

# Guidelines to On-Farm Melia volkensii Growing in the Dryland Areas of Kenya



# Guidelines to Growing *Melia volkensii* in the Dryland Areas of Kenya

Nairobi March 2018



### ©CADEP-SFM /KFS 2018

This publication may be reproduced in whole or in part in any form for educational purposes or non-profit uses without permission of the copyright holder provided acknowledgement is made.

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



### **Cover captions:**

Front top and Back:Melia volkensii plantation (Photo CADEP-SFM)Clockwise:Flower and fruits of Melia volkensii, young seedlings of Melia, a<br/>mature tree of Melia and stylish furniture made using Melia<br/>timber. (Photos CADEP-SFM and BGF)

### For more information contact:

Kenya Forest Service, Headquarters,

Off Kiambu Road, Nairobi P. O. Box 30513-00100, Nairobi, Kenya Email: info@kenyaforestservice.org Tel: +254 20 3754904/5/6, 2014663, 2020285 Fax: +254 20 3764249 Website: http://www.kenyaforestservice.org/

Printed by: Coregra Concepts, Nairobi, Kenya | Email: info@coregra.co.ke

### **FOREWORD**

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

*Melia volkensii* (Mukau) is a multipurpose, fast growing tree that produces high value timber in rotations of between 10 and 18 years. It is therefore, a suitable species for investment in the dry lands.

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

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

The beneficiaries of the Guidelines include; farmers, forest extension agents, producers of Melia tree seeds and seedlings, National and County Governments, NGOs/CBOs / FBOs involved in forestry and/or tree growing, private companies, schools and learning institutions involved in forest and/ or tree resource management activities.

July

Monica N. Kalenda Ag. Chief Conservator of Forests Kenya Forests Service

### ACKNOWLEDGEMENTS

Melia silviculture guidelines and Melia woodlot investment forecast and model are a product of concerted efforts by the CADEP-SFM technical team and other key stakeholders.

Special gratitude and appreciation to the Ag. Chief Conservator of Forests (KFS), Ms. Monica Kalenda and Deputy Chief Conservator of Forests (Farm and Dryland Forestry), Mr. Patrick Kariuki for their wise counsel, guidance and valuable advice throughout the process of writing these guidelines.

Special mention and recognition to the core Technical team; Dr. James Kimondo (KEFRI), Mr. Kenichi Takano, Ms. Naomi Matsue, Dr. Clement Ngoriareng', Ms. Jane Ndeti, Mr. Joseph Njigoya, Ms. Diana Kishiki and Mr. Abednego Osindi who put in long hours in drafting, reviewing, revising and editing this document.

Dr. Kamiri Ndufa (Centre Director, KEFRI, Kitui) offered invaluable support and information during the preparation of this document.

Appreciation also to JICA's short-term consultant, Mr. Shinji Ogawa who proposed and came up with the idea of developing these guidelines. The critical inputs and suggestions by Mr. Jan Vandenabeele of Better Globe Forestry (BGF) including provision of useful photographs is highly appreciated.

Sincere thanks to Dr. Michael Mukolwe (KEFRI) for laboriously editing the entire document. There are other esteemed people who directly or indirectly contributed to the success of this document. Your efforts, dedication and participation throughout the process of writing these guidelines are recognized and appreciated.

Special thanks to the Government of Japan through JICA for providing financial, technical and logistical support that has enabled production and printing of these guidelines.

Peter N. Nduati Project Manager

### **TABLE OF CONTENTS**

FOREW	ORDii
ACKNO	WLEDGEMENTS
LIST OI	F TABLES vi
LIST OI	F FIGURES vi
LIST OI	F TEXT BOX vii
LIST OI	F PLATES
ABBREV	VIATIONS AND ACRONYMS ix
CHAPT	ER 1: INTRODUCTION
1.1	Melia volkensii and its natural distribution 1
1.2	Importance of Melia 1
1.3	Objectives of the guidelines
CHAPT	ER 2: COLLECTION AND PROCESSING OF MELIA SEED 3
2.1	Collection of Melia Fruits
2.2	Seed Processing
	2.2.1 <i>De-pulping</i>
	2.2.2 Seed extraction and packaging
CHAPT	ER 3: RAISING OF MELIA SEEDLINGS
3.1	Nursery Location
3.2	Nursery Seedbeds
3.3	Seed Pre-treatment
3.4	Seed Sowing7
3.5	Potting and Pricking out
3.6	Management of Melia Seedlings in the Nursery
	3.6.1 Shading young seedlings
	3.6.2 Watering
	3.6.3 Root pruning and hardening-off

CHAPT	ER 4: PEST AND DISEASES MANAGEMENT OF MELIA IN THE .	••••
NURSEF	ξΥ	. 11
4.1	Diseases of Melia seedlings	. 11
4.2	Pest problems associated with Melia seedlings	11
4.3	Managing nematodes in the Melia nursery	12
4.4	Managing spider mites on Melia seedlings	12
4.5	General management of Pests and diseases in Melia seedlings production	12
CHAPT	ER 5: MANAGEMENT OF MELIA PLANTATIONS	13
5.1	Selection of planting site	. 13
5.2	Preparation of planting site	. 13
5.3	Methods of site preparation	. 13
5.4	Fencing	. 14
5.5	Spacing	. 15
5.6	Planting	. 15
5.7	Tending	. 17
5.8	De-budding	. 18
5.9	Pruning	. 18
5.10	Thinning	20
	5.10.1 Types of thinning	21
5.11	Harvesting	23
5.12	Pests and diseases of mature melia TREES	23
CHAPT	ER 6: COST AND BENEFIT ANALYSIS OF GROWING MELIA	. 27
6.1	Advantages of growing melia for timber production	27
6.2	Cost and benefit of growing melia	27
REFERI	ENCES	. 30
APPENI	DICES	31

### **LIST OF TABLES**

Table 1:	Summary of revenue returns for various Melia enterprise options	24
Table 2:	Revenue calculations for a Melia tree	25
Table 3:	Comparison of Melia enterprise cost and benefits for different options	25

### **LIST OF FIGURES**

Figure 1:	Distribution of Melia volkensii in Eastern Africa 1
Figure 2:	Silvicultural process of growing Melia2
Figure 3:	Seed of Melia7
Figure 4:	Steps of Melia Seed pre-treatment
Figure 5:	Watering seedlings
Figure 6:	Root pruning using a clean knife
Figure 7:	Diagrammatic spacing of Melia plantationat (a) 5 m x 5 m and (b) 10 m x 5 m
Figure 8:	Demonstration of the preparation of the planting holes16
Figure 9:	After firming soil by hand, squeeze it more by foot 17
Figure 10:	Example of tree classification in thinning
Figure 11 <i>a</i> :	Reducing stock density by removing immediate rows of trees
Figure 11 <i>b</i> :	Reducing stock density by removing alternate rows of trees

### LIST OF TEXT BOX

Text Box 1: Pruning Instruction by BGF	
--	--

### **LIST OF PLATES**

Plate 1:	Melia plantation at Lake Kiambere in Kitui	2
Plate 2:	Melia fruits at different stages of maturity (a) Mature but not ripe, (b) Ripe and ready for collection (c) Overrip	3
Plate 3:	De-pulping of Melia fruits using: (a) Pestle and Mortar	
	(b) Wooden plank and a stone	3
Plate 4:	De-pulped fresh Melia nuts	4

Plate 5:	Drying Melia nuts under the sun 4
Plate 6:	Extraction of Melia seeds from nuts using: (a) Melia nut-cracker and (b) Wooden plank and knife
Plate 7:	Dried Melia seeds
Plate 8:	Non-mist propagators for Melia seed sowing
Plate 9:	Seeds sown in the tunnel under the plastic sheet
Plate 10:	Melia seedlings germinated in non-mist propagator7
Plate 11:	Young Melia seedling from natural gemination in discarded sand
Plate 12:	Seedlings in their first stages after pricking out, protected by plastic tunnels and also shade-netting
Plate 13:	Melia's carrot-like root deformed because of hitting the bottom of the bag9
Plate 14:	Hardening-off of seedlings in full sunlight, and aerial root pruning 10
Plate 15:	(a) Fusarium species, (b) Seed rot and (c) Root rot11
Plate 16:	Red spider mite infection on: (a) Melia leaves and (b) Rotten Melia seedling11
Plate 17:	Death caused by nematode and root infection12
Plate 18:	Example of unsuitable site for Melia plantation (rocky land)13
Plate 19:	Dead dry branches fence14
Plate 20:	A 10-year-old Melia plantation in Tiva with dead dry branches fence in the background14
Plate 21:	Young Melia seedling (a few months old) surrounded by protective fence14
Plate 22:	Barbed wire fence for tree plantation14
Plate 23:	The pitting process: (a) Digging up the pit and (b) Refilling the pit16
Plate 24:	Seven-year old Melia plantation in Kitui County18
Plate 25:	De-budding process: ( <i>a</i> ) before de-budding ( <i>b</i> ) de-budding, and ( <i>c</i> ) de-budded stem
Plate 26:	Properly pruned Melia to $^{2}/_{_{3}}$ height
Plate 27:	Appropriate pruning method-start: <i>(a)</i> with an underside cut and <i>(b)</i> finish off with an upper cut19
Plate 28:	Proper pruning. Clean bole up to 5 m20
Plate 29:	A home-made wooden ladder fixed with ropes20

Plate 30:	A Melia woodlot showing canopy closure due for thinning	21
Plate 31:	Stem canker on Melia tree ( <i>a</i> ) most likely from fungal infection and ( <i>b</i> ) with exudation of gum	24
Plate 32:	Flooring boards (2cm thickness) made out of Melia timber (1-inch thickness)	29
Plate 33:	Vanished samples of Melia timber	29
Plate 34:	Furniture of Melia timber: (a) Cupboard and (b) Bench	29

### LIST OF APPENDICES

Appendix 1a:	Cost and benefit analysis for on-farm Melia enterprise intercropped with cow peas 10m x 5m option (Round Wood)
Appendix 1b:	Cost and benefit analysis for on-farm Melia enterprise intercropped with cow peas 10m x 5m option (Sawn Timber)
Appendix 2a:	Cost and benefit analysis for on-farm Melia enterprise intercropped with cow peas 5m x 5m option (Round Wood)
Appendix 2b:	Cost and benefit analysis for on-farm Melia enterprise intercropped with cow peas 5m x 5m option (Sawn Timber)
Appendix 3:	The schedule of various activities involved in raising Melia plantation

### **ABBREVIATIONS AND ACRONYMS**

ASAL	Arid and Semi-Arid Land			
BCA	Biological Control Agent			
BGF	Better Globe Forestry			
CADEP -SFM	Capacity Development Project for Sustainable Forest Management in the Republic of Kenya			
CBO	Community-Based Organisation			
cm	Centimetre(s)			
DAP	Dia-ammonium Phosphate (fertilizer)			
DBH	Diameter at Breast Height			
FAO	Food and Agriculture Organization of the United Nations			
FBO	Forest-Based Organisation			
ft	Feet			
ha	Hectare(s)			
JICA	Japan International Cooperation Agency			
KEFRI	Kenya Forestry Research Institute			
KFS	Kenya Forest Service			
kg	Kilogramme(s)			
Ksh	Kenya Shillings			
m	Metre(s)			
NGO	Non-Governmental Organisation			
US\$	United States of America Dollar			
yrs	Years			

## **CHAPTER 1: INTRODUCTION**

### 1.1 Melia volkensii and its Natural Distribution

*Melia volkensii* is a multipurpose deciduous tree that is endemic to drylands of Eastern Africa with natural distribution range in Ethiopia, Kenya, Somalia and Tanzania (Figure 1). It grows in sandy-clay and shallow stony soils but prefers sandy soils with good drainage from 0-1,700 m above sea level in areas with mean annual rainfall of between 300 – 800 mm and temperature range of 26-38°C. The species belongs to the Meliaceae family and is locally known as Mukau (Kamba, Tharaka, Mbeere), Tile (Boran), Bamba (Oromo), Maramarui (Samburu), Boba (Somali) and Kirumbutu (Taita) (Kamondo *et al.*, 2016).



Figure 1: Distribution of Melia volkensii in Eastern Africa

### 1.2 Importance of Melia

Melia is a fast-growing tree attaining a height of up to 20 m and 40 cm diameter in 10 to 18 years, depending on site conditions. It is highly preferred in the drylands because of its drought tolerance, high quality and termite resistant timber. Other products of Melia include poles, posts, fodder, medicine, firewood and bee forage (Luvanda et al., 2015). However, a 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.



Plate 1: Melia plantation in Kitui, 10-year old with spacing 4 m x 4 m at the shores of Kiambere dam

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.

### 1.3 **Objectives of the Guidelines**

The potential for forest and tree growing expansion is more in the arid and semiarid lands (ASALs) of Kenya. This is unlike high potential areas where there is intense competition for land between forestry and agriculture. This document will be continuously updated as new research and/or information emerge.

The Guidelines outline the entire process of growing Melia including: seed collection, seed processing and handling for production of healthy seedlings. More emphasis is laid on the field management aspects of site selection, land preparation, planting, tending and all silvicultural treatments of Melia to its harvesting (Figure 2). The Guidelines also provide a cost-benefit analysis of growing Melia for income generation to facilitate farmers or tree growers to make informed investment decisions.



Figure 2: Silvicultural process of growing Melia

### CHAPTER 2: COLLECTION AND PROCESSING OF MELIA SEED

### 2.1 Collection of Melia Fruits

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



Plate 2: Melia fruits at different stages of maturity (a) Mature but not ripe, (b) Ripe and ready for collection (c) Over-ripe

### 2.2 Seed Processing 2.2.1 De-pulping

Immediately after harvesting, Melia fruits are de-pulped using a pestle and mortar (Plate 3*a*). Alternatively, de-pulping can be done by placing an individual fruit on a piece of timber or stone and hitting with a plank of wood (Plate 3*b*).



Plate 3: De-pulping of Melia fruits using: (a) Pestle and mortar (b) A wooden plank and a stone

The nuts are then washed thoroughly, and sun dried for at least two days (Plates 4 and 5). Seven (7) kg of fruits yield about one (1) kg of clean nuts.



Plate 4: De-pulped fresh Melia nuts



Plate 5: Drying Melia nuts under the sun

### 2.2.2 Seed extraction and packaging

Melia seeds are extracted from nuts using either a Melia nut cracker (Plate 6*a*) or a knife and wooden plank (Plate 6*b*). The Melia nut cracker is a tool developed by KEFRI and has adjustable mechanism for cracking nuts of different sizes. When a knife and wooden plank are used in extracting seed, the nut is placed in a groove carved out on the plank of wood. Different sizes of grooves may be made on one plank of wood to accommodate nuts of different sizes. The nut is placed in the groove and a cut is made at right angle, i.e. perpendicular to the nut length, slightly off-centre near the blunt end of the nut. Seeds extracted from freshly de-pulped ripe fruits are brown while those extracted from old de-pulped nuts are black (Plate 7).



Plate 6: Extraction of Melia seeds from nuts using: (a) Melia nut-cracker and (b) Wooden plank and knife



**Plate 7: Dried Melia seeds** 

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

Tree growers are encouraged to source their improved certified Melia seeds from the KEFRI Tree Seed Centre in Muguga or Kitui. The current prices of Melia seeds at KEFRI are Ksh. 4,000 per kg for local type and Ksh. 6,000 per kg for improved type as of March 2018.

The advantages of using improved certified seeds are: clean seeds, guaranteed quality assurance, new genetics (better yields, drought tolerance, pest resistance), faster growth and high germination rates.

For any further information, please access KEFRI's website: www.kefri.org/wp-content/uploads/PDF/SEED%20CATALOG.pdf.

### **CHAPTER 3: RAISING OF MELIA SEEDLINGS**

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

### 3.1 Nursery Location

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

### 3.2 Nursery Seedbeds

Melia seed should be sown in a seedbed filled with sterilised river sand. The sand can be sterilised by drenching it using 450 millilitres (ml) of sodium hypochlorite e.g.  $\mathcal{J}IK$  in 20 litres of water and sprayed with a fungicide. Melia is best sown in raised seedbeds covered by clear polythene sheet. A non-mist propagator can also serve as a suitable substitute. A non-mist propagator consists of a simple frame of timber covered with clear polythene sheet (Plate 8).



Plate 8: Non-mist propagators for Melia seed sowing

The propagator is filled with the clean river sand to a depth of 15-20 cm and its lid closed to avoid contamination. Small propagators can also be improvised using perforated washing basins covered with polyethylene sheet and tightly wrapped with rubber-band to hold the sheet in place. Tunnels can also be used (Plate 9).

> Plate 9: Seeds sown in the tunnel under plastic the sheet (right)



### 3.3 Seed Pre-treatment

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

- Step 1: Nipping the seeds by breaking the sharp tip of the seed between the fingers.
- Step 2: Soaking the seeds in cold water for 12 to 24 hours.
- Step 3: Slitting the seed coat longitudinally.

Plumule Seed coat

**Figure 3: Seed of Melia** 

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



Figure 4: Steps of Melia Seed pre-treatment

### 3.4 Seed Sowing

Sowing in the seedbed is done immediately after slitting the seed coat. The pre-treated seeds are spread on clean river sand that has been thoroughly watered and covered with a layer of sand equal to double the thickness of the seed. After sowing, the seedbed is drenched with suitable fungicide. The propagator is closed tightly to ensure that the chamber inside the seedbed remains humid. The months of June, July and the rainy seasons are not favourable for Melia germination due to low temperatures. Germination of Melia seeds occurs within 3-6 days (Plate10).



### 3.5 Potting and Pricking Out

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

> Plate 11: Young Melia seedling from natural germination in discarded sand(right)



### 3.6 Management of Melia Seedlings in the Nursery

### 3.6.1 Shading young seedlings

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

Seedlings can also be put in a tunnel during the first 2-3 weeks to protect them against cold spells at night (Plate12). Tunnels are opened during the day and closed at night to observe right temperature and moisture levels.





Plate 12: Seedlings in their first stages after pricking out, protected by plastic tunnels and also shade-netting

### 3.6.2 Watering

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

### 3.6.3 Root pruning and hardening-off

Root pruning refers to cutting of roots that extend from the potting container to the ground. Unpruned roots is confirmed by seedlings sticking on the ground. Root pruning can be achieved either by lifting seedlings off the ground, systematic transfer of seedlings or cutting any roots that have penetrated the ground with a clean sharp knife (Figure 6), (TEAC; FAO, 2013).





Figure 5: Watering seedlings





Plate 13: Melia's carrot-like root, in this case deformed because of hitting the bottom of the bag

Melia seedlings develop a carrot-like root which is full of nutrients and oils that allow them to survive dry circumstances (Plate 13).

Hardening-off is the gradual exposure of seedlings to field conditions just before out-planting. This is achieved by reducing the watering frequency and exposing the seedlings to full sunlight. Seedlings are ready for planting out in the field when they are 30 cm tall. Guidelines to On-Farm Melia volkensii Growing in the Dryland Areas of Kenya



Plate 14: Hardening-off of seedlings in full sunlight and aerial root pruning (open ended polybags or sleeves)

## CHAPTER 4: DISEASES AND PEST MANAGEMENT OF MELIA IN THE NURSERY

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

### 4.1 Diseases of Melia Seedlings

Diseases of Melia seedlings in the nursery are caused by fungi mainly *Fusarium* spp (Plate 15*a*). Fungal attack causes seed rot (Plate 15*b*), root rot (Plate 15*c*) and eventually no germination or death. Depending on severity of the attack, impacts vary from losses of just a few seedlings to 100% seedling loss. Melia seedlings are also affected by powdery mildews, which attack the surface of leaves and interfere with photosynthesis, resulting in yellowing and stunted growth of seedlings.



Plate 15: (a) Fusarium spp, (b) Seed rot and (c) Root rot

### 4.2 Pest Problems Associated with Melia Seedlings

Nematode attack in Melia nurseries is often characterized by soft rot of roots and rootcollar rot, yellowing and death of seedlings mainly due to over-watering. Other pests that attack Melia seedlings are spider mites (Plate16). Mites suck sap from the leaves of Melia seedlings, which turn yellowish grey or whitish grey and sometimes cause death. Mite infections are favoured by hot and dry weather.



Plate 16: Red spider mite infection on: (a) Melia leaves and (b) Rotten Melia seedling

### 4.3 Managing Nematodes in the Melia Nursery

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

- Sterilize nursery media by subjecting it to high temperatures by heating/baking (over 70°C). Allow the soil to cool before it is used for sowing of seeds.
- Fumigate soils infected by nematodes.
- Cover the soils with black polythene and leave it undisturbed for 2 months. Alternatively, drench the soils with nematicides twice or thrice before planting.
- Add nematicide powder such as *Nemacur* or *Mocap* to nursery pots during the transplanting of seedlings (Plate 17).
- Avoid over-watering of Melia seedlings.
- Mixing Neem extract with the media to act as a repellent to the nematodes.



Plate 17: Death caused by nematode and root infection

### 4.4 Managing Spider Mites on Melia Seedlings

In managing spider mites, the following steps can be undertaken:

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

### 4.5 General Management of Pests and Diseases in Melia Seedlings Production

The following steps can be used to reduce incidence of pests and diseases:

- Pre-soak Melia seed in fungicide solutions for 12 24 hours before sowing.
- Pre-treat the nipped seeds first with dilute sodium hypochlorite e.g.  $\mathcal{J}IK$  before sowing and subsequently spray them every 14 days during the first month.
- Spray with systemic fungicide Ridomil (active ingredient Mancozeb and Metalaxyl) against blights.
- Control mildews by spraying with Copper oxychloride or Agrocop 50 wp (Copper based fungicides) 45g/20 litres of water at intervals of 21 days until the mildew clears.
- Rotate the nursery site to reduce build-up of pests and diseases.
- Use of biological control agent (BCA), *Trichoderma* against Fusarium. Trichoderma can be purchased from some companies, such as Real IPM Ltd. (Thika, Kiambu County), Dudutec (Naivasha, Nakuru County) and JUANCO (Ngong, Nairobi County).
- As a rule of thumb, plant only healthy seedlings and avoid seedlings from areas of infestation.

### **CHAPTER 5: MANAGEMENT OF MELIA PLANTATIONS**

### 5.1 Selection of Planting Site

An appropriate site for Melia planting should be gently sloping such that no water logging can take place. The species requires well drained soils that are either sandy, sandy loam or sandy clay. The tree is fast growing and therefore, requires soils with high plant nutrients. Rocky and poor sites should be avoided (Plate 18).

For the purpose of management, the sites should be accessible to facilitate the implementation of the various silvicultural operations such as the site preparation, delivery of seedlings, planting, weeding, de-budding, pruning, thinning and harvesting of the trees.



Plate 18: Example of unsuitable site for Melia plantation (rocky land)

### 5.2 **Preparation of Planting Site**

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

### 5.3 Methods of Site Preparation

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

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

appropriate than the others because they enhance the breaking of the hardpan and deep sub-soiling, which greatly improves survival and growth of seedlings. Any planting site can be sprayed with a weed-killer, as pre-planting land preparation. A chemical like glyphosate, is suitable for spraying. This is a cheaper way of land preparation.



Plate 19: Dead dry branches fence



Plate 20: A 10-year-old Melia plantation in Tiva with dead dry branches fence in the background



Plate 21: Young Melia seedling protected by a fence (used when a few trees are planted)



Plate 22: Barbed wire fence for tree plantation

### 5.4 Fencing

The selected site should therefore, be fenced to protect the young seedlings from browsing animals. There are different types of fences that can be used for Melia plantation (Plates 19-22). Donkeys, goats and cows are known to de-bark Melia trees, hence it is recommended that the fence should be maintained throughout the life of the plantation/woodlot.

### 5.5 Spacing

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

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



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

Spacing can also be influenced by lopping off branches to provide dry season fodder for livestock. Repeatedly lopped trees tend to grow a narrow canopy of columnar shape, which is more conducive to smaller spacing, hence more trees per hectare.

### 5.6 Planting

The process of planting starts with staking out the prepared site at the recommended spacing and digging out the holes or pits. The purpose of digging the planting hole is to make the soil loose so that the roots of Melia can easily penetrate into the soil. The loose soil can also hold and retain more moisture. Planting holes should be prepared during the dry season and be at least 45 cm x 45 cm x 45 cm in size. Larger pits are however, advantageous during the initial stages of tree growth as they collect, store more rain water and avail it to the growing seedling for a longer period. When digging the pit, the top soil should be put on one side and the subsoil on the opposite side (Plate 23a).

After attaining the required depth of the pit, top soil should be used to refill it first. Subsoil is then used to top up the pit (Plate 23b) to the ground level. If manure is available, this should be mixed with subsoil and used to refill the pit. This enhances the amount of plant nutrients available to the seedling directly to the roots. Once the hole has been refilled, the stake should be returned at the centre of the pit.



Plate 23: The pitting process: (a) Digging up the pit and (b) Refilling the pit

The above process is shown diagrammatically in Figure 8 below.



Figure 8. Demonstration of the preparation of the planting holes

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

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

# Figure 9: After firming soil by hand, squeeze it more by foot (right)



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

The firm contact of the soil particles and the root hairs enhances the uptake of nutrients and moisture from the soil.

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

Melia seedlings should not be planted inside the water harvesting structures, including in those areas receiving very limited amount of rainfall. On sloping ground, farmers are encouraged to make soil conservation structures along the contours spaced appropriately. An example is a *"fanya-chini"* terrace where soil is put on the lower side of the contour trench. The resulting embankment can be used to grow fodder for livestock. It is useful not only to conserve soil but also to divert water. If possible, the soil to fill the pit can be mixed with manure (fertilizer), ashes (lots of Potassium for drought resistance) or charcoal dust (fixing humidity), in a ratio of soil: manure: ashes: charcoal dust of 6:2:1:1.

### 5.7 Tending

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

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



Plate 24: Seven-year-old Melia plantation in Kitui County, showing the result of regular spraying with glyphosphate in a 2 m wide strip alongside the tree lines. At this stage, the trees do not need the spraying anymore, because of canopy closure that naturally suppresses the weeds and grasses.

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

### 5.8 **De-budding**

De-budding of Melia should only be done during the first year of planting. The tiny developing buds (Plate 25a) should be removed by hand while preserving the branchlets up to half height of the tree (Plate 2b and c). This exercise should be done as soon as the buds appear during the first year, after which de-budding should be stopped. Whenever it becomes difficult to remove the buds by hand, use of secateurs is recommended



Plate 25: De-budding process: (a) Before de-budding (b) De-budding, and (c) De-budded stem

### 5.9 Pruning

Pruning of Melia should be from the second year. It should be carried out after considering three factors; 1) trees with double leaders; 2) possession of large branches (relative to stem diameter and height, e.g. larger than 1 inch); and 3) presence of whorls. If double leaders are observed, it is recommended to remove one of them as early as

possible. This is to ensure that the tree has only one main leader. Removal of branches is applied selectively, by considering their size in relation to the main stem. If the branches are of large diameter and appear to be competing with the main stem, they should be pruned irrespective of their location on the tree. Smaller branches should be left as they have little effect on the main stem.

Reduction of branches at the whorls is encouraged to retain an appropriate number that leaves the tree balanced on all sides. The branches that develop from the same position on the tree should be gradually removed. Selective pruning to remove all branches with diameters above 2.5 cm should be undertaken as appropriate until the trees attains a clear bole of at least 8 m or up to age 5 years (Plate 26). Selective pruning of individual trees should be up to a maximum of two thirds of their total height.



Plate 26: Properly pruned Melia to 2/3 height

Pruning should be carried out just before the onset of the rains to enhance growth and healing of the wound. Pruning tools should be disinfected by use of disinfectants, e.g. Hydrogen peroxide every time a tree is pruned. The operation should start by making an under-side cut (Plate 27a) and finish with an upper side cut (Plate 27b) to ensure there is no tearing of the bark.



Plate 27: Appropriate pruning method-finish off : (a) with an underside cut, and (b) with an upper cut

Over-pruning a tree will result in production of epicormic shoots that have to be removed again and will stimulate the tree to grow more branches higher up the stem, where less pruning takes place because it is more difficult to attain. This often results in trees with a clean bole of 3 m high and a dense canopy, while the potential length of the clean bole could be 5-6 m. This results in a serious financial loss for the grower. In particularly good sites, a clean bole of 7-8 m length can be achieved. Most pruning is achieved by year 4, and it is important to prune high up the stem, using a ladder (Plates 26 and 29). In addition, Text Box 1, provides a case study on pruning instruction by Better Globe Forestry (GBF).

### CASE STUDY: Pruning Instruction by Better Globe Forestry

### Main objectives:

- Producing a clean bole of minimum 5 m long with 10 cm DBH by year 4. All pruning scars must be inside this inner core of 10 cm diameter.
- 2. Produce a stout, fat stem for the young seedling (1-2 years) that is not top-heavy and that does not bend over through a gust of wind.

### Steps:

- Year one: no pruning, except for removing double leaders and whorls.
- Year two: pruning after rains (May/Jun and Nov/Dec)
- Year three: 2-4 passages
- Year four: 2-4 passages

### Notes:

- Branches are removed selectively with the biggest ones (2.5 cm) going and the smaller ones staying. This goes also for whorls.
- Take care to leave branches along the stem to allow for increased diameter growth so that the stem gets stronger and will not bend easily in the event of strong winds i.e. DO NOT REMOVE BRANCHES LESS THAN 2.5 CM
- This is NOT the cleaning of the stem of branches like in the case of pine or cypress trees.
- Special attention to reduce branch density towards the TOP of the tree.

Text Box 1: Pruning Instruction by BGF



Plate 28: Proper pruning. Clean bole up to 5 m



Plate 29: A home-made wooden ladder to help in pruning. It is fixed with ropes to the stem of a Melia tree.

### 5.10 Thinning

The main objective of thinning is to enhance the growth of the remaining trees for optimum production of timber. The 1<sup>st</sup> thinning should be carried out at 6-7 years by removing 25% of the original planting density of 400 to leave 300 stems/ha. The 2<sup>nd</sup> thinning should be carried out approximately 3 years after the 1<sup>st</sup> thinning or when the canopy closes up. The 2<sup>nd</sup> thinning reduces the tree density from 300 to 200 stems/ha. During the thinning operation, the dead, weak, diseased, deformed or crooked trees should be removed. In relatively poor sites, the thinning operation may be delayed as the trees grow slowly before canopy closure.



Plate 30: A Melia woodlot showing canopy closure due for thinning

In situations where the criterion applied above does not attain the required density, the remaining trees should be removed in such a way that the trees left are uniformly distributed in the plantation. The removed materials can be utilized as poles, firewood or timber depending on their size. The best time for thinning operation is during the dry seasons when the trees are not growing actively. This period is also off-farm season and easy to get human resources for the operation.

### 5.10.1 Types of thinning

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

### a) Qualitative thinning

In qualitative thinning operation, trees with unfavourable characteristics such as the dead, weak, diseased, deformed or crooked are removed. This is the first option to be taken in thinning operation. It is also recommended to classify the standing trees according to a criterion such as good, fair and inferior to mark those trees to be removed before starting the thinning operation (Figure 10). In case the tree spacing after the theoretical removal of the marked trees is considered as relatively high, some of the marked trees can be left standing even though their characteristics are not very good. After qualitative thinning operation, the stock density should be assessed, and if the number of trees is relatively high to create sufficient spaces for remaining trees, some good trees should be removed in order to achieve the target stock density in such a way that the trees left are uniformly distributed in the plantation.



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

### b). Quantitative thinning

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



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



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

The contractor buying the thinned material should not be allowed to carry out thinning without proper supervision. However, this can only be done where trees to be thinned are clearly marked and these are the only trees to be cut.

### 5.11 Harvesting

It is advisable that when the planted trees attain a diameter at breast height (DBH) of at least 30 cm, the trees can be harvested. In sites with moderately poor soil conditions and very low rainfall, it may take about 18 years to reach such diameters. However, the same diameters can be attained earlier in sites that have more favourable conditions and with better management practices. Generally, it is recommended to harvest Melia trees from the age of 12 years because wood properties for timber do not change significantly with age after this. From a sawmilling point of view, bigger diameters like 40-50 cm are more advantageous, and will produce planks of bigger sizes, that command a premium price. On a good site, these diameters will be achieved after 15-20 years.

### 5.12 Pests and Diseases of Mature Melia Trees

Melia trees have few significant pest and diseases in the plantations. However, there are reported cases of cankers, mites and fungal attack on the main stems (Plate 31). Cases of hear rot have also been observed in the field, and they seem to be stimulated by stress conditions (extended periods of drought, unfertile soils). While there may be no known remedies to these cases, any cases of pests and diseases should be reported immediately to the nearest Forest office. Old trees of 20 years and above are susceptible to the disease which affects heart wood, hence the quality of timber. Unfortunately, there is no economically feasible fungicide to use on a heart rot hosting tree. The best way to prevent heart rot is to keep your tree healthy using proper management techniques such as:

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





Plate 31: Stem canker on Melia tree (a) most likely from fungal infection and (b) with exudation of gum

### CHAPTER 6: COST AND BENEFIT ANALYSIS OF GROWING MELIA

### 6.1 Advantages of Growing Melia for Timber Production

Melia wood has many advantages, similar to the other high quality of hardwoods, such as mahogany, teak (*Tectona grandis*) and mvule (*Milicia excelsa*). Its timber compares well with those of other important valuable indigenous tree species such as Meru Oak (*Vitex keniensis*) and East African Camphor (*Ocotea usambarensis*). The timber is suitable for different purposes, such as furniture, panelling, door and window framing, floor parquets and poles. In Kenya, the current timber demand greatly exceeds supply. Dealing with a high quality and valuable timber such as that of Melia will be good business investment as the country meets the high timber demand.

### 6.2 Costs and Benefits of Growing Melia

A tree grower has the option of selling the trees as round wood (standing trees) or convert them into timber for domestic and/or commercial use.

With the correct silvicultural treatments, Melia is expected to attain an average DBH of 30 cm with a height of 9 m in 18 years. The current farm-gate price per tree is Ksh. 5,000 as compared to the expected Ksh. 8,000 from a well-managed plantation with a rotation age of 18 years. However, if the tree grower opts for the sawn timber option, each tree is expected to fetch Ksh. 9,300 after deducting sawing cost. Tree growers are advised whenever possible to sell the final product as sawn timber as this will fetch better returns. The details are described in Appendices 1-2. The summary of the expected revenue from the various Melia enterprise options are shown in the Tables 1 to 3.

Item/Activity	Round wood 10m x 5m	Timber 10m x 5m	Round wood 5m x 5m	Timber 5m x 5m
	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)
Final crop proceeds (approx. DBH of 30 cm) -sawn timber	1,600,000	2,403,000	1,600,000	2,403,000
Gross income	3,520,000	4,603,000	2,670,000	3,753,000
Net income (18 years)	3,057,200	3,344,800	2,145,400	2,688,400

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

Timber Measurements	Timber pieces	Running feet	Unit cost (Ksh.)	Total (Ksh.)
4" x 2" x 15'	2	30	75	2,250
3" x 2" x 15'	10	150	50	7,500
2" x 1" x 15'	6	90	25	2,250
Total		270		12,000
Cost of sawing		270	ft x Ksh. 10 per ft	2,700
Profit				9,300
Cost of Melia tree after deducting transport and profit for the buyer				8,000

### Table 2: Revenue calculations for a Melia tree

### Table 3: Comparison of Melia enterprise cost and benefits for different options

Item/Activity	Round wood 10m x 5m	Timber 10m x 5m	Round wood 5m x 5m	Timber 5m x 5m
	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)
(a) Inputs - cost				
Seedling	12,000	12,000	24,000	24,000
Cow peas seeds	21,600	21,600	10,800	10,800
Pesticides (Act force, cyper force or cyperdiforc)	54,000	54,000	27,000	27,000
Fertilizer (DAP)	54,000	54,000	27,000	27,000
Total cost	141,600	141,600	88,800	88,800
(b) Labour for Melia cost	-	-	-	-
Cutting stakes	400	400	400	400
Staking out (marking planting points)	400	400	400	400
Pitting (45 cm x 45 cm x 45 cm)	1,600	1,600	3,200	3,200

Guidelines to On-Farm Melia volkensii Growing in the Dryland Areas of Kenya

Item/Activity	Round wood 10m x 5m	Timber 10m x 5m	Round wood 5m x 5m	Timber 5m x 5m
	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)
Planting (fill the planting hole to the top to ensure no water settles at the base)	400	400	400	400
Beating up (20%)	400	400	400	400
De-budding (4 times in a year for 1 years	1,600	1,600	1,600	1,600
Pruning for up to 5 years (Remove all branches with more than 1-inch diameter. Also heavy branching at the nodes should be reduced)	7,200	7,200	16,000	16,000
Slashing (year 4 to year 7)	-	-	32,000	32,000
1 <sup>st</sup> thinning (at age 6-7 yrs)	-	-	800	800
2 <sup>nd</sup> thinning (3 yrs after 1 <sup>st</sup> thin)	-	-	400	400
Clear fell (cost of harvesting final crop at age 18 yrs)	-	-	-	-
Cost of sawing timber	-	540,000	-	540,000
Total (Ksh.)	12,000	552,000	55,600	595,600
(c) Labour for Food crops (Cow peas) cost	-	-	-	-
Land preparation (clearing and harrowing)	25,000	25,000	13,000	13,000
Planting	7,200	7,200	1,200	1,200
Weeding (4 times)	192,000	192,000	96,000	96,000
Grain harvesting and threshing	48,000	48,000	24,000	24,000
Total	247,200	502,600	318,200	318,200
(d) Other costs	-	-	-	-
Transportation of seedling	2,000	2,000	2,000	2,000

Item/Activity	Round wood 10m x 5m	Timber 10m x 5m	Round wood 5m x 5m	Timber 5m x 5m
	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)	Amount (Ksh.)
Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	60,000	60,000	60,000	60,000
Total cost	62,000	62,000	62,000	62,000
Total expenditure (a+b+c+d)	462,800	1,258,200	524,600	1,064,600
Benefits	-	-	-	-
Cow peas grains (6 seasons)	1,920,000	1,920,000	960,000	960,000
Sale of off cuts	-	280,000	-	10,000
Proceeds from 1 <sup>st</sup> thinning (firewood or poles)	-	-	10,000	100,000
Proceeds from 2 <sup>nd</sup> thinning (timber)	-	-	100,000	280,000
Final crop proceeds (approx. DBH of 30 cm) - sawn timber	1,600,000	2,403,000	1,600,000	2,403,000
Gross income	3,520,000	4,603,000	2,670,000	3,753,000
Net income (18 years)	3,057,200	3,344,800	2,145,400	2,688,400

\*The figures in Table 3 are not based on any research but were generated through field visits to the Melia growing areas and interviews with timber sawyers and merchants.

### Assumptions

- 1. The tree grower will undertake the silvicultural operations, i.e. weeding, pruning and thinning in the Melia plantation as per the prescribed instructions.
- 2. The cover crop (e.g. cow peas) shall be grown using the recommended agricultural practices.
- 3. Rainfall during the growth period, will be moderate and not extremely low.
- 4. The Melia stand with a 10 m x 5 m spacing option and where thinning operations will not be undertaken, will grow uniformly to maturity.

### Recommendations

- 1. Tree growers are advised to saw timber rather than sell standing trees as these will earn them better returns.
- 2. The 10 m x 5 m spacing option is recommended for farmers who have limited land as this will allow them grow agricultural crops for a longer period before the canopy closes.
- 3. A spacing option of 5 m x5 m is recommended for commercial tree growers as it will ensure quality and fetch more returns from the enterprise.



Plate 32: Flooring boards (2 cm thickness) made out of Melia timber (1-inch thickness), by H-Tes Ltd. Current price for a mahogany wooden floor is about is Ksh. 1,200/m2 (US\$ 12)



Plate 33: Vanished samples of Melia timber



Plate 34: Furniture of Melia timber: (a) Cupboard (b) Bench

### **REFERENCES**

Kamondo B.M., Kariuki J.G., Luvanda A.M., Muturi G.M. and Ochieng D. (2016).(eds.). *Guideline on Production, Distribution and Use of Improved Melia Seed and Seedlings in the Drylands of Kenya.* KEFRI, Kenya.

Langat K.D. and Cheboiwo J. (2015). *Guide to Estimating Financial Returns from Tree Growing in Kenya: A guide for tree growers, extension agents and forest managers.* KEFRI, Kenya.

Luvanda A.M., Musyoki, J., Cheboiwo J., Wekesa, L. and Ogawa M. (2015). An Assessment of the Socio-economic Importance of Melia volkensii based on Enterprises in Kenya. KEFRI, Kenya.

TEAC, FAO (2013). *Establish a tree nursery*. Available at http://teca.fao.org/read/7808, (accessed 31 January 2018).

$\mathbf{v}$	
(T)	
5	
$\mathbf{\Sigma}$	
Z	
-	
-	

# Appendix 1: (a) Cost benefit analysis for on-farm Melia enterprise intercropped with cow peas - 10 m x 5 m option (Round Wood)

		•												1				1				
Cos	st benefit analysis for on-farm Mel	lia enterp	-ise inter	cropped	with cow p	eas (Vigna	unguicula	(a)														
Spaci	ing: 10.0 m by 5.0 m		Area: Ihacta	tre		Rotation Age: 1	8 years															
Raint	fall: >nnn 400-800 mm,		Altitude; 30(	0 -1680 ma.s	3.1.																	
Speci	ies: Melia volkensii Soil type: sandy, clay and shal	llow	Working cyc	le: Round W	poo	Y: Year	mds: mandays															
											-		ost(Ksh)			-						
No.	Item/Activity	Unit	Qty	Unit price	VI I	Y2	<b>V3</b>	Y4	Y5	Y6	5	8	0 XI(	KI	Y12	XI3	Ť.	t VI5	Y16	Y17	Y18	Amount (ksh)
	Seedline	No	240	50	12.000																	12.000
	Cow peas seeds	Kg	30	120	3,600	3,600	3,600	3,600	3,600	3,600												21,600
	Pesticides (Act force, cyper force or cyper diforc)	Lts		3,000	9,000	9,000	9,000	6,000	9,000	9,000												54,000
	Fertilizer (DAP)	50 Kg bag	9	3,000	9,000	000'6	9,000	9,000	9,000	9,000												54,000
	Total cost				33,600	21,600	21,600	21,600	21,600	21,600												141,600
1	() Labour for Me lia volkensii																					
	Cutting stakes	spm	1	400	400																	400
	Staking out ( marking planting points)	spm	1	400	400																	400
	Pitting (45 cmx45 cmx45 cm)	mds	4	400	1,600																	1,600
	Planting (Fill the planting hole to the top to ensure no water settles at the base)	spur	1	400	400																	400
	Beating up (20%)	spm	1	400	400																	400
	De-budding (4 times in a year for 1 years	spm	8	400	1,600																	1,600
	Pruning for up to 5 years (Remove all branches with more than 1 inch diameter. Also heavy	spu	4	400		1,600	1,600	2,000	2,000													7,200
	prancining at the mores should be reduced) Slashing (year 4 to year 7)	spur	20	400														+				
	1 <sup>st</sup> thinning (at age 6-7 yrs)	spur	7	400																		
	2 <sup>nd</sup> thiming (3 yrs after 1 <sup>st</sup> thin)	spM	1	400																		
	Clear fell (Cost of Harvesting final crop at age 18	8	_ <	0																		
	yis) Total	CINIT			4,800	1,600	1,600	2,000	2,000					,							0	12,000
	3) Labour for Food crons (Cow ne as)																					
	Land preparation ( Clearing and hallowing)	spur	-	5,000	5,000	4,000	4,000	4,000	4,000	4,000												25,000
	Planting	spm	9	400	1,200	1,200	1,200	1,200	1,200	1,200												7,200
	Weeding (4 times)	spur	80	400	32,000	32,000	32,000	32,000	32,000	32,000												192,000
	Grain har vesting and threshing	spur	20	400	8,000	8,000	8,000	8,000	8,000	8,000												48,000
	Total				41,200	41,200	41,200	41,200	41,200	41,200	•	•	•		•				•		•	247,200
9	<ol> <li>Other costs</li> </ol>																					
	Transportation of seedling	Car hire	-	2,000	2,000																	2,000
	Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	ou	-	60,000	60,000																	60,000
	Total cost				62,000						•	•				,	,	,		1	•	62,000
	Total e xpenditure(a+b+c+d)				141,600	64,400	64,400	64,800	64,800	62,800							,		•		0	462,800
e	3) Output/product																					
	Cow peas grains (6 seasons)	Kg	4000	80	320,000	320,000	320,000	320,000	320,000	320,000												1,920,000
	Final crop proceeds (approx DBH of 30 cm) - sawn timber	Sawlog	200	8,000	'																1,600,000	1,600,000
	Gross Income				320,000	320,000	320,000	320,000	320,000	320,000											1,600,000	3,520,000
	Net Income (18 years)				178,400	255,600	255,600	255,200	255,200	257,200	•					,				'	1,600,000	3,057,200

Cost benefit analysis for on-farm Melia enterprise intercropped with cow peas - 10 m x 5 m option (Sawn Timber) **9** 

			-	2		-														•
Cost benefit analysis for on-farm M	elia enterp	rise inter	rcropped	with cow F	eas (Vign	1 unguicu	tata )													
Spacing: 10 m X 5 m			4	rea: I nactare			Kotation Age.	18 years												
Rainfall: > 400-800 mm,			×	ltitude; 300 -1,t	580 ma.s.l.															
Species: Melia volkensii Soil type: sandy, clay and sl	allow		-	Vorking cycle: S	awn Timber	Y: Y	ear r	nds: mandays												
	:	į	? ;			67		2		1/0	Cost	(Ksh)	V11		V 01	1.1 1716	210	217	V10	
No. Item/Activity	Unit	Qty	Unit price	_	77	2	Y4	a c	11	13	YY	X10	X11	717	1 011	14 YI.	011 0	X1/	118	Amount (ksh)
a) inputs coorditing	No	040	05	12 000		T		+	+	+		+			T	+				17 000
occurring	- 71	047	00	2 600	3 600	3 600	2 600	3 600	3 600	+	+	+			1					12,000
Low peas seeds	Ng	05	120	000,0	000,0	000,0	000,0	0.00,0	0.00,0	+	+	+	+		t	+				21,000
Pesticides (Act force, cyper force or cyper diforc)	TIS	ν.	5,000	000'6	000,6	000'6	000'6	000'6	0006											54,000
Fertilizer (DAP)	50 Kg bag	Э	3,000	9,000	9,000	9,000	000'6	9,000	9,000											54,000
Total cost				33,600	21,600	21,600	21,600	21,600	21,600											141,600
b) Labour for Melia volkensii																				
Cutting stakes	spm	1	400	400																400
Staking out (marking planting points)	spm	1	400	400																400
Pitting (45 cmx45 cmx45 cm)	spm	4	400	1,600																1,600
Planting (Fill the planting hole to the top to ensure no water settles at the base)	spu	-	400	400																400
Beating up (20%)	mds	-	400	400																400
De-budding (4 times in a year for 1 years	mds	∞	400	1,600																1.600
Pruning for up to 5 years (Remove all branches	spun	4	400		1.600	1.600	2.000	2.000							T					7.200
with more than 1 inch diameter. Also heavy branching at the modes should be reduced)																				
Slashing (year 4 to year 7)	spur	20	400																	•
1 <sup>st</sup> thinning (at age 6-7 yrs)	spur	2	400		ļ															
2 <sup>nd</sup> thinning (3 yrs after 1 <sup>st</sup> thin)	Mds	1	400																	
Clear fell (Cost of Harvesting final crop at age yrs)	18 mds	0	0																	
Cost of sawing timber	Feet	54,000	10																540,000	540,000
Total				4,800	1,600	1,600	2,000	2,000					- 0				•		540,000	552,000
c) Labour for Food crops (Cow peas)					Ţ															
Land preparation (Clearing and hallowing)	mds	1	5,000	5,000	4,000	4,000	4,000	4,000	4,000											25,000
Planting	mds	3	400	1,200	1,200	1,200	1,200	1,200	1,200											7,200
Weeding (4 times)	spm	80	400	32,000	32,000	32,000	32,000	32,000	32,000											192,000
Grain harvesting and threshing	spu	20	400	8,000	8,000	8,000	8,000	8,000	8,000											48,000
Total				46,200	91,600	91,600	92,400	92,400	88,400	•										502,600
d) Other costs																				
Transportation of seedling	Car hire	-	2,000	2,000	Ī															2,000
Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	ou	1	60,000	60,000																60,000
Total cost				62,000		•		•	•		•		•	•	•	•		'	0	62,000
Total expenditure(a+b+c+d)				146,600	114,800	114,800	116,000	116,000 1	10,000		•		- 0					•	540,000	1,258,200
e) Output/product																				-
Cow peas grains ( 6 seasons)	Kg	4,000	80	320,000	320,000	320,000	320,000	320,000 3	320,000											1,920,000
Sale of offcuts	DO	1,600	150									40,0	00						240,000	280,000
Final crop proceeds (approx DBH of 30 cm) - sawn timber	Feet	54,000	45	'															2,403,000	2,403,000
Gross Income				320,000	320,000	320,000	320,000	320,000 3	120,000	•	•	. 40,6	- 00	•	•		•	•	2,643,000	4,603,000
Net Income (18 years)				173,400	205,200	205,200	204,000	204,000 2	10,000	•		40,0	- 00	•	•	•		'	2,103,000	3,344,800

••	-
2	-
×	
•	
E C	
0	-
2	5
2	-
-	

(a) Cost and benefit analysis for on-farm Melia enterprise intercropped with cow peas 5m x 5m option (Round wood)

Snaci	no: 5 0 m × 5 0 m	-		Area: Thactare		,	Rotation Ao	ie: 18 vears													
Rainf	all: > 400-800 mm			Altitude; 300 -16	680 ma.s.l.		h r nonmost	6 mail 01 - 20													
Speci	ies: Melia volkensii Soil type: sandy, clay a	and shallow		Working cycle: 1	Round Wood	Y: Yea	u n	ds: mandays													
											Cost(	Ksh)	-	-				-	-		
No.	Item/Activity	Unit Qty	Unit price	YI	Y2	Y3	Y4	Y5	Y6 Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Amount (ksh)
8	() inputs									-		_				_	_				
	Seedling	No 4,	80 56	0 24,000																	24,000
	Cow peas seeds	Kg	30 120	3,600	3,600	3,600															10,800
	Pesticides (Act force , cyper force or cyper diforc)	Lts	3 3,000	6,000	6,000	000'6															27,000
	Fertilizer (DAP)	50 Kg bag	3 3,000	0006	9,000	6,000				-											27,000
	Total cost	>		45,600	21,600	21,600															88,800
ſ	) La bour for Melia volkensii																				
	Cutting stakes	mds	1 400	400																	400
	Staking out ( marking planting points)	mds	1 400	1 400																	400
	Pitting (45cmx45cmx45cm)	mds	8 400	3,200																	3,200
	Planting (Fill the planting hole to the top to	-	1004	400																	UUF
	Ensure no water sectors at the base) Reating in (20%)	unus mrds	1 1	400																	400
	Da-budding (4 times in a mear for 1 more	mde	400	1600						+											1 600
	Demine for m to 5 more (Demine of Learnhose	mds	0 400	1,000	000 0	000 0	1 000	000		+											1,000
	rrunning for up to 5 years (remove all or ancires with more than 1 inch diameter. Also heavy branching at the modes should be reduced)	STRUC	401		9,200	007'5	4,800	4,800													10,000
	Slashing (year 4 to year 7)	mds	20 400				8,000	8,000	8,000 8,	000											32,000
	1st thirming (at age 6-7 yrs)	spu	2 400							800											800
	2 <sup>nd</sup> thinning ( 3 yrs after 1 <sup>st</sup> thin)	Mds	1 406									,	100								400
	Clear fell (Harvesting final crop at age 18 yrs)	spur	0																		
	Total			6,400	3,200	3,200	12,800	12,800	8,000 8,	800	-		- 100			-				0	55,600
c	:) Labour for Food crops (Cow peas)																				
	Land preparation (Clearing and hallowing)	meds	1 5,006	5,000	4,000	4,000															13,000
	Planting	mds	3 400	1,200																	1,200
	Weeding (4 times)	mds	80 400	32,000	32,000	32,000															96,000
	Grain harvesting and threshing	mds	20 400	8,000	8,000	8,000															24,000
	Total			46,200	93,600	93,600	25,600	25,600	16,000 17,	600											318,200
P	1) Other costs										_	_				_	_		_		
	Transportation of seedling	Car hire	1 2,000	0 2,000							_					_					2,000
	Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	no	1 60,000	60,000																	60,000
	Total cost			62,000				•					- 0			_	-			0	62,000
	Total expenditure (a+b+c+d)			160,200	118,400	118,400	38,400	38,400	24,000 26	400			- 100	'		_			•	0	524,600
9	() Be nefits																				
	Cow peas grains (6 seasons)	Kg 40.	90 80	320,000	320,000	320,000					_					_	_				960,000
	Proceeds from 1st thinning (firewood or poles)	no li	00 100						Ξ	000											10,000
	Proceeds from 2nd thinning (timber)	no li	90 1,006									100,0	000								100,000
	Final crop proceeds (approx DBH of 30 cm) - sawn timber	Round wood 20	0008	'																1.600.000	1.600.000
	Gross Income			320,000	320,000	320,000	•	•	- 10	000		100,	- 000	'				•	•	1,600,000	2,670,000
	Net Income (18 years)			159,800	201,600	201,600	(38,400)	(38,400)	(24,000) (16.	400)	•	99,	- 005	'			'	'	'	1,600,000	2,145,400

(b) Cost and benefit analysis for on-farm Melia enterprise intercropped with cow peas 5 m x 5 m option (Sawn Timber)

Spacing: 5.0 m by 5.0 m		A	crea: 1hactare			Sotation Age: 1	8 years													
kainfall: >mm 400-800 mm,		V	dtitude; 300 -16	580 ma.s.l.																
Species: Melia volkensii Soil type: sandy, clay and shal	wo	1	Vorking cycle: 5	Sawn Timber	Y	Year r	nds: mandays													
											Cos	t(Ksh)								
No. Item/Activity	Unit	Qty L	Unit price Y1		2	K	Y4	<u>Y5</u>	6 Y	7 Y8	Y9	Y10	VII	Y12	Y13	Y14 Y	15 <u>V</u> I	6 Y17	Y18	Amount (ksh)
a) inputs		T			T					+										
Seedling	No	480	50	24,000																24,000
Cow peas seeds	Kg	30	120	3,600	3,600	3,600														10,800
Pesticides (Act force, cyper force or cyper difine)	st.	"	3 000 00	6,000	6,000	9,000														27.000
Fertilizer (DAP)	50 Kg bag		3,000.00	9,000	9,000	9,000			$\left  \right $	$\left  \right $										27,000
Total cost				45,600	21,600	21,600														88,800
b) Labour for Melia volkensii																				
Cutting stakes	nds	-	400	400				T	F	$\vdash$										400
Staking out (marking planting points)	spu:	-	400	400																400
Pitting (45 cmx45 cmx45 cm)	spu:	8	400	3,200																3,200
Planting (Fill the planting hole to the top to	nde	-	400	400																UUV
Danting in (2002)	opm		OUF OUF	400				T		+										100
Detauring up (20%)	snu -		400	1 200																0.04
De-budding (4 times in a year for 1 years	spun .	×	400	1,600						+										1,600
Pruning for up to 5 years (Remove all branches with more than 1 inch diameter. Also heavy branching at the nodes should be reduced)	spu	×	400		3,200	3,200	4,800	4,800												16,000
Slashing (year 4 to year 7)	spu	20	400				8,000	8,000	8,000	8,000										32,000
1 <sup>st</sup> thinning (at age 6-7 yrs)	spu:	61	400							800										800
2nd thinning (3 yrs after 1st thin)	Mds	-	400										400							400
Clear fell (Harvesting final crop at age 18 yrs)	spu:	0	0																	
Cost of sawing timber	Feet	54000	10																540,00	540,000
Total				6,400	3,200	3,200	12,800	12,800	8,000	8,800	•		400	•	•	•		•	- 540,00	595,600
c) Labour for Food crops (Cow peas)																				
Land preparation (Clearing and hallowing)	mds	-	5,000.00	5,000	4,000	4,000														13,000
Planting	mds		400	1,200																1,200
Weeding (4 times)	mds	80	400	32,000	32,000	32,000														96,000
Grain har vesting and threshing	mds	20	400	8,000	8,000	8,000														24,000
Total				46,200	93,600	93,600	25,600	25,600	16,000	17,600										318,200
d) Other costs																				
Transportation of seedling	Car hire	1	2,000.00	2,000																2,000
Fencing (4 rolls of barbed wire, 135 posts, U nails, nails, 2 bags of cements, concrete, sand)	0		50.000.00	60,000		_														60,000
Total cost				62,000	•		•						- 0	'	•	•				62,000
Total e xpenditure(a+b+c+d)				160,200	118,400	118,400	38,400	38,400	24,000	26,400			400 -	'	•	•	•		- 540,00	1,064,600
e) Output/product																	-		_	-
Cow peas grains ( 6 seasons)	Kg	4000	80	320,000	320,000	320,000														960,000
Proceeds from 1st thinning (firewood or poles)	10	100	100							10,000										10,000
Proceeds from 2nd thinning (timber)	10	100	1,000.00									100	000							100,000
Sale of offcuts	00	1600	150.00							_	_	40,	000						240,00	280,000
Final crop proceeds (approx DBH of 30 cm) - sawn timber	Feet	54000	44.50	•		_													2,403,00	2,403,000
Gross Income				320,000	320,000	320,000				10,000		- 140,	- 000	'					- 2,643,00	3,753,000
Net Income (18 years)				159,800	201,600	201,600	(38,400)	(38,400)	(24,000)	(16,400)		- 139,	- 009	•		•	•		- 2,103,00	2,688,400

••
3
×
•
5
R
0
2
<b>Q</b>

The schedule of various activities involved in raising a Melia plantation

A										(ear								
Activity	-	8	e	4	2	9	7	œ	6	10	1	12	13	14	15	16	17	18
Purchase of seedling																		
Fencing																		
Land preparation (clearing and harrowing)																		
Staking out (marking planting points)																		
Pitting of planting holes																		
Planting																		
Beating up (20%)																		
Weeding (8 times)																		
De-budding (4 times in year 1)																		
Pruning up to 5 years																		
Slashing (year 4 to year 7)																		
1₅t thinning (at age 6-7 yrs)																		
2 <sup>md</sup> thinning (3 yrs after 1st thining)																		
Clear fell (harvesting final crop10-18 yrs)																		
The highlights indicate the timarking of 'the clear felling harvesting	ming o from 11	f the   year	activ 's ma	ity. H y or r	owev nay n	er, co ot tal	mside ke pla	ring t ce del	hat h: pendi	arvest ng on	ing m t when	iay tal 1 the t	ce plac rrees a	ce froi ire coi	m age nsider	e 10 ye red ma	ars, th ature fo	le Dr

