Guideline on Production, Distribution and Use of Improved Melia Seed and Seedlings in the Drylands of Kenya

KENYA FORESTRY RESEARCH INSTITUTE
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Forest Tree Breeding Center

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Cover captions:
Clockwise: improvised potting containers, Melia seedlings, Orchard and on-farm planatation, germinating seedlings
Inset: Melia Fruits, aerial view of Melia plantation.

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Email: director@kefri.org
Website: www.kefri.org

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FOREWORD

Potential for economic empowerment of communities living in the drylands lies in diversification of investments in low-risk high return activities. Planting of high value trees is one such venture. Melia volkensii (Melia) a high value timber tree is a candidate species for investment in the drylands. The species is fast growing and yields high-value timber in a short rotation of 10 – 15 years. However, the species has high diversity of tree form and growth.

KEFRI in collaboration with JICA are a addressing the form and growth diversity challenges through a tree improvement programme for Melia under the auspices of the KEFRI/JICA project on "Development of Drought Tolerant Trees for Adaptation to Climate Change in the Drylands of Kenya". The Project focuses on DNA analysis, tree breeding, tree physiology and extension. The Project is undertaking: improvement of Melia for production of high quality timber through selection of superior genotypes that are drought tolerant; building of stakeholder capacity; awareness creation; and establishing an effective and efficient extension system for distribution of improved Melia seed and seedlings.

This information on developed improved Melia seed and seedlings is urgently required by both existing and potential stakeholders within the Melia value chain. Objectives of this guideline are therefore to: provide practical guidance to stakeholders of improved Melia seeds and seedlings distribution system; provide procedures for establishment of on-station and on-farm Melia plantations and demonstration farms; and provide a basis for preparation and distribution of training materials to different stakeholders.

This Guideline provides appropriate practices in tree breeding; seed collection, processing and handling for production of healthy Melia seedlings; propagation; distribution and marketing; capacity building; and institutional and legal issues in use of improved seeds and seedlings for Melia. The target beneficiaries of this Guideline include; county government environment officers, extension agents, non government organizations, learning institutions, community based organizations and faith based organizations involved in natural resource management activities. The guideline will also be useful to producers of improved Melia tree seed and seedlings, and tree growers.

Ben E.N. Chikamai (PhD)
Director, Kenya Forestry Research Institute

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CHAPTER 1: INTRODUCTION

G. Muturi, J. K. Ndufa and Y. Takeda

1.1 *Melia volkensii* and its Distribution

Melia volkensii is a multipurpose tree that is endemic to drylands of eastern Africa with natural distribution range in Ethiopia, Kenya, Somalia and Tanzania (Figure 1.1). The species naturally occurs in deciduous bushlands in association with Acacia-Commiphora vegetation. *Melia volkensii* (Melia) grows in sandy-clay and shallow stony soils but prefers sandy soils with good drainage from sea-level to 1700 m a.s.l with mean annual rainfall of 300 – 800 mm and temperature range of 26-38 ^{o}C (Jaetzold and Schmidt, 1983; Orwa *et al*., 2009). *Melia volkensii* 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).

1.2 Importance of Melia and Constraints to its Planting

Melia is a fast growing (up to 20 meters in 10 to 15 years, attaining a diameter of up to 25 cm), multipurpose deciduous tree. Melia 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 (Rajab and Bentley, 1988; Al Sharook *et al.*, 1991; Kidundo, 1997; Roothaert and Franzel, 2001). 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.

Over the years, Kenya Forestry Research Institute has promoted growing of Melia on-farms for sustainable supply of its products. Initial attempts to promote planting of Melia on-farm were constrained by propagation challenges. However, with breakthroughs in breaking 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. Planting of Melia responds to demand driven tree farming in drylands because of the periodic drought-related crop failures and severe competition between crop and forestry production in humid areas.

As Melia planting and its enterprises take root, the need for improved Melia planting stock has become evident. Instead of being uniform in terms of height, diameter growth and vigour, the existing plantations of Melia have shown diversity in tree form and growth. KEFRI is addressing these emerging challenges and has initiated a tree

improvement programme for Melia under the auspices of the ‘‘Project on Development of Drought Tolerant Trees for Adaptation to Climate Change in Drylands of Kenya.’’

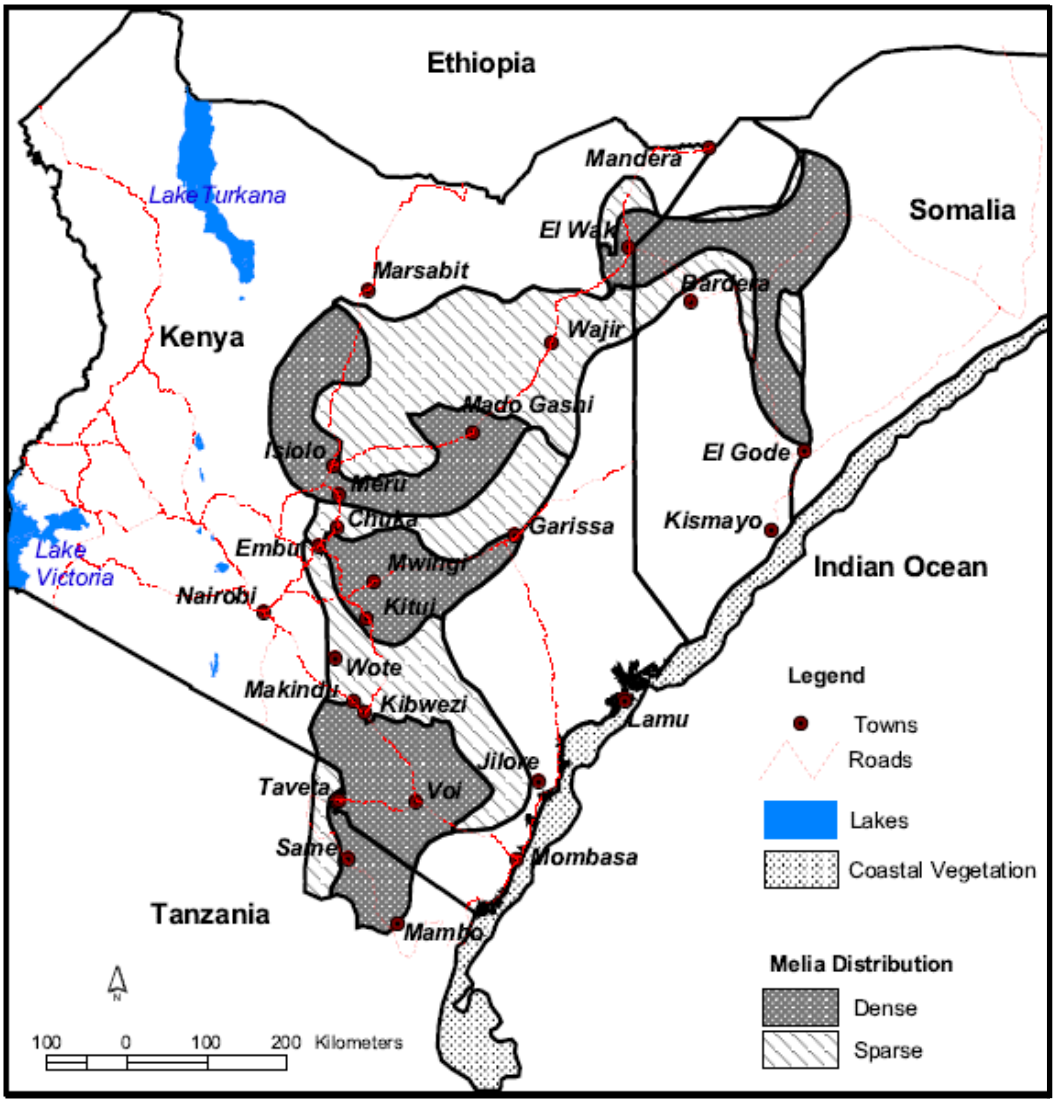

Figure 1.1: Distribution of Melia volkensii in eastern Africa

1.3 Project on Development of Drought Tolerant Trees for Adaptation to Climate Change in Drylands of Kenya

The Project on Development of Drought Tolerant Trees for Adaptation to Climate Change in the Drylands of Kenya is jointly implemented by KEFRI and JICA on behalf of the governments of Kenya and Japan. The project is handling two species namely; *Melia volkensii* and *Acacia tortilis*. Specifically for Melia, the Project is improving the species for production of high quality timber through selection of superior genotypes that are drought tolerant. The Project aims at; building stakeholder capacity, creating awareness and establishing an effective and efficient extension system for distribution of improved Melia seed and seedlings.

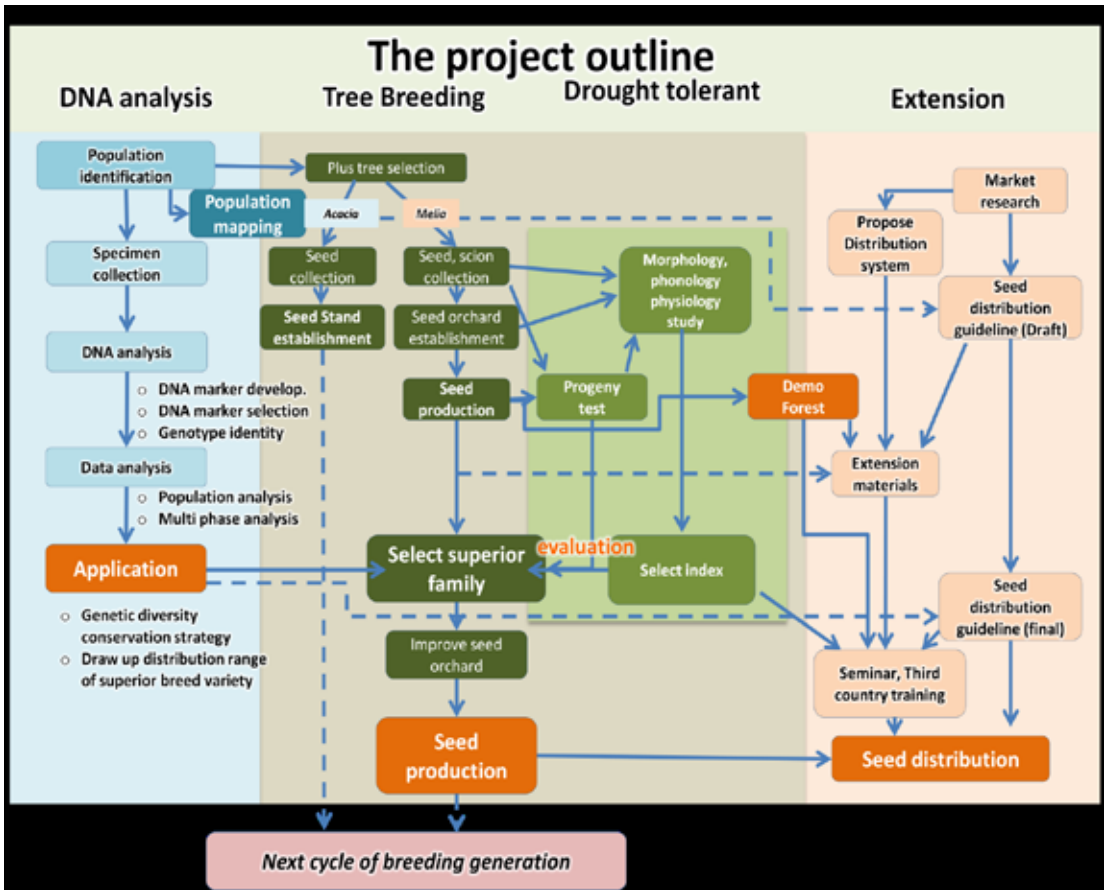

Figure 1.2: Components and main activities for Project on Development of Drought Tolerant Trees for Adaptation to Climate Change in the Drylands of Kenya

The Project has four components namely: DNA analysis, Tree Breeding, Physiology (drought tolerance) and Extension (Figure 1.2).

The DNA analysis component has developed molecular markers which have been used to document DNA sequence of all trees that have been used in establishment of Melia seed orchards. The markers will also be useful in ascertaining when non improved Melia is passed off as improved material.

The tree breeding component entailed selecting of candidate plus trees, establishment of two Melia seed orchards and eight progeny trials. Future work in this component will involve; evaluating the progeny trials, assessing adaptability to different ecological conditions, and removal of inferior materials from the orchards.

The drought tolerance or tree physiology component aims at developing a drought tolerance index for Melia. The index is being developed through a series of physiological and phenological studies that assess response of Melia to drought. The index will be applied to match appropriate Melia genotypes to different ecological regions Weather stations have been established in the two Melia orchard sites and in four progeny test sites to collect biophysical data and correlate it to Melia growth.

The extension component provides an avenue of sharing Project findings and outputs with stakeholders on Melia enterprises. The component has identified and established baseline information of major Melia enterprises and opportunities for up-scaling use of improved Melia seed and seedlings. The extension component will build capacity of stakeholders (extension agents, farmers, teachers and other community leaders) through organized trainings and demonstrations using improved Melia seeds and seedlings.

1.4 Documentation of Improved Melia Seed and Seedling Production, Distribution and Use

Documentation is important in production and use of improved Melia seed and seedlings. It is important to document all activities including; tree breeding activities, the seed collection process, distribution of seeds, nursery operations, and distribution of seedlings. Key parameters that need to be documented are shown in Annex 1.

1.5 Objectives of the Guideline and Target Audience

This Guideline addresses various aspects of Melia including: tree breeding; seed collection, processing and handling for production of healthy seedlings; field Melia tree growing demonstrations; distribution system and marketing; capacity building; and institutional and legal issues in use of improved Melia seeds and seedlings.

Objectives of this guideline are as follows:

1. Inform stakeholders on production and distribution of improved Melia seed and seedlings
2. Provide procedures for establishment of on- and off-farm Melia plantations using improved Melia seeds and seedlings
3. Provide a basis for preparation and distribution of training materials to different stakeholders to promote use of improved Melia seeds and seedlings

The guideline will be useful to; county government officers-in-charge of natural resources, extension agents, non government organizations, learning institutions, community based organizations, faith based organizations involved in natural resource management activities, tree seed and seedling producers, and tree growers.

CHAPTER 2: BREEDING FOR IMPROVED MELIA SEED AND SEEDLINGS

J. Kariuki, S. Hanaoka, H. Miyashita, and D. Muchiri

2.1 Overview of Tree Breeding

Natural selection favors trees that are best adapted to the local environment. Artificial selection, which is initially based on physical (phenotypic) characteristics favours trees that have desirable characteristics suited for specific planting purposes and intended end uses. In phenotypic selection, individual plus trees are selected (mass selection) based on a set of pre-determined criteria. Subsequent selection and further improvement is based on evaluating genetic worth of the selected trees based on performance of their respective progenies in well designed and replicated trials (progeny testing).

Opportunities exist to improve silvicultural value of a species by identifying the best wild seed sources and selecting individuals within these to develop varieties that are better than the wild materials. Tree breeding or tree improvement is the process of improving the genetic quality of a tree species. Tree breeding programmes are therefore established to select and breed from the best individuals within best populations. The wide variation in traits such as growth rate, stem form and wood quality that exists in tree species provides tree breeders with opportunity to develop improved varieties. These improved varieties have potential to produce larger volumes of better quality wood than can be achieved from wild material. Techniques used by tree breeders include: Candidate Plus Tree (CPT) identification and selection; establishment of seed orchards using selected material; progeny testing; improvement of seed orchards using results of progeny tests; controlled crossings; and clonal testing.

2.2 Melia Improvement Process

2.2.1 General process of Melia improvement

The general process of Melia improvement includes: deciding on selection criteria for Candidate Plus Trees (CPTs); selection of CPTs; clonal propagation of the CPTs; and setting up of orchards and progeny trials. Results of progeny trials are used to improve existing orchards and to set up subsequent generations of seed orchards for further improvement (Figure 2.1).

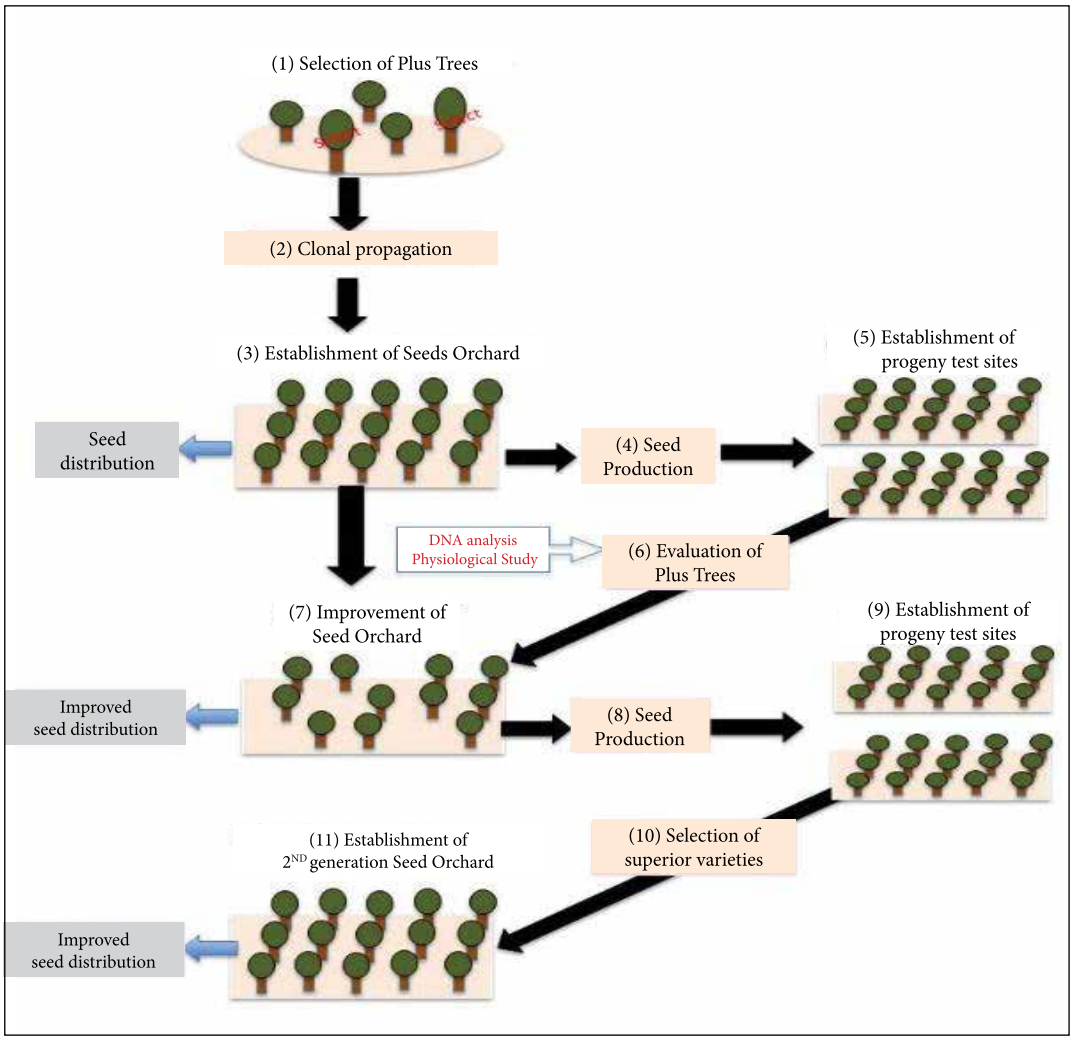

Figure 2.1: General tree breeding system applied in Melia improvement

2.2.2 Selection criteria for Candidate Plus Trees

Objective of setting the selection criteria was to facilitate selection of 100 Candidate Plus Trees of Melia from their natural range in Kenya. Selection targeted traits that maximize uses and benefits of the species, and developing varieties of Melia that are drought tolerant for adaptation to climatic change in the drylands of Kenya, while at the same time maintaining fast growth and good tree form.

After evaluation of the most common uses of Melia and probable future uses, the following were adopted as selection criteria for identifying an individual CPT:

1. A tree in the dominant or co-dominant crown class (at or above the general tree canopy level) compared with surrounding Melia trees
2. Superior height growth in comparison to 5 surrounding Melia trees
3. Superior diameter growth in comparison to 5 surrounding Melia trees
4. Good tree form (stem straightness and light branching habit)
5. No spiral grain tendency
6. Free of any signs of pests and diseases

For very dry sites, tree form was not a major consideration due to nature of populations as drought tolerance was more important.

2.2.3 Candidate Plus Tree selection

Sites known to have viable populations of Melia within the species natural range were surveyed and location of Candidate Plus Trees (CPT) documented. For purposes of selection, Melia growing regions were divided into 13 transects as follows: Mutha-Inyali, Katulani-Kavisuni, Voi-Mwatate, Voi-Galana, Embu-Ishiara-Gatunga, Embu-Dams, Mwea Special, Mwingi-Nuu, Mwingi-Tseikuru, Isiolo-Meru, Garissa-Bangale, Garba-Wamba and Wamba-Marsabit.

During initial reconnaissance surveys, hundreds of trees were screened in each transect and 5 to 10 CPTs selected in each (Plate 2.1). Individual CPT selection involved comparison of 5 potential trees and picking the candidate tree based on the selection criteria compared to 5 surrounding Melia trees. In total 100 Melia CPTs were finally selected from the whole Melia natural range. Each of the CPT was assigned a unique name, code and number as its identity. All CPTs were genotyped (i.e. genetically identified) by using DNA markers in order to ensure future identity of the material.

In addition to selection of CPTs, site characterization within areas of occurrence of selected plus trees was done. This included documentation of geographic location data, vegetation type, soil type and climatic conditions.

Plate 2.1: Examples of Melia Candidate Plus Trees (CPT)

2.2.4 Clonal propagation (multiplication) of CPTs

Melia rootstock was raised in the nursery. Thirty (30) scions were collected from each of the 100 CPTs and grafted on to the rootstock. Each individual graft was labeled using original CPT identity and its pre-planned planting position in the orchard (Plate 2.2).

Plate 2.2: Grafted seedling of Melia CPT ready for planting

2.2.5 Establishment of seed orchards

Seed orchards were established using the seedlings grafted from Melia CPTs. The Melia seed orchard is replicated in Tiva (Kitui County) and Kibwezi (Makueni County) and cover an area of 30 acres (≈11 hectares) each (Plate 2.3). Each orchards is divided into 6 blocks and planted with 100 Melia tree families, with each family represented by 30 ramets. In planting layout, the 100 families were subjected to computer randomization to facilitate cross pollination among the families while also making sure that no ramet of the same CPT were within 4 spaces of one another. Through randomization in design and natural cross pollination of the CPTs, it is expected that even more superior Melia trees will be obtained from seeds collected in the orchards.

Plate 2.3: Melia seed orchard in Kitui at 26 months after planting

2.2.6 Progeny Testing

Progeny tests were carried out to: test genetic worth of each of the 100 selected CPTs; provide information for second generation selection; and test site x progeny interactions that will help in selection of suitable families in different geographic areas. Open pollinated seeds were collected from the two seed orchards in Kitui and Kibwezi, and their seedlings planted in various test sites across the Melia natural growing range.

As phenotypic traits and physiological performances are determined by both genetic effect and planting site environment, the families are being tested in multiple test sites to evaluate genetic capacity across sites. It is important to start with a large number of trees to ensure there are sufficient trees to select parameters for assessment from the juvenile to mature stages. Four main test sites were established i.e. in Tiva, Kibwezi, Kasigau and Marimanti in 2014 (Plate 2.4) and 2015. In 2015, another four supplementary test sites were planted on farmers' land using fewer families. Assessment of the progeny tests was done one month after planting and subsequently every six months.

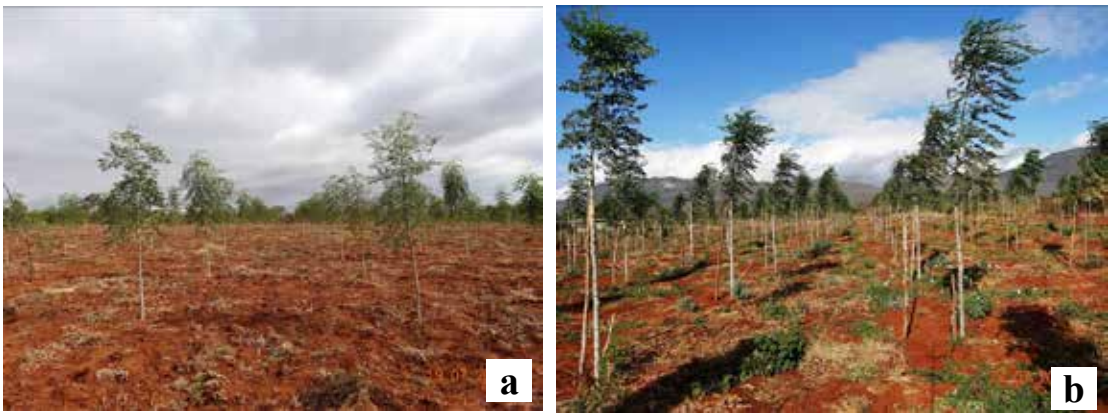

Plate 2.4: Melia progeny test site 7 months after planting at (a) Kitui and (b) Kasigau

2.2.7 Evaluation and further selection

In future, superior trees (parent) will be selected based on results of statistical analyses of data from the progeny trials. This selection of superior trees will take into account initial growth rate in test sites. A trait of drought tolerance is very important in the juvenile stage as this helps in avoiding high mortality during plantation establishment and will also be considered. Selection will also consider resistance to fungi and insects that may be related to either the juvenile or the mature stage. Stem form, volume and wood density will be applied in selection when the trees are older.

Selected superior trees will be retained while inferior trees will be removed from seed orchards based on the progeny tests results. This will lead to production of further improved seed from existing orchards.

In the medium to long term, artificial controlled crossing among selected trees based on progeny trials will lead to second generation CPTs. New seed orchards will be established using second generation CPTs. Average performance of trees established from seeds collected from second generation orchard is expected to be high compared to that of first generation CPTs. The foregoing cycle of events i.e. crossing, evaluation and selection can be replicated many times to have third, fourth and future generations seed orchards with each subsequent cycle expected to yield superior varieties.

2.3 Expansion of Improved Melia Seed Production Sites

2.3.1 Areas with potential for expansion of improved Melia seed production

Demand for improved Melia seed and seedlings from users is expected to grow beyond what the current established Melia seed orchards in Kitui and Kibwezi can provide. Counties with areas of similar agro-ecological conditions and potential for Melia growing will be considered for future expansion of improved Melia seed orchards. KEFRI will coordinate supply and distribution of improved Melia seed and seedlings; and provide technical advice on layout and establishment of upcoming improved Melia seed orchards.

2.3.2 Site selection criteria for improved Melia seed orchard establishment

KEFRI shall be involved in selecting sites for improved Melia seed orchards. KEFRI shall also provide a schedule of establishment considering the following requirements:

- At least 4 ha of flat or gentle slope land to be provided
- The area should be guarded and permanently fenced to prevent livestock damage
- The site should be close to a reliable water source

- The site should be easily accessible
- The improved Melia seed orchards will be managed by foresters who will carry out orchard management, and seed collection and processing
- Two permanent staff will be assigned to each Melia seed orchard for daily maintenance
- Casual labourers on a need-be basis
- Melia seed orchard site at least a radius of 200 m away from nearby Melia trees

KEFRI will prepare a management protocol for the improved Melia seed orchards. The protocol will provide information on; location, site conditions, protection and security measures, and maintenance. The protocol will also provide information on marketing of improved Melia seed and seedlings.

CHAPTER 3: COLLECTION AND PROCESSING OF IMPROVED MELIA SEED

G. Gitehi, B. Kamondo and E. Kyalo

3.1 Collection of Melia Fruits

Melia in the orchards flower and seed throughout the year with peak flowering and collection time being April – May and July – August. Melia seed should be collected when ripe. Yellow fruits though mature are not ready for collection until they have developed brown patches. Collection in the orchard should be undertaken at individual tree level with fruits from one tree kept separately up to the point of processing. 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. A net/canvas or any other appropriate material is spread under the tree to trap the fruits. Care should be taken not to break the branch while shaking. 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 3.1). Naturally fallen Melia fruits should be avoided as they are either immature or infested. High quality mature fruits are collected in sisal bags and temporarily stored under shade before they are transported to the processing yard.

Plate 3.1: Melia fruits at different stages of maturity (a) Mature but not ripe , (b) Ripe (ready for collection) (c) Over ripe

3.2 Seed Processing

3.2.1 De-pulping

Immediately after harvesting, Melia fruits are de-pulped using a mortar and pestle (Plate 3.2a). Alternatively de-pulping can be done by placing an individual fruit on a piece of timber/stone and hitting with a plank of wood (Plate 3.2b). The nuts are then washed thoroughly and sun dried for at least two days. Seven kilograms of fruits yield about one kilogram of nuts. Nuts from different ramets of the same clone (family) are mixed and stored in airtight containers under cool dry conditions. awaiting extraction for future use. Seeds extracted from such stored nuts have maintained their initial germination percentage for up to 6 months.

Plate 3.2: De-pulping of Melia fruits using: (a) Mortar and pestle (b) A wooden plank and a stone

3.2.2 Seed extraction and packaging

Melia seeds are extracted from nuts using either a Melia nut cracker or a knife and hammer (Plate 3.3). A Melia nut cracker is a tool developed by KEFRI and has adjustable mechanism for cracking nuts of different sizes. When a knife and hammer are used in extracting Melia seed, the nut is placed in a groove carved out on a piece 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 a 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. A nut contains 1 to 5 seeds and on average there are 200 seeds per kilogram of nuts. The number of seeds per kilogram of extracted seeds range from 4,000 to 4,500. The extracted seeds are cleaned by hand sorting to remove broken seeds and other debris.

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. For dispatch, Melia seeds are best packaged in khaki paper or envelop and kept in dry and cool place. Extraction date and use-by-date should be clearly indicated on the packet. The seed should be used within one month to avoid loss of viability.

Plate 3.3: Extraction of Melia seeds from nuts using: (a) a Melia nut cracker and (b) knife

CHAPTER 4: RAISING OF IMPROVED MELIA SEEDLINGS

J. Musyoki and J. Njuguna

Activities involved in raising of improved 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.

4.1 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 as well as be able to accommodate any possible expansion of the nursery in future. Generally, Melia nursery should be sited in an open space, well protected and secure from animals. A reliable water supply should also be available at the selected site. The topography should preferably be flat with a gentle slope to allow for drainage since Melia cannot withstand water-logging. As much as possible, the Melia nursery should be accessible to ease nursery field operations and supervision.

4.2 Nursery Seedbeds

A nursery seed-bed should be prepared well in advance. 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). 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 4.1). 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.

Plate 4.1: Use of non-mist propagators for Melia seed sowing

4.3 Seed Pre-treatment

Melia seeds have two coats, which hinder moisture penetration and radical protrusion. The mechanical barrier inhibits seed germination. To break dormancy and improve germination, Melia seeds are pre-treated as follows:

- Nipping the seeds
- Soaking the seeds in cold water for 12 to 24 hours
- Slitting the seeds coat longitudinally

Nipping entails breaking the sharp tip of the seed between the fingers. Since Melia seeds are very sensitive to fungal attack, it is important to maintain a clean sterile environment during the pre-treatment process. To reduce chances of fungal infestation at germination, fungicide (such as Ridomil or Bavistin) should be added to the water used for soaking seeds during pre-treatment. The recommended rate of fungicide application is 5 g/l of water. The seeds are then rinsed with 1% sodium hypochlorite solution before slitting. Slitting is achieved by cutting the seed coat longitudinally from the tip that was nipped downward to other end with a clean sterile sharp blade. Care should be taken not to injure the radicle and endosperm.

4.4 Seed Sowing

Sowing in the seed-bed is done immediately after slitting the seedcoat. 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 length of the seed. After sowing, the seedbed is drenched with fungicide e.g. Ridomil at a concentration of 5 g/l of water. The propagator is closed tightly to ensure that the seed-bed remains humid. Temperatures in the propagators should range from 30 – 40 ^{o}C. The months of June, July, and August and rainy seasons are not favorable for Melia germination due to low temperatures. However, an external source of heating may be introduced to raise temperatures of the seed-bed. For example, where electricity is available high voltage bulbs (200 w) can be used. Germination of Melia seeds occurs within 3 - 6 days (Plate 4.2).

Plate 4.2: Melia seedlings germinated in a non-mist propagator

4.5 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 6” x 9” size polythene bags and watered thoroughly. The recommended pricking out (transfer of germinated seedlings to the polythene bags) time is 1-3 days after germination. High mortality and deformed seedlings may result from a delay in pricking out.

4.6 Management of Improved Melia Seedlings in the Nursery

4.6.1 Shading young seedlings

Pricked seedlings are young and tender, hence may suffer desiccation and mortality if exposed to direct sunlight. To protect them from sun damage, pricked out seedlings should be shaded. Shade can be provided with a hessian cloth or any other suitable material. Initially a shading of 70% is recommended within the first two weeks which is then reduced to 50% shading for another 4 weeks. After the 6th week, the shade is removed. During the rainy season, seedlings should be covered with polythene sheet or any other appropriate materials to avoid water-logging that could lead to damping off and other fungal diseases in seedlings.

4.6.2 Watering

Melia seedlings are sensitive to water-logging and so it is important to control watering. Over watering pre-disposes the seedlings to fungal attack (Fusarium spp) causing damping-off disease. Therefore, seedlings should be watered when the potting media is dry.

4.6.3 Root pruning and hardening-off

Root pruning refers to cutting of roots that extend from the potting container to the ground. To determine if root pruning is due, a few seedlings are lifted off the ground randomly to assess if roots have penetrated the ground. Root pruning can be achieved either by systematic transfer of seedlings short distance from their original positions by lifting them off the ground, or cutting any roots that have penetrated the ground with a sharp pruning knife.

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

4.7 Management of Common Pests and Diseases in Raising of Improved Melia Seedlings

Early and prompt diagnosis of pests and disease is important to avoid spread of fungi and pests in the nurseries and in the field. Diseases or pests can spread very quickly with devastating results. Careful monitoring for pests and disease incidences in nursery and field minimizes spread.

4.7. 1 Diseases of Melia seedlings

Diseases of Melia seedlings in the nursery are mainly caused by fungi. The succulent nature of Melia roots creates conducive conditions for fungal infection. Fungal attack causes seed rots, pre- and post- germination damping off and also death. Depending on severity of the attack, impacts vary from losses of just a few seedlings to 100% seedling loss. The major fungi causing diseases in Melia seedlings are the Nectriaceae (*Fusarium* - *Nectria* group) (Plate 4.3). These fungi are both seed-borne and also soil-borne.

Melia seedlings are also affected by powdery mildews which attack the surface of leaves and interface with photosynthesis resulting in yellowing and stunted growth of seedlings.

Plate 4.3: Death of Melia seedling from fusarium root rot

4.7.2 Pest problems associated with Melia seedlings

Nematodes attack in Melia nurseries is often characterized by soft rots of roots and root collar rots, yellowing and death of seedlings. This problem seems to be mainly due to over-watering of seedlings which also increases chances of fungal attack. Other pests that attack Melia seedlings are spider mites (Plate 4.4). Mites belong to the Acari (mite) group family Tetranychidae and are usually found on the underside of leaves. 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 and cause damage by puncturing the plant cells during feeding.

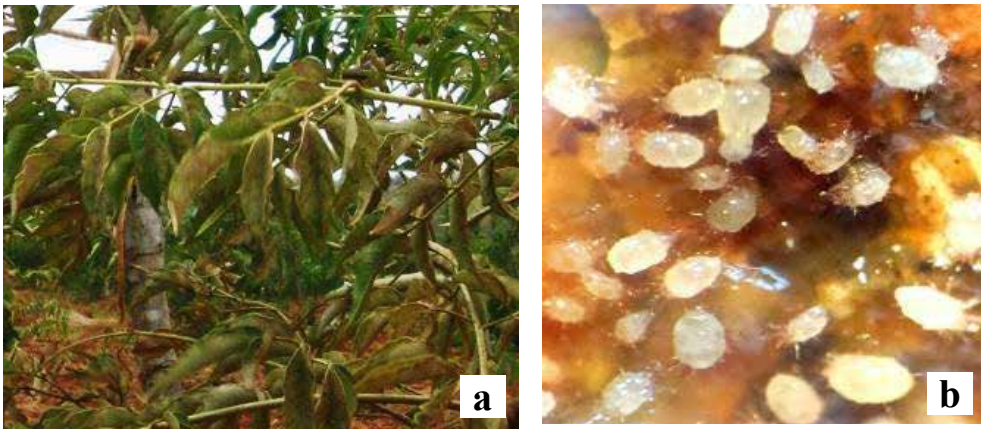

Plate 4.4: Red spider mite infection on: (a) Melia leaves and (b) rotten Melia seedling

4.7.3 Managing nematodes in the improved Melia nursery

It is difficult to eradicate nematodes in infected soils once in use. However, at the nursery level the following steps should be undertaken;

- Sterilize nursery media by subjecting it to high temperatures (over 70 °C). The media should be allowed to cool before it is used in sowing of seeds
- Fumigate soils suspected to be infected by nematodes. Cover the soils with black polythene and add a fumigant and leave it undisturbed for 2 months. Alternatively,
    - ✓ drench the soils with nematicides twice or thrice before planting
      Note: *A chemical drench contains at least 1.5 times the recommended strength of a chemical by the manufacturer*

  OR
    - ✓ Add nematicide powder such as Nemacur or Mocap to nursery pots and when transplanting seedlings
- Avoid over-watering of Melia seedlings as it creates conducive conditions for nematodes to reproduce

4.7.4 Managing spider mites on Melia seedlings

The outside coating of spider mites allows them to resist pesticides. Chemical control methods can therefore become ineffective when the same pesticide is used over a prolonged period.

- Spray seedlings with termiticide or acaricide at 10 to 14 day intervals until the mite population goes down
- Alternate chemicals after about 4 sprays to avoid resistance

4.7.5 Managing diseases during grafting

Grafting is a sensitive process as it can transfer disease from the scion to the root-stock and vice-versa. To prevent disease incidence associated with grafting, observe the following:

- Certify that the root stock and scions are healthy
- Maintain strict hygiene during the grafting process by using clean equipment at all times and surface sterilize grafting knives before grafting
- After grafting and transplanting in the field, spray with systemic fungicides such as Carbendazim (Bavistin 50WP) and Benomyl to improve long term immunity of the growing plants

4.7.6 General management of diseases and pests in improved Melia seedlings production

- Pre-soak Melia seed in fungicide solutions (manufacturers recommended rate) for 12 - 24 hours before sowing. Fungicides include; Benlate, Ridomil, Bavistin and Thiram
- Pre-treat the nipped seeds first with dilute sodium hypochlorite or fungicide solution before sowing and thereafter spray the seedlings every 14 days during the first month and thereafter as may be recommended by a pathologist
- Autoclave infected nursery soil twice if it must be re-used and preferably do not re-plant seedlings in a hole where a seedling has died
- Control mildews by spraying with Agrycop 50 wp (Copper based fungicides) 45g/20 l of water at intervals of 21 days until the mildew clears
- In principle, plant only healthy seedlings and restrict movement of seedlings from areas of infestation
- After transplanting in the field spray once a month with a combination of Mancozeb and Chlorothalonil or sulfur-copper based fungicides (e.g. Baycor EC 300 and Kocide) for six months

Note: *Read the material data sheet and follow the manufacturer's instructions for all chemicals. The drench type mode of application is best for soil based applications.*

CHAPTER 5:TRANSPLANTING AND MANAGEMENT OF IMPROVED MELIA IN THE FIELD

J. Kariuki, B. Kamondo, D. Muchiri, B. Kigwa, S. Auka. and D. Ochieng

5.1 Site Selection and Preparation

Sites for planting Melia should be selected and prepared well in advance before onset of rains. Suitable sites should have sandy soils, sandy loams or sandy clay soils with good drainage. Sites prone to flooding should be avoided as the species is sensitive to water-logging. Melia does not grow well on shallow soils and those with hardpans.

The area to plant Melia should be completely ploughed to improve water infiltration and reduce competition from weeds. After ploughing, staking should be done during the dry season. The staking should be at a spacing of 4 m x 4 m or 5 m x 5 m. Pitting is also done during the dry season by digging pits of 45 cm x 45 cm x 45 cm. Top soil is placed on one side of the pit and sub-soil on the other. Refill the holes starting with original top soil just before the onset of rains and mark the centre of the pit with a stake. The depression left after refilling with top soil will allow the collection of water which is important for initial seedling growth.

5.2 Field Planting

5.2.1 Seedling handling before leaving nursery

Seedlings for field planting should be healthy and free from defects. In the nursery, seedlings should be handled with care and lifting should be by the pot and not by their stems. The seedlings should be well watered before leaving the nursery. Care should be taken to avoid physical damage to both the roots and shoots during loading, transportation, and off-loading. On transit to planting site, the seedlings should be protected from wind and sun burn.

5.2.2 Actual planting

The ideal planting season for Melia is during the long rains which occur in October to December in the eastern and northern drylands but in April - May in coast region. Start planting as soon as the rainy season begins and enough soil moisture build-up attained. To test if the soil has enough moisture, dig up some soil from lower horizons of the planting pit after a few days of continuous rain but on a non rainy day. Then squeeze this soil in your hand. If the soil particles form a muddy wet bond, then this is ideal planting time. Planting should be done early in the morning before the sun becomes too hot. For planting, a hole the size of the seedling container is made in the middle of the planting pit. Gently squeeze the sides of the pot to loosen the potting media and carefully remove the seedling from the bag ensuring as much ball of soil around the roots remain intact. While resting the ball of soil on the palm, and holding the seedling by its root collar, gently place the seedling upright in the hole. Cover the roots to the root collar with soil. Pack the soil firmly around the seedling by hand or foot to maintain good root-to-soil contact which also eliminates air pockets. Where necessary, supplementary watering can be done.

***Note**: It is important to ensure that no water collecting basin is left around the base of the planted seedling.*

5.3 Tending and Management

Tending and management in Melia involves weeding, protection, debuding, pruning and, disease and pest control.

Weeding: For young Melia to establish and grow well, ensure complete weed control for the first 3 years. Complete weed control can be achieved through intercropping with legume crops. Any climber legumes like cowpeas should be avoided and when planted should be approximately one meter away to avoid strangulation of young Melia seedlings.

Protection: The major problem experienced in growing Melia is browsing of young trees by domestic and wild animals. Planted Melia should be fully protected from browsers for up to 2 years after planting, Due to fast growth, and loose and wet soil conditions during the rains Melia occasionally suffers wind blow. In such cases, it is necessary to provide support to young Melia trees.

Debuding: (Plucking off young buds): This is recommended to start as early as one month after planting. Buds if not removed develop into branches which lower the growth rate and quality of timber. It is therefore important to debud as frequently as

necessary. During debuding, all leaves on the seedling should be left intact. Debuding should be done to at least 4 m to provide a clean bole of more than 12 feet. Debuding high up the stem require use of ladders.

Pruning: Branches at the canopy level should be reduced to avoid overhanging and bending of the main stem. Pruning also becomes necessary where debuding is overlooked. A secateur is used for cutting fine branches. For thick branches, a pruning saw is recommended. When using a pruning saw, an undercut is first made followed by an upper cut flash with the stem. Pruning scars should be smeared with topogen to cover the wounds. This minimises avenue for pathogen entry

Singling: Forking is rare in Melia. However, a few seedlings may fork naturally. In such cases singling should be done by removing the weaker stem as early as possible.

Disease and pest control: Melia has few significant pest and diseases at field level. However, there are reported cases of cankers, mites and fungal attack. Any cases of pests and diseases should immediately be reported to KEFRI.

5.4 Harvesting and Utilization

Melia is harvested for timber in 12 - 15 years. With breeding, improved Melia stock could be ready for harvesting in 10 - 12 years. Improved Melia is expected to be harvested mainly for high quality timber with yields estimated to improve by 20%. Currently, it is estimated that a hectare of standing Melia with a stocking of 300 trees yield timber valued at 3.6 million based on a yield of 300 ft per tree and a farm gate price of 40 shillings per ft of 6 x 1 planks. With breeding and correct management, the value is expected to be about 4.3 million shillings per hectare. It is notable that the increased value is also realized earlier due to shortening of rotation.

CHAPTER 6: DEMONSTRATION OF IMPROVED MELIA SEED AND SEEDLINGS

A. Luvanda, S. Ogawa, J. K. Ndufa and J. Musyoki

The purpose of establishing demonstrations is to enable farmers understand economic benefits of improved Melia seed and seedlings for enhanced tree planting. Prices of improved Melia seed and seedlings should fetch higher returns and act as incentive for seed and seedling distributers. Demonstrations also should make it is easy for farmers to recognize the economic advantage of using improved materials in terms of productivity and shortened period for realizing the benefits. Therefore performance of trees from improved Melia seed should be compared to trees established from general seed collection so that farmers can recognize superiority of the improved seeds and seedlings. KEFRI is implementing a demonstration programme to sensitize stakeholders on superiority of using improved Melia seed and seedlings (Figure 6.1).

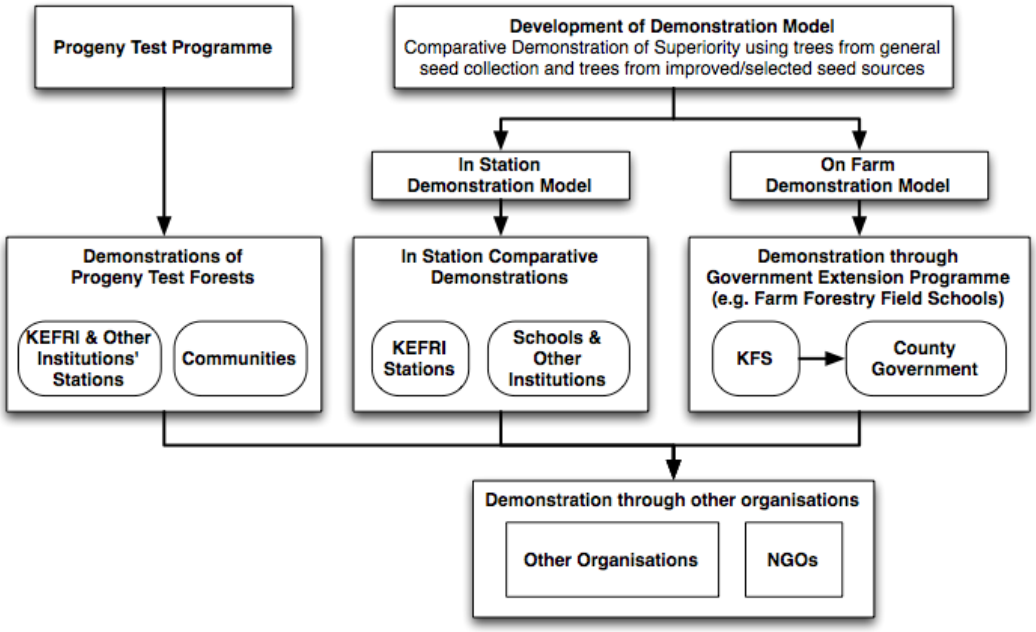

Figure 6.1: Improved Melia demonstration programme

6.1 Demonstration through Progeny Test Sites (Large scale)

KEFRI has established four (4) large scale progeny test sites, which will be used as demonstration for performance of improved Melia trees on large scale (Plate 6.1). The progeny test sites are at Tiva (Kitui County), Tharaka Nithi, Kitui, Makueni and Taita Taveta Counties

Plate 6.1: Melia progeny test site at Marimanti, Tharaka Nithi County 9 months after planting

6.2 On station Demonstrations for Public Institutions (Medium scale)

To promote medium scale comparative demonstrations KEFRI has established four supplementary progeny trials at Tharaka Nithi, Embu, Makueni and Taita Taveta counties in a school, community land and private farm to demonstrate improved Melia in areas accessible to community members. The Melia progeny trials will be compared to Melia trees established from general seed collection (Figure 6.2).

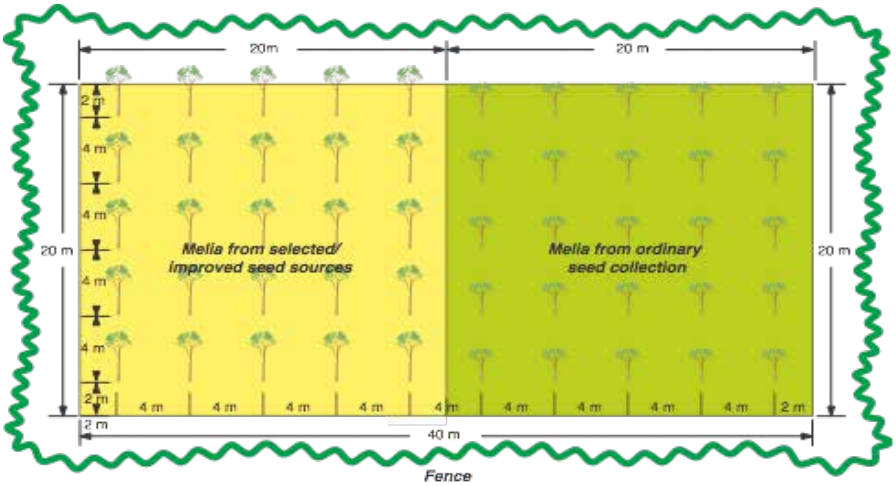

Figure 6.2: Layout for improved Melia performance demonstration plot in Kitui County

6.3 Small Scale On-farm Demonstrations through Government Extension Programmes

KEFRI and KFS have established on-farm demonstrations through FFFS methodology using "Participatory Comparative Experiment (PCE)". The demonstration consists of a woodlot established to compare Melia raised from improved seeds with Melia raised from local collection seed and *Grevillea robusta* trees in Kitui County (Figure 6.3). The PCE will be up-scaled in other selected counties with potential for growing Melia. Up-scaling will be done in collaboration with county governments and relevant NGOs. Growth performance of trees in the demonstration plot is assessed by FFFS members over one-year period which culminates in field day and thereafter graduation ceremony. After the graduation, the demonstration plot is managed by the host farmer but remains accessible to community members for guiding adoption of good performing genotypes.

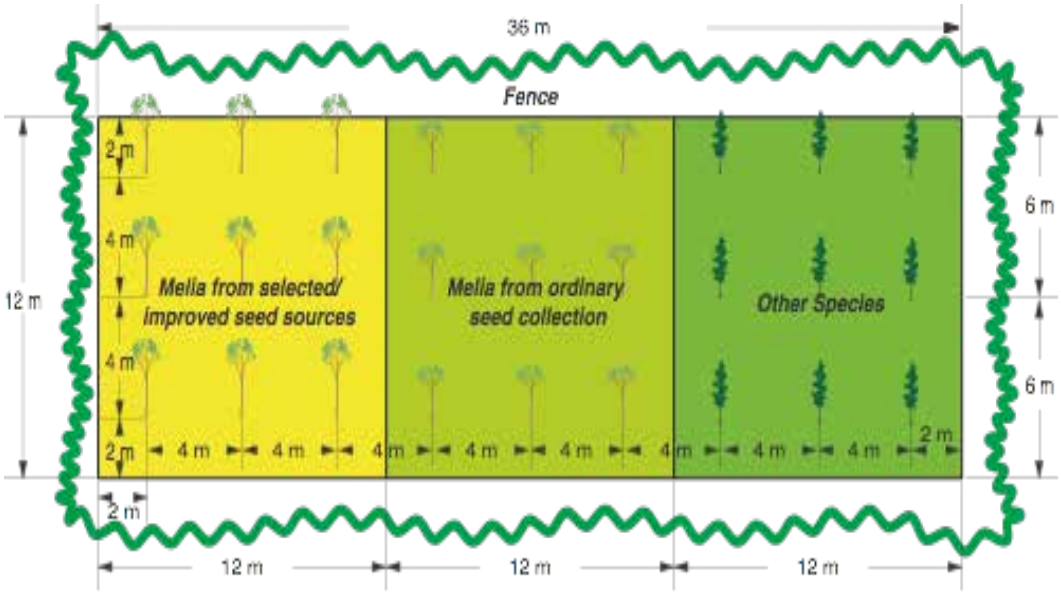

Figure 6.3: Participatory Comparative Experiment (PCE) plot layout

CHAPTER 7: DISTRIBUTION SYSTEM OF IMPROVED MELIA SEED AND SEEDLINGS AND CAPACITY BUILDING

A. Luvanda, S. Ogawa, Y. Takeda, J. Kariuki and B. Kamondo

7.1 Source of Improved Melia Seed and Seedlings

Currently, improved Melia seed is supplied and distributed from KEFRI through Kenya Forestry Seed Centre and/or authorized Eco-region Research Programmes. Upon undergoing training and capacity building, other suppliers such as county governments, individuals and private firms will be registered with KEFRI as improved Melia seed distributors (Figure 7.1). Improved Melia seed will be supplied to public and private institutions, community groups and individuals.

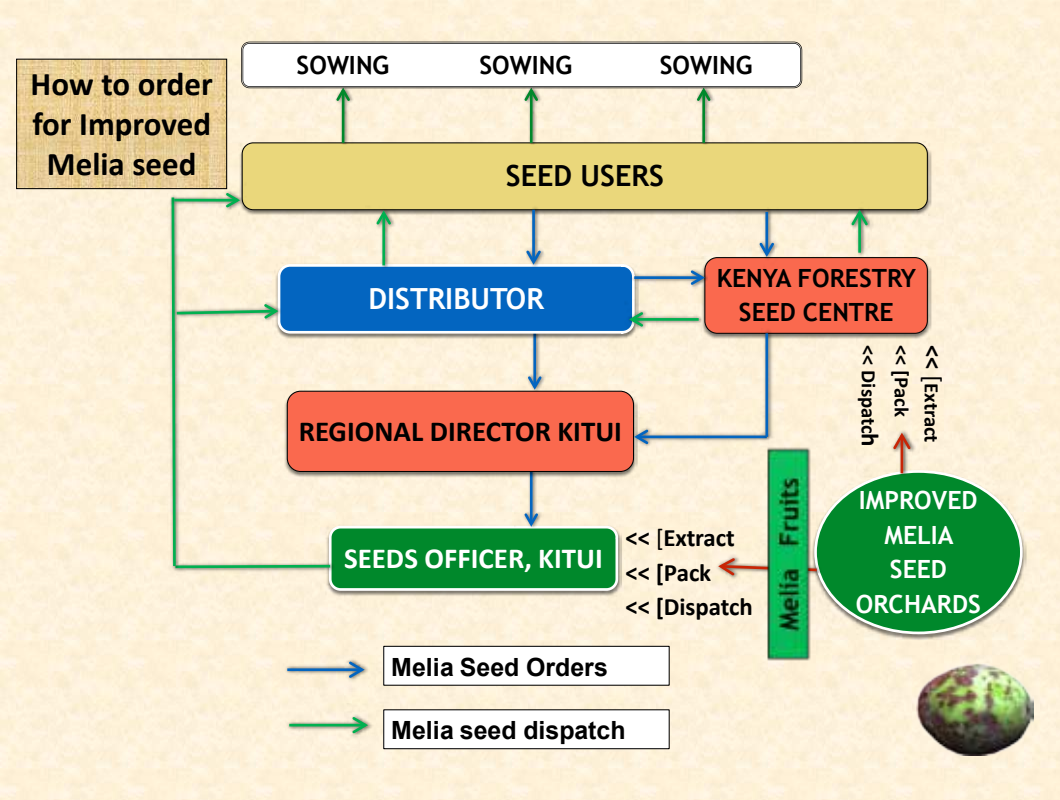

Figure 7.1: Improved Melia Seed procurement process

All distributors shall apply to KEFRI to purchase improved Melia seed and seedlings. They must be trained through "**Training for Distributors of Improved Melia Seed and Seedlings"** course and be registered with Kenya Forestry Seed Centre as improved Melia seed distributors. The distributors must exercise equity, fairness and professionalism when availing improved seed and seedlings to users. KEFRI shall maintain an updated list of improved Melia seed and seedling distributors.

7.2 Record Keeping

Distributors will keep a record of all orders and supply of improved Melia seed or seedlings. This will ensure tracking of products and provision of after sale technical advice as well as resolution of users' problems/complaints. Among important details to keep include customer details, weight required, weight issued, batch number supplied, date of dispatch, and expected number of seedlings.

7.3 Capacity Building through Training

KEFRI in collaboration with KFS will train improved Melia distributors and users on production, distribution and use. Training on improved Melia seed production will be for seed orchard managers while training in distribution will target registered seed distributors. Nursery owners will be trained on seed handling and seedling production from improved Melia seed.

7.3.1 Training for improved Melia seed orchard managers

Establishment of seed orchards and production of improved Melia seeds require specialized training in orchard establishment and management. The training content shall focus on Melia breeding which includes: Principles and objectives of tree breeding; Selection of Melia Candidate Plus Trees (CPTs); Establishment of first and subsequent generation seed orchards; Progeny trials; Seed production and management of Melia seed orchards; and Collection and processing of improved Melia seed.

7.3.2 Training for distributors of improved Melia seed and seedlings

The seed and seedling distributors should understand and appreciate importance of improved Melia seeds/seedlings and participate in dissemination of appropriate information on use of improved Melia seed to stakeholders. The training content shall mainly focus on: Principles and objectives of tree breeding; Principles of tree seed production; Collection and processing of Melia seeds from orchards; Melia seed pre-sowing treatment; Management of Melia seedlings in the nursery; and Institutional and legal environment applicable to use of improved Melia seed. Distributors of improved Melia seed should train and provide customers with instructions on use of improved Melia seed and seedlings using training materials developed by KEFRI such as posters, leaflets, flipcharts and brochures.

7.3.3 Training for users of improved Melia seedlings

The improved Melia seed users should understand and appreciate the importance of using improved Melia seeds/seedlings and techniques of raising Melia seedlings at the nursery. The training content shall mainly focus on: Overview of tree breeding as it applies to Melia; Seed collection, handling and pre-sowing treatment, and Nursery practices for Melia; and Melia plantation establishment and management.

7.4 Marketing of Improved Melia Seed and Seedlings

Improved Melia has potential to improve livelihood of farmers in the drylands through income generation. For this to happen, appropriate marketing of improved Melia seed and seedlings is essential to promote its adoption and subsequent production of better quality Melia timber for tree growers. Relevant public and private players have major roles in improved Melia seeds and seedling production and marketing. With new players in the improved Melia seed and seedling industry, tracking is crucial to ensure that only certified material circulate in the market. Currently, improved Melia seed is supplied and distributed from KEFRI through Kenya Forestry Seed Centre and/or authorized Eco-region Research Programmes but will with time involve other players. Key roles for involvement of various stakeholders in marketing of improved Melia seeds and seedling include the following:

- KEFRI to recruit and register distributors to undertake marketing of improved Melia seed and seedling
- Training registered distributors on relevant business aspects to support marketing of improved Melia seed and seedlings enterprise such as: record and bookkeeping, seasonality, market surveys, and advertising
- KEFRI to use a pricing system that is affordable as a benchmark for improved Melia seed and seedlings value
- Package Melia seed in various quantities to suit needs of different users
- Link improved Melia seed distributors and famers to affordable credit providers and markets to increase demand
- Encourage improved Melia seed and seedling distributors to form cooperatives / associations to boost their savings while at the same time creating an opportunity for purposes of; self-regulation to ensure seed quality, and attract borrowing and lending services

- Promote trade in improved Melia seeds by seed distributors through awareness creation by training, extension services, and advertisement
- Ensure improved Melia seedlings are sold to users at Ksh 50 per seedling at KEFRI nurseries though private nursery can charge higher prices based on production cost and a reasonable profit margin. To achieve an average annual income of at least Ksh 1 million, private Melia nursery owners should target an annual production capacity of about 60,000 seedlings
- Sensitize local farmers and other stakeholders such as KEFRI, KFS and Nyumbani village to step up their efforts in improved Melia seedling production and marketing

The marketing system should ensure increased production of Melia seedlings for research and afforestation programmes during the long rains and peak establishment period (October-December).

CHAPTER 8: INSTITUTIONAL AND LEGAL ISSUES APPLICABLE IN PRODUCTION, DISTRIBUTION AND USE OF IMPROVED MELIA SEED AND SEEDLINGS

B. Kamondo, J. Kariuki, G. Muturi and A. Luvanda

8.1 Institutional Roles

Currently, the main player in production, distribution and use of improved Melia seed is Kenya Forestry Research Institute working in partnership with JICA. In project development, it was anticipated that KEFRI would work closely with Kenya Forest Service (KFS) to facilitate expanded establishment of Melia plantations. In the current dispensation where forestry is a devolved function, KEFRI will work closely with both and the county governments in promoting establishment of improved Melia plantations. It is anticipated that private sector will also have a role to play in production, distribution and use of improved Melia seed and seedlings (Table 8.1).

Table 8.1: Role of key stakeholders in improved Melia production

No.	Institution	Role
1	Kenya Forestry Research Institute (KEFRI)	Continuous breeding and provision of improved materials Improved Melia seed production and supply Provide technical support in development of improved Melia seed orchards in counties Consultancy to private sector in growing Melia Seed distribution though Seed Centre and Eco-region Research Programmes Training Orchard Managers, Producers, Distributors, Retailers and Growers Linkages with other countries Demonstrations of improved Melia through appropriate avenues such as FFS (collaborate with KFS, counties) Tracking and monitoring use and performance of improved Melia

No.	Institution	Role
2	Kenya Forest Service (KFS)	Support counties in extension and demonstration through FFS (Collaborate with KEFRI, counties)
3	County Governments	Extension and demonstration through FFS (collaborate with KEFRI, KFS)
4	Private Sector (Companies, large scale farmers, Seed Distributor)	Contracted improved Melia seed production Planting of improved Melia Distribute improved Melia seed Raise and distribute improved Melia seedlings Instruct customers on use of improved Melia
5	Seedling users	Plant, manage and sell improved Melia products Report challenges and opportunities in improved Melia growing to KEFRI

8.2 Legal Issues

The current seed act (Seed and Plant Varieties Act, CAP 326) mainly deals with agricultural crop seeds. However, regulations to control production and trade in tree seed are under development (Seed and Plant Varieties Act (Tree Seed Regulations)). According to the Tree Seed Regulations, oversight authority on tree seed is vested with the National Tree Seed Advisory Committee. The Committee will be responsible for registration of Tree Seed Dealers. Tree Seed Dealers will be required to have necessary equipment for collection, processing and storage of tree seed and basic training in tree seed production.

Kenya Forestry Research Institute is developing requirements for Tree Seed Dealers (distributors) of improved Melia seed and seedlings. For one to be registered as a distributor of improved Melia seed and seedlings, one must;

- Have own or registered group nursery,
- Be trained by KEFRI and implement the learnt best practices,
- Deal exclusively with improved material provided by KEFRI,
- Grant access to KEFRI for inspection of facilities and seed/ seedlings whenever required, and
- Be willing to train others on improved Melia

KEFRI has developed mechanisms for tracking and identifying improved Melia germplasm through DNA techniques (Figure 8.1). It is therefore easy to ascertain when non improved Melia is passed off as improved material. Such misrepresentation is prosecutable under Kenyan law.

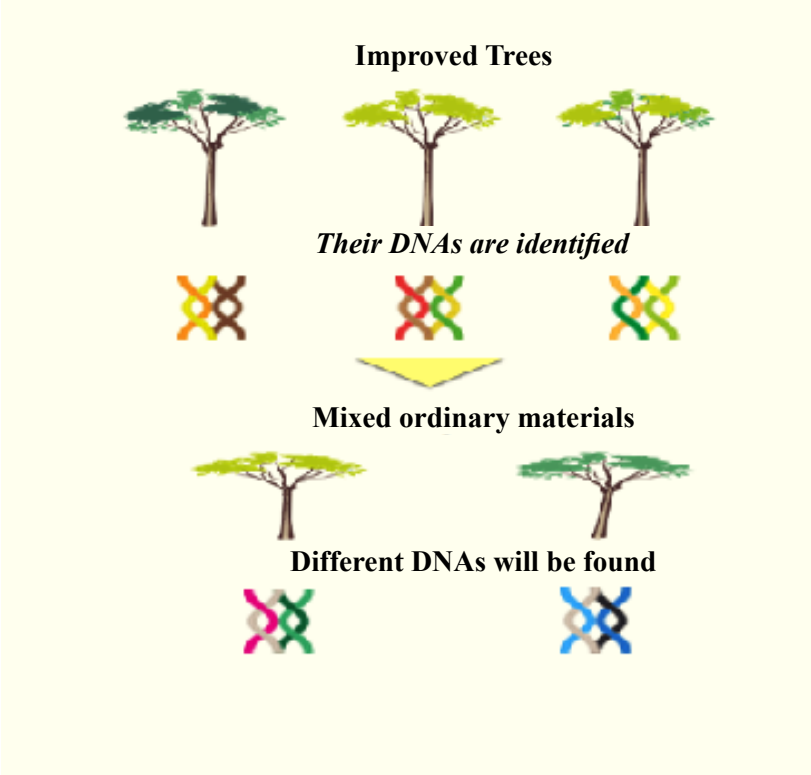

Figure 8.1: Scientific tracking of improved Melia seed /seedlings

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ANNEX 1: IMPORTANT DOCUMENTATION DETAILS FOR VARIOUS ACTIVITIES IN PRODUCTION AND DISTRIBUTION OF IMPROVED MELIA SEED AND SEEDLINGS

Activity	Documentation details
Selection of CPTs	Species, Site data (Temp, Rainfall, AEZ, Altitude, Latitude, Longitude,) Identity, photo, tree parameters (height, dbh)
Seed orchard	Name of seed orchard, Species, date of establishment, spacing, identity of propagation material, seed source category, spacing, clones, ramets, ownership, area, locality, Map, layout, Altitude, Latitude, longitude, soils, rainfall, temp, topography, site history, assessment schedule and record of actions, observations
Seed collection	Date of collection, collectors, species, seed source identity, method of collection, ramet and clones collected, amount collected, transportation containers, identity of seedlot
Seed processing and storage	Species, identity of seedlot, duration of temporary storage, extraction method, amount extracted, drying method, weight stored, running balance
Seed distribution	Species, batch number, customer details, 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
Seedling distribution	Species, seed batch number, customer details, number required, number issued, date of dispatch, planting instructions

Kenya Forestry Research Institute
P.O. Box 20412-00200, Nairobi, Kenya
Tel: +254-724-259781/2, +254-722-157414, +254-20-2010651/2
Email: director@kefri.org
Website: www.kefri.org