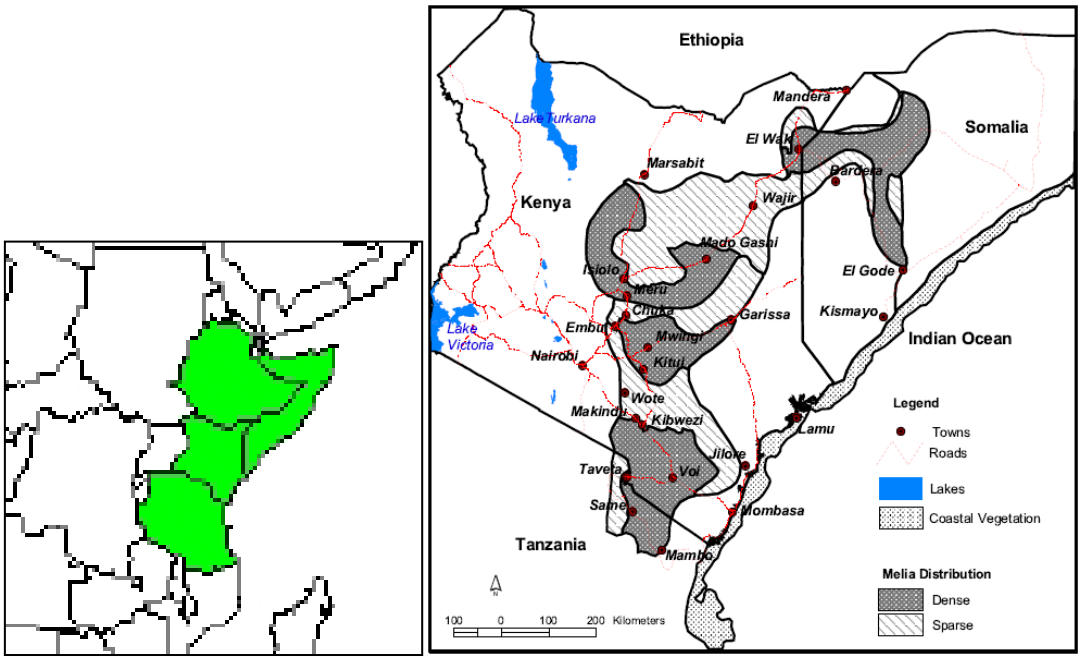

Figure 1: Distribution of *Melia volkensii* in the drylands of eastern Africa

M. volkensii is a fast growing tree species which coppices well with a rotation of 8-15 years. The species is preferred because of its high value timber used for construction and furniture. The wood is durable and termite resistant and easy to work and shape and therefore used to make log hives. Twigs, leaves and fruits are used as fodder for goats, cattle and sheep during the dry season. The species also contains compounds that are toxic to insects and aqueous extracts of the fruits are

traditionally used to control fleas and ticks.

Melia is planted around homesteads for shade and firewood. In the south eastern rangelands of Kenya, it is a common tree on cultivated and cleared lands where it is planted at 10 to 15 m spacing and pruned to avoid competition for light with the crops. Pruning is carried out during periods when other fodder sources are scarce. Because of its drought tolerance and high timber value, Melia has a great potential as a commercial tree species for farmers and investors in marginal areas.

In an effort to leverage on the species potential, Kenya Forestry Research Institute (KEFRI) with support from Japanese International Cooperation Agency (JICA) developed and implemented a Melia breeding strategy from 2012 that constituted, among others, selection of Candidate Plus Trees (CPTs), collection of scions from the CPTs, raising of grafted seedlings that were used in establishment of seed orchards. Subsequently, progeny trials were established to test the genetic worth of the selected CPTs. In this manual we share the process of and experiences gained during establishment of Melia clonal seed orchards at Kitui and Kibwezi.

2. Purpose of the Manual

This Manual for establishment and managing *Melia volkensii* seed orchards is to guide how to establish and manage Melia clonal seed orchards through documenting the process and experiences of establishing the first generation Melia seed orchards. It will assist public and private tree seed producers, forestry and orchard managers in effective establishment and management of future seed orchards. The contents of this manual include introduction to the basic principles of seed production, documentation of the selection process of candidate plus trees and criteria used, scion collection from CPTs, grafting, and field establishment of clonal seed orchards. The manual also covers aspects of management of seed orchards including monitoring, weeding, pruning, reducing pests and diseases, and seed production.

3. Basic Principles of Tree Seed Production

3.1 Tree seed quality

Tree seed quality is a measure of the potential performance of trees when the seed is planted under optimal conditions. Seed quality is determined by genetic composition, physiological and physical components. Genetic quality is determined by characteristics inherited from parents (genes). Physiological quality is determined by seed maturity, moisture content and germination ability whereas physical quality depends on seed size, colour, age, seed health, and purity. High quality seed is: Genetically improved or of selected known sources; generally having high viability; of high nursery performance and the selection and breeding process properly documented.

3.2 Types of tree seed sources

Tree seed sources are either selected from existing vegetation or are established. Seed sources from existing vegetation are general seed sources, selected single trees and selected seed stands while established seed sources are established seed stands and seed orchards.

3.2.1 General seed source and selected single trees

A population of better performing and healthy trees mostly from natural forests or in planted areas are selected and used as sources of tree seeds and designated as general seed source. If there are individuals of outstanding performance, these individuals can be selected and designated as selected single tree seed sources rather than collecting seed from the whole population.

3.2.2 Selected seed stand

This is a stand of trees that has been chosen as a site for collection of seed as a secondary purpose due to its outstanding performance. The primary purpose could have been for other end-use such as timber, pulpwood and wood fuel.

3.2.3 Established seed stands and seed orchards

These are tree stands deliberately established for production of high quality tree seed. An established seed stand is a source established from a selection of known superior sources. A seed orchard usually consists of families of superior genetic quality and is planted at regular spacing and specific design by tree breeders. Seed orchards are established using either seed as seedling seed orchards or from vegetative propagation as clonal seed orchards.

4. Selection of Melia Candidate Plus Trees (CPTs)

4.1 Delineation of selection zones

The initial step for seed orchard establishment is to identify viable populations within the species natural range in which to select CPTs. Sites known to have such populations of *Melia volkensii* were surveyed and location of potential candidate plus trees documented. Melia growing regions were divided into 13 transects (Figure 2). A transect consisted of a more or less homogenous zone with almost similar climatic conditions. Four (4) of the 13 transects i.e. Voi-Galana, Garissa-Bangale, Garbatulla-Wamba and Wamba-Marsabit are very dry areas while the rest were semi-arid areas. The trees were selected from across a latitudinal gradient from 100 m to 1400 m above sea level. Details of the transects are shown in Table 1.

4.2 Criteria for selection of individual CPTs

Once viable populations are delineated, the next step in establishing of a first generation Melia clonal seed orchard is to select superior trees from populations of the species, using predetermined criteria. For second generation orchards, planting clonal materials are sourced from specific trees selected based on results of first generation progeny tests. This is a cyclic process that can be applied for third and subsequent generation orchards.

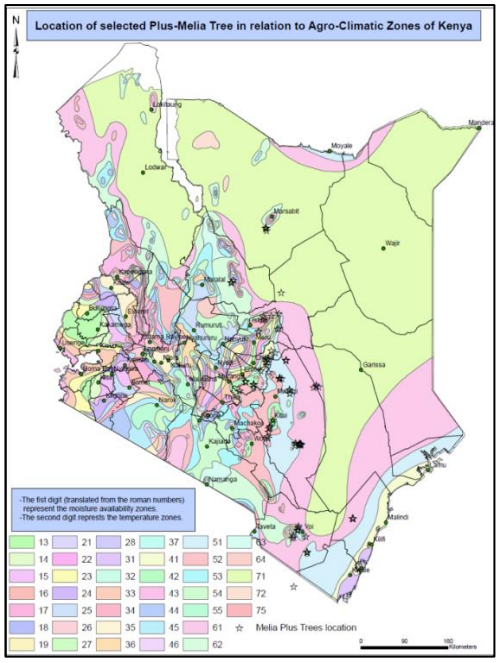

Figure 2: *Melia volkensii* Candidate plus Trees location sites in relation to Agro-climatic zones

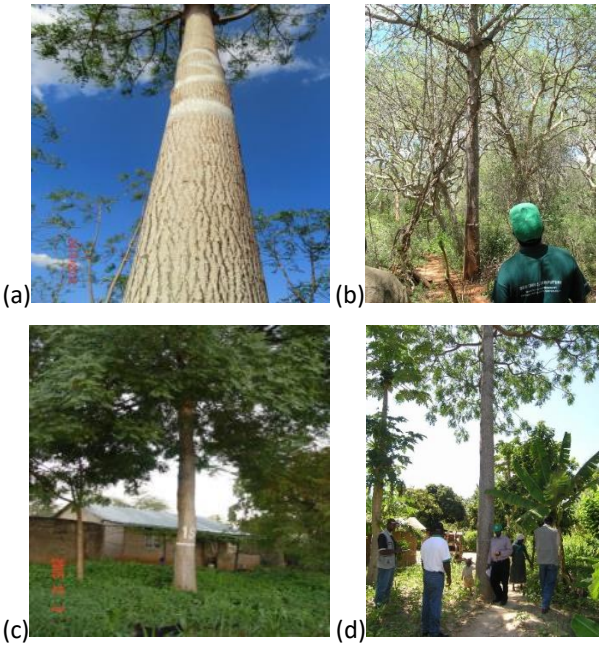

Plate 1: Examples of *Melia volkensii* CPTs selected from various transects:
(a) Tharaka, (b) Mutha, (c) Mwea, (d) Dams

Selection of Melia CPTs should be done by trained tree breeders who use the following criteria.

1. A tree in the dominant or co-dominant crown class (at or above the general tree canopy level) compared with the surrounding trees;
2. Superior in height and diameter growth in comparison to surrounding 5 trees
3. High growth vigour in comparison to surrounding 5 trees
4. Good tree form (Straight straightness and light branching habit)*
5. Light-medium branching, less steep angled branches
6. Not crooked or twisted stems/branches, No spiral grain
7. Free from insect pests and free of any signs of diseases

*All the above criteria are applied in totally in scoring and selection for each CPT

In implementing the criteria for 1st generation selections, tree form was not a major consideration in very dry sites. Survival and growth of the trees in these areas was important for meeting the project objective of breeding for drought tolerance.

Box 1: Process used in selection of *Melia volkensii* CPTs for breeding populations

100 CPTs were selected from 13 transects (populations) in areas of natural occurrence of the species in Kenya. The selection process involved reconnaissance in these areas to have an overview of the tree attributes in a particular population. This was followed by actual selection within viable populations. Individual tree selection involved identification of potential CPT then comparing it with 5 surrounding Melia trees based the assessment criteria to confirm superiority of the plus tree. Each of the selected CPTs was assigned a unique name, code and number as its identity. In addition to selection of CPTs, site characterization within areas of occurrence of the selected plus trees was done. This included documentation of geographic location of tree (GPS), vegetation type, soil type and climatic conditions.

Table 1: Transects across *Melia volkensii* areas of occurrence and number of CPTs selected

Region	**S/No.**	**Transect Name**	**No. of CPTs**	***Code***
Coastal	1	Voi - Mwatate	10	VM
	2	Voi-Galana	10	VG
South Eastern	3	Mutha - Inyali	12	MTA
Central Eastern	4	Katulani - Kavisuni	10	KT
Central	5	Mwea Special	2	MWA
Eastern	6	Mwingi - Tseikuru	8	TSK
	7	Mwingi - Nuu	4	NUU
	8	Embu - Dams	7	EmbD
	9	Embu-Ishiara-Gatunga	13	EmbIG
Northern	10	Meru - Isiolo	4	MI
	11	Garissa-Bangale	4	GB
	12	Garbatulla-Wamba	6	GW
	13	Wamba-Marsabit	10	WM
		TOTAL	**100**	

5. Process of establishing Melia Clonal Seed Orchards

Establishment of clonal seed orchards was done using the selected Candidate Plus Trees as sources of reproductive material (scions). The process of clonal seed orchard establishment involves, raising of rootstock, collection of scions and grafting, raising of grafts in the nursery, identification of suitable land/site for orchard establishment land preparation and fencing, orchard layout design, staking, pitting and finally planting (Figure 3). A suitable site for Melia orchard establishment should be fairly dry, slightly slopping with well-drained deep soils devoid of rocks.

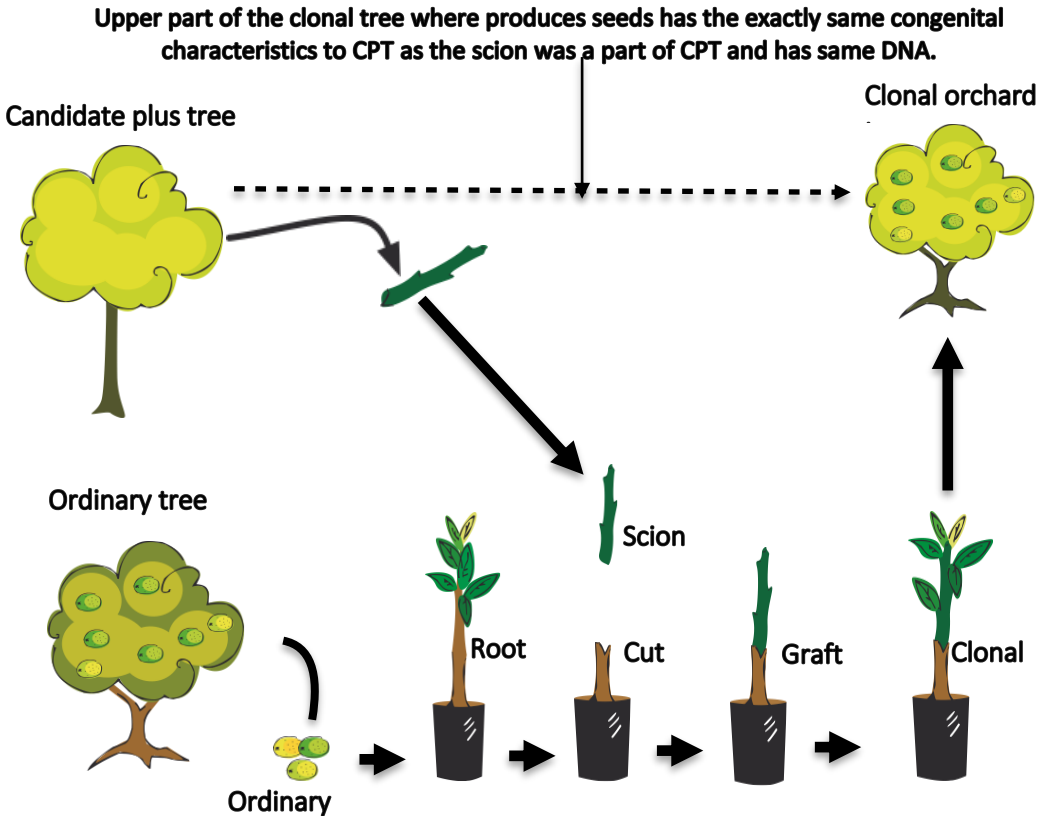

Figure 3: Concept of seed orchard establishment

5.1 Raising of rootstock, collection of scions and grafting

5.1.1 Rootstock potting soil preparation

The soil for raising rootstock seedlings should rendered weed free. This was done by collecting and storing the soil for one month to allow germination of weed seeds. The soil was fumigated using Nemasol fumigant (Mentam sodium 510 GH) then covered completely with a polythene sheet for 10 days before potting. The potting mixture was made of forest soil, sand and manure in a ratio of 2:1:1 (Figure 4).

(a)

SUGGESTED STANDARD MIX

Forest soil (Loamy clay)	River sand	Manure (decomposed)
2	1	1

Test the mixture by rolling a damp sample in your hand.
A good mixture should roll and hold its shape
but it breaks if the roll is bent.
If it does not hold add 1 part Forest soil (Clay).

(b)

Figure 4: (a) Soil potting mixture for drylands and (b) Forest soil, sand and manure

5.1.2 Melia Seed pre-treatment and sowing for raising rootstock

For the clonal seed orchards, scions are grafted onto Melia rootstock. The rootstocks should be minimum of 4 months old before grafting. However, rootstock raised up to one year can also be used provided frequent root pruning is done. The time of seed sowing to raise the rootstocks is therefore determined by the projected grafting time. For example, in establishing the first generation orchards rootstock seed were sown in April 2012 for grafting done in September 2012.

For successful germination, *Melia volkensii* seed is pretreated as follows

- Nipping of seed by breaking the caruncle (Plate 2a) and soaking in cold water mixed with fungicide e.g. Ridomil or Benlate (5 g/l) for 12 to 24 hours.
- After soaking, the seeds are slit longitudinally starting at the point of nipping to the other end of the seed using a sterilized razor blade or scalpel (Plate 2b). The slit should be restricted to the seed coat. Slitting allows leaves to be released on germination.
- For optimum germination, Melia seed should be sown on sterilized river sand. The sand is sterilized by drenching it using 450 ml of sodium hypochlorite solution (e.g. JIK) per 20 litres of water and also sprayed with a fungicide (e.g. Ridomil). The sterilized sand is placed in germination bed, a non-mist propagator or a plastic basin. Seed are sown by placing the seed on the sterilized sand and covering with a layer of sand equal to double the length of the seed. The sand is watered thoroughly using sterilized water. After sowing, the germination media is covered with a clear polythene sheet. A space of six inches between the polythene sheet and media should be allowed to avoid contact of the tender germinating seedlings which cause mortality. Watering of the bed after sowing is done only when necessary by observing the wetness of the germination media. Melia will germinate in 3 to 6 days (Plate 3).
- The germinated seeds are then transplanted into pots filled potting mixture.

(a) Nipping

(b) Slitting

(c) Soaking

Plate 2: *Melia volkensii* seed pretreatment

Normal tree nursery management practices should be undertaken to ensure a healthy root stock. The rootstock is managed in the nursery through watering, weeding, root pruning where necessary and pest control.

(a) See pre-treatment (b) Sowed seed (c) Geminated/pricked out (d) Ready rootstock

Plate 3: Seed Pretreatment, sowing and nursery management

5.1.3 Collection of scions

M. volkensii scions should be collected and grafted within 72 hours. The size of the scions collected should be matched to the size of the rootstocks for best union. The number of scions collected should allow for 25% more than the number to be grafted. Also, the number of grafted seedlings should be 20% more than what is needed for planting to allow for any beating up. For the first generation clonal orchards, the scion collection process from the 100 selected CPTs was as follows:

(i) Scion identification - This was precisely done to ensure that scions collected were appropriate to the size of the rootstock in the nursery. Clean, healthy and mature scions were identified and cut from the CPTs with a secateur/sickle type knife mounted on 8 to 12 m extended rods and about 6 inch scions cut using a secateur (Plate 4a)

(ii) About 75% of the leaves were removed and the scions drenched with clean water to keep them moist (Plate 4b)

(iii) They were then wrapped with newspapers, fastened with masking tape and labeled. A batch from one plus tree was placed in a polythene bag and labeled again and packed in a cool box (Plate 4c)

(iv) The scions should be delivered to the grafting centre in the soonest time possible to avoid dessication but not later than 2 days after collection

The equipment used in scion collection, packaging and transportation were: Ladder, standard secateurs, long handled secateurs (8 -12 m long) or looping shears, cool boxes and cooling ice blocks, labeling material, packaging material and sanitizers (sodium hypochlorite, surgical spirit) for cleaning the equipment. The equipment should be cleaned after scion collection from any single CPT.

(a) Scion collection

(b) Scion drenching

(c) Scion packaging

(c) Transport scions in coolbox

Plate 4: Scion collection and processing

5.1.4 Grafting

Grafting is done such that the cambium layer of the scion matches or rests on the cambium layer of the rootstock. Cambium is a thin layer of living cells between the bark and the wood from which bark and wood tissues are formed. It is the source of all girth growth in woody stems. As the cambium cells divide, bark is produced to the outside and wood to the inside. During the healing of the wound incurred during grafting, the cambium produces callus cells which will join the scion and the rootstock. Eventually, the callus cells differentiate to form the vascular connections between the rootstock and scion (Plate 5). The best practice recommended for grafting in Melia was followed in grafting of the scions collected from CPTs. Of the 80 scions collected from each CPT, 72 were grafted onto Melia rootstocks at the KEFRI's Kitui nursery in September 2012 using the top grafting method (see Plate 5). Proper documentation and labeling of grafted seedlings using allocated CPT code should be done so that each grafted seedling has a source identity.

The following equipment is required for grafting:

- Grafting knife (or surgical blades); Grafting tape; Secateurs, Grafting paste
- Chairs/table and small stool, basin/bucket
- Fungicide and 70% surgical spirit
- Cotton wool and gloves
- Labeling material
- Shade nets 30% and 50%
- Polythene sheet

A high level of hygiene should be maintained at all times. Grafting knives/blades should be dipped periodically into methylated spirits to sterilize them during grafting.

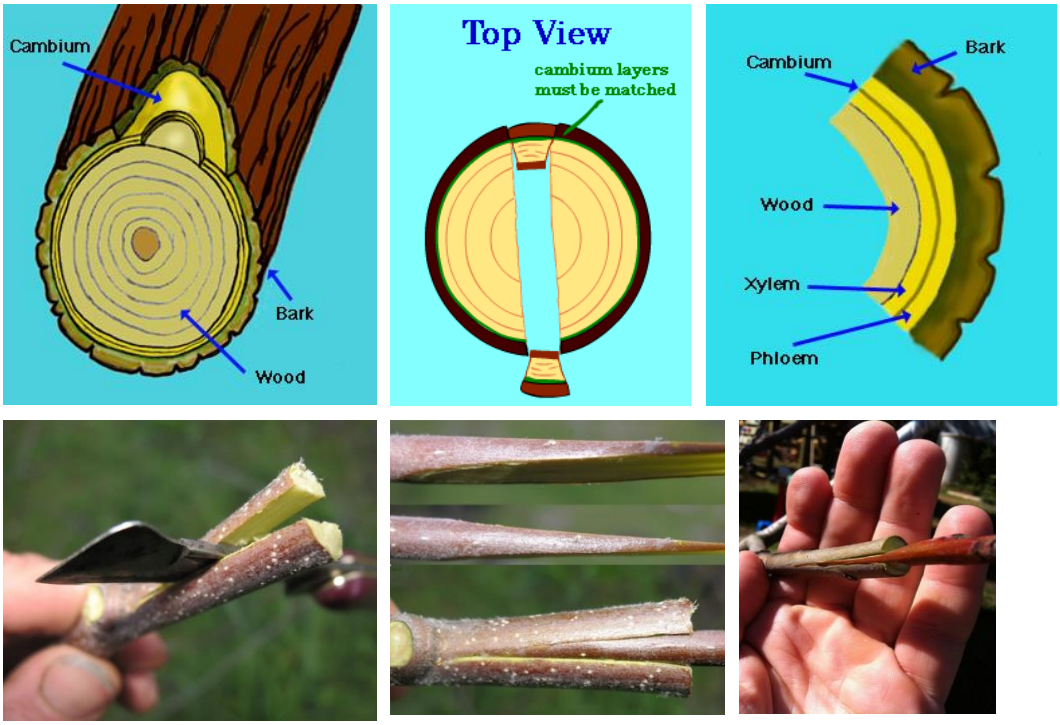

Plate 5: Cambium layer and grafting cross section

The grafting process involved watering the rootstocks soil to saturation an hour before grafting. The grafting equipment were assembled, cleaned and sterilized using 70% surgical spirit before commencement. Grafting of Melia was done using the following steps:

- Sterilize the scions by dipping the scions into water mixed with appropriate amount of fungicide for 5 to 10 minutes
- Using a secateurs, make a clean horizontal cut and discard at least the top half of the rootstock (Plate 6a)
- On the remaining rootstock, use a sharp grafting knife or surgical blade to make a vertical cut (wedge) at the top centre. The wedge should be 2 to 2.5 cm deep
- On the scion, make 2 clean cuts to shape the lower part of the scion into a balanced V shape using a sharp grafting knife or surgical blade. The size of the cut on the scion should match the size of the wedge on the rootstock for a perfect fit
- Insert the V shaped part of the scion into the rootstock wedge. Ensure proper contact of scion and rootstock. It is important that the graft union be a clean, snug fit with intimate contact of the cambium layers in both the scion and root stock. Wrapping the union with grafting tape or parafilm provides this intimate contact as well as providing support for the scion on the root stock
- Completely cover the top part including stem of the grafted seedling with a polythene bag (Plate 6e) and secure at the base of the seedling using a cotton twine
- Place the grafted seedlings in nursery beds covered with a 50% shade net (Plate 6f). Reduce shading to 30% after one month. Remove the polythene bag covering the grafts once a graft has developed leaves

- Two weeks before planting, expose the seedlings to full sunlight for acclimatization. In case of heavy rains at any time during the nursery phase, cover the grafts with a polythene sheet supported by a frame
- Manage the grafts in the nursery through watering, root pruning and disease control for about 4 months until they are ready for planting

5.1.5 Management of grafts

This is a crucial stage of the grafting process necessary to maximize survival of grafted seedlings. For Melia, it is important to maintain a moist environment around the grafted wound and the reason why the grafts are enclosed in polythene to ensure high humidity that promotes wound healing. On the other hand, overwatering damages Melia grafts. Watering should be done directly to the potted soil and not the leaves (once the polythene paper is removed). The rootstock portion of the graft should be checked for buds and sprouts frequently and removed as they can grow and suppress the grafted scion development and growth.

Plate 6: The *Melia volkensii* grafting process:
(a) Cutting off rootstock (b) Fixing scion on rootstock (c) Parafilm tape
(d) Tied graft using parafilm (e) Cover graft using Polythene (f) Shading of new grafts

(a) Grafting (b) Covered grafts (c) Growing grafts

Plate 7: Grafting and graft management


Plate 8: Grafting of seedlings at Kibwezi

5.2 Layout and planting

Seed orchards represent the link between tree breeding and operational forestry. Before field establishment of new orchards, several factors such as the number of selected CPTs and the number of copies (ramets) per CPT should be considered to optimize their spatial distribution. Design and layout of seed orchards should be done by trained tree breeders.

In designing seed orchards, the permutated neighborhood design (Bell and Fletcher 1978, Chakravarty and Bagchi 1994) is considered to be the most efficient in randomizing the selected clones and separating their respective ramets through the use of a specified exclusion zone i.e., number of positions between two ramets of the same clone to avoid inbreeding.

Seed orchards must also be protected or isolated from contamination by outside pollen. Pollen dilution zones, created through distancing orchards away from potentially contaminating inferior pollen are critical for seed orchards establishment because of the potential loss of genetic gains. For *M. volkensii*, the following activities were undertaken in establishing the first generation orchards:

5.2.1 Site preparation

The Kitui and Kibwezi Melia orchard sites were initially covered by wooded bush land. The bush was cleared and ploughed using a bulldozer. Eleven hectare plots were earmarked for planting of orchards at each of the sites. The sites were ripped to a depth of 2 feet using a heavy duty ripper and thereafter fenced. Where deep ripping is not possible due to unavailability or cost of ripper, at least ploughing using a tractor should be done. (Plate 9a). A 6-metre firebreak was established around the orchards.

5.2.2 Site layout and planting

The orchard is divided into 6 blocks planted with 100 Melia families (CPTs) each with 5 ramets translating to 3,000 planting positions. The planting positions of the 100 families was subjected to randomization to facilitate cross pollination among the families and avoid planting ramets of the same CPT near each other. The field layout preparation and transportation process was guided as follows:

- A layout was pre-designed and consisted of 6 blocks, each containing 5 ramets of each of the 100 CPTs (Figure 5)

- Staking was done at a spacing of 6x6 metres. However, for future orchards, a spacing of at least 7x7m should be used (Plate 9a). This is informed by observation of current seed orchards. During staking, each planting spot was labelled with a tag that showed the identity of the grafted seedling and its predetermined position
- Pits of 45 x 45 x 45 cm were dug, then backfilled first using mixture of top-soil and charcoal dust (To help retain moisture) followed by the rest of the soil
- Properly labelled seedlings were transported to the sites in crates, keeping same family in a given crate

Plate 9: Kibwezi orchard site preparation and fencing

Plate 10: Staking and field labeling and seedling placement

Plate 11: Kibwezi site before preparation

The grafted seedlings should be preferably planted during rainy season. In case of inadequate rain at the time of planting supplementary watering can done 1 to 2 times a week using bottle feeding method (See plate 12e&g). During establishment of clonal seed orchards, there are many possibilities of errors, such as wrong labeling the scions, mix up during handling the material in the nursery, transportation and planting. This is avoided thorough monitoring and supervision of the exercise. For planting of the Melia orchards, the following procedures were followed:

- The transported seedlings were sorted in the field according to planting lines. Each seedling had a pre-determined planting position, (C: x-y) where C is clone/family and x,y position in layout (Figure 5).
- Para film on the grafted spot were removed in the field before planting
- The planting crew was organised to ensure that the each ramet was planted at its predetermined position

(a) Sorting grafts in nursery

(b) Transporting grafts

(c) Sorting grafts in field site

(d) Movement of grafts

(e) Planting using bottle feeding

(f) Documentation and checking

(g) Planted graft

(h) Removal of para film

(i) Planted grafted seedling

Plate 12: The planting process

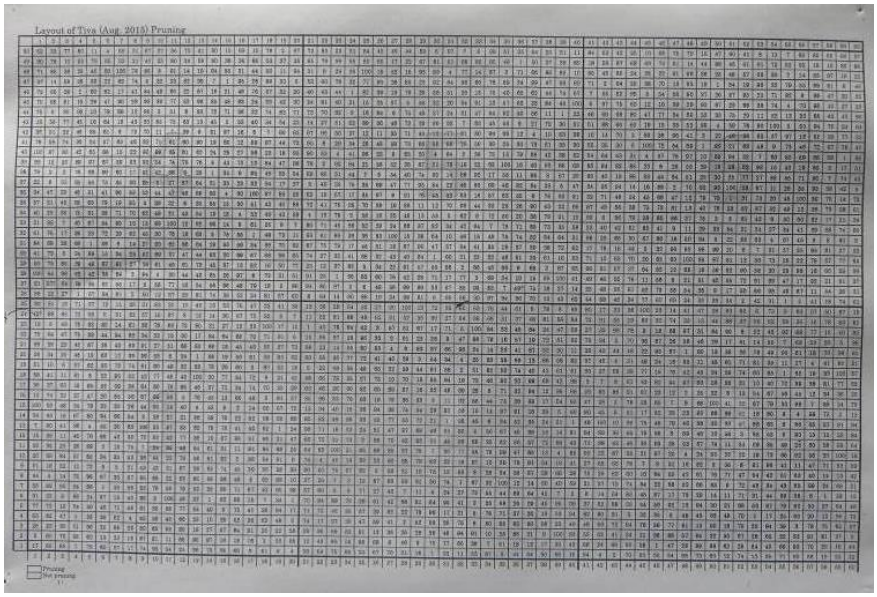

Figure 5: Layout of Melia Orchard in Tiva, Kitui

6. Seed Orchard Management

Seed orchards are special plantations that need strict management interventions for optimum seed production. They should be free of weeds, pests and diseases, properly pruned to allow sunlight for flowering and well protected from human and animal damage. Clonal orchards require a special pruning to remove suckers and sprouts from the rootstock section of the graft.

The following orchard management activities were carried out for Melia orchards at Kitui and Kibwezi:

- Weeding at least twice a year after the rainy seasons: This was done to avoid weed competition and to remove fire hazard (Plate 15)
- Pruning/de-budding/removal of sprouts: At an early age, unwanted buds and sprouts are removed from the rootstock below the grafted union (Plate 12h). If these branches are left to grow, they will produce seed of poor quality. In addition, low branches are pruned by use of secateurs at a point below 1m of the tree height to encourage more branch foliage for seed production as well as good crown form. At 2.5 years, the crowns of Melia orchard trees were pruned to encourage the development of a short, wide and bushy growth habit and to keep the trees below 5 meters. After pruning, the cut areas should be treated with a glue based fungicide such as Topsin (*Thiophanate-methyl*), or wood glue mixed with a fungicide.
- Supporting: Melia trees grow fast and tend to lean/bend as result of strong wind blow. Thus supporting the trees using V-shaped struts is highly encouraged to help the trees withstand adverse effect of strong winds and promote tree straightness.
- Disease and pest Control: The orchards are monitored on regular basis in order to detect pest and disease occurrences and to take necessary interventions. Support should be sought from qualified entomologists and pathologists in case of outbreaks. Trees seriously

affected by diseases were uprooted and burnt away from the orchards to avoid further spread.

- Protection: Orchards are expensive to establish and are of very high value. They should be protected at all times from damage through monitoring and maintaining integrity of fences and firebreaks.

Plate 13: Well weeded Melia orchard

Plate 14: Melia pest and disease monitoring (L) and Pruning/lopping (R)

Plate 15: Weeding

7. Collection and Processing of *Melia volkensii* Seed from Orchards

7.1 Flower and seed survey

M. volkensii generally flowers and seeds throughout the year with peak flowering and collection time being February – March and July - August. The same trend has been observed in the orchards. During seed survey, the maturity status should be established to estimate actual time of seed collection. Seed productivity potential should also be estimated.

Plate 16: Orchards at 2 and 3 years

7.2 Fruit collection

Equipment and materials needed for Melia seed collection should be assembled and confirmed to in good working condition. This equipment includes: Orchard layout, labels, seed collection forms, ladders, canvas, Y-shaped shaking rods, looping shears, gunny bags, and weighing scale. In addition, supporting logistics such as staff and vehicle.

Melia fruits should be collected when they are ripe. Yellow fruits, though mature are not ready for collection until they have developed brown patches (Plate 17). Collection in the orchard should be undertaken at individual family/clone level with fruits from one family/clone kept separately. Collection is done from the crown by either hand-picking or use of looping shears to cut branch-lets bearing ripe fruits. Canvass sheet or net should be spread under the tree to trap the fruits during collection. Collected fruits should be carried in gunny bags and always kept under shade. Shaking of branches during collection is discouraged as fruits on the tree are normally at different stages of maturity which may lead to loss of young fruits.

(a) Immature Melia seed (b) Mature Melia seed (c) Over-mature Melia seed

Plate 17: Melia fruits at different levels of maturity

7.3 Fruit processing and storage of Melia nuts

Fruits should be weighed and documented and de-pulping commenced immediately. Depulping is done using a mortar and pestle or hitting a fruit with a plank of wood. Depulped nuts are then thoroughly washed and dried under direct sun for at least two days. Dried nuts are weighed and stored awaiting extraction. Dried nuts from different ramets of the same clone (family) are mixed and stored in airtight containers under cool dry conditions.

Plate 18: Collected *Melia volkensii* fruits and drying (R)

7.4 Seed extraction

Melia should be extracted when one is ready for sowing in nursery. Melia seed is extracted by cracking the nut using a Melia nut cracker. However, cracking the nut with a knife and hammer is equally effective if handled by an experienced person. Once seed is extracted, it should be sown as soon as possible. On average, 8 kg of fruits yield 1 kg of nuts while 1 kg of nuts yields 200 seeds. The number of seeds per kilogram of extracted seed ranges from 3,000 to 3,500.

8. Documentation of improved *Melia volkensii* seed production and distribution

Documentation is an important part of production and use of improved Melia seed and seedlings. It is important to document and keep records of the clones used in establishment of seed orchards, the seed collection materials and processes and distribution of seeds. Key parameters that need to be documented are shown in Table 2. In addition, orchards should have appropriate signposts.

Table 2: Documentation in production and distribution of improved *Melia volkensii* seed

Activity	Documentation details
Selection of CPTs	Species, Site data (Temp, Rainfall, Agro-ecological zone, Altitude, Latitude, and Longitude), Identity and tree code allocated, photo, tree parameters (height, DBH, stem form, branching habit). Similar parameters for 5 surround trees
Seed orchard management	Name and location of seed orchard (+GPS), source and identity of propagules, map layout, Management activities planned and undertaken (weeding , pruning, pest control etc).M&E activities
Seed orchard (Seed source)	Name of seed source, species, date of establishment, spacing, identity of propagation material used, seed source category, clones, ramets, ownership, area, locality, Map, layout, Altitude, Latitude, longitude, soil type, rainfall, temp, topography, site history, assessment/monitoring schedule and record of actions, observations
Seed collection	Species, date of collection, collectors names, seed source identity, method of collection, ramet and clones collected, weight collected, transportation containers, identity of seedlot
Seed processing and storage	Species, identity of seedlot, duration of temporary storage, extraction method, weight extracted, drying method, weight stored, Records of quantity received and dispatched, current weight balance

Activity	Documentation details
Seed distribution	Species, batch number, client details including name, location weight required, weight issued, date of dispatch, seed sowing instructions, expected number of seedlings
Seed sowing and pricking out	Species, date of sowing, seed batch number (identity) amount of seed sown, date of pricking out, number of seedlings pricked out
Seedling management at nursery	Species, Seed batch number (identity) Tending activities (weeding, control of pests and diseases, date of root pruning, date of hardening off, number of ready seedlings, observations and dates

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Forest Tree Breeding Center, Forestry and Forest Products Research Institute
3809-1 Ishi, Juo, Hitachi, Ibaraki 319-1301, Japan
E-mail: ikusyu@ffpri.affrc.go.jp ♦ Website: www.ffpri.affrc.go.jp/ftbc/en/index.html

Kenya Forestry Research Institute
Head Office: Muguga off Nairobi-Nakuru Highway
P.O. Box 20412-00200, Nairobi Kenya
Tel: +254-724-259781/2, +254-722-157414, +254-734-251888
E-mail:director@kefri.org ♦ Website: www.kefri.org

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