Research and Technology Development of Mukau (*Melia volkensii* Gürke)

Proceedings of the First National Workshop Held at Kitui Regional Research Centre 16 to 19 November 2004

Edited by B.M. Kamondo, J.M. Kimondo,

J.M. Mulatya and G.M. Muturi

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Front cover: Mukau tree in a farm at Katulani village, Kitui District Kenya
Photograph by: James M. Kimondo

Back cover: Mukau seedlings grafted with scions of some superior trees growing in the green house, in the field and in an open nursery at Tiva, Kitui District Kenya
Photograph by: James M. Kimondo

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Preface

The First Melia National Workshop was held from 16 to 19 November 2004 at Kenya Forestry Research Institute (KEFRI) - Kitui Regional Research Centre. The objective of the workshop was to consolidate and share research experiences by scientists and stakeholders in order to produce a document on status of Melia tree development. KEFRI's vision was to compile a comprehensive document that would guide a coordinated approach in Melia research building on existing knowledge while avoiding duplication of past research efforts.

These proceedings present the status of Melia research to date within the following four themes: Melia Ecology and distribution; Propagation; Management; and Utilisation. The first theme provides an overview of Melia distribution, its genetic variation and threats. The second theme captures the know how on seed extraction, pre-treatment and both technical and indigenous alternative propagation methods. Melia management theme addresses tree spacing, tree-crop interactions and on farm tree management. Utilisation theme covers productivity, the tree economic potential and various uses of the tree. The proceedings have outlined current research gaps that require to be addressed and promising technologies that require dissemination for wider adoption to support the species' planting programme.

Acknowledgement

We acknowledge the Board of Management of Kenya Forestry Research Institute for the financial support towards hosting of the workshop and compilation of the proceedings. We are also grateful to the Japanese International Cooperation Agency (JICA) through Intensified Social Forestry Project (ISFP) for supporting this publication.

We also acknowledge the participation of different institutions such as Forest Department (FD), International Plant Genetic Resources Institute (IPGRI), International Centre for Research on Agroforestry (ICRAF), Intensified Social Forestry Project (ISFP) and farmers who made enormous contribution to the success of this first Melia national workshop.

We would also like to thank individuals who made presentations in the workshop, workshop participants and those who worked tirelessly during the various stages of hosting this important workshop.

Director, KEFRI

Speech by Director KEFRI on the occasion of opening of the Mukau workshop in Kitui: Wednesday, 17 November 2004

Mr. Chairman, Ladies and Gentlemen,

I am happy to be here to open this workshop on research and technology development of Mukau. Mukau is becoming an important species for planting in the drylands of Kenya, especially in eastern and coastal regions.

During the KEFRI Consultative Committee meeting held in July this year, there were many proposals on Mukau, which were submitted for funding through GoK research grants. However, preparation of the proposals was not coordinated and there were some duplication. The Committee therefore resolved to have the proposals consolidated with a view to addressing research and technology development in Mukau more holistically, which KEFRI Board of Management endorsed and consequently provided funds for this workshop.

Ladies and Gentlemen, this meeting has been organized with three objectives:

- One, to document various research results carried out to date on the species;
- Two, identify existing knowledge gaps; and
- Three, to draw up research themes to address identified knowledge gaps.

Ladies and Gentlemen, looking at the workshop programme, I note that presentations and discussions will be on:

- Distribution of Mukau.
- Genetic variation, conservation and tree improvement;
- Propagation;
- Tree and pest management;
- Agroforestry aspects of Mukau;
- Economic returns of growing Mukau; and
- Utilization

As you discuss the above, I urge you to pay attention to the following important areas or themes:

- Physiology of Mukau
- Marketing of Mukau products including value adding;
- Dissemination of technologies and links with extension

Mr. Chairman, in conclusion, our challenge is to come up with a comprehensive project proposal on Mukau. The other challenge is to form a focused multidisciplinary team for implementation.

Finally, let me thank you for your participation. I thank the organizers for their efforts to make the workshop a reality. I also thank JICA for jointly funding the workshop with KEFRI.

With those few remarks, it is my pleasure to declare the workshop on Mukau officially open.

Thank you.

An overview of natural distribution, propagation and management of *Melia volkensii*

J. M. Kimondo and K. Kiamba

Abstract

Melia volkensii is a tree species endemic to the semi arid areas of eastern Africa. Its natural range falls within areas which are characterised by dry bush land and wooded grassland, lying between 400 and 1600 metres above sea level. Recently, the inhabitants of these areas have increased their awareness about its importance as a source of timber. However, its propagation is limited by the difficulties associated with seed dormancy. Alternative methods have been suggested for propagating the species and this paper highlights future research areas to address the various hindrances to its expanded planting.

Keywords: *Melia volkensii*, natural distribution, propagation

Natural distribution

Melia volkensii is a multipurpose tree species endemic to arid and semi arid lands of eastern Africa. Its approximate distribution range is shown in Figure I (Milimo 1989).

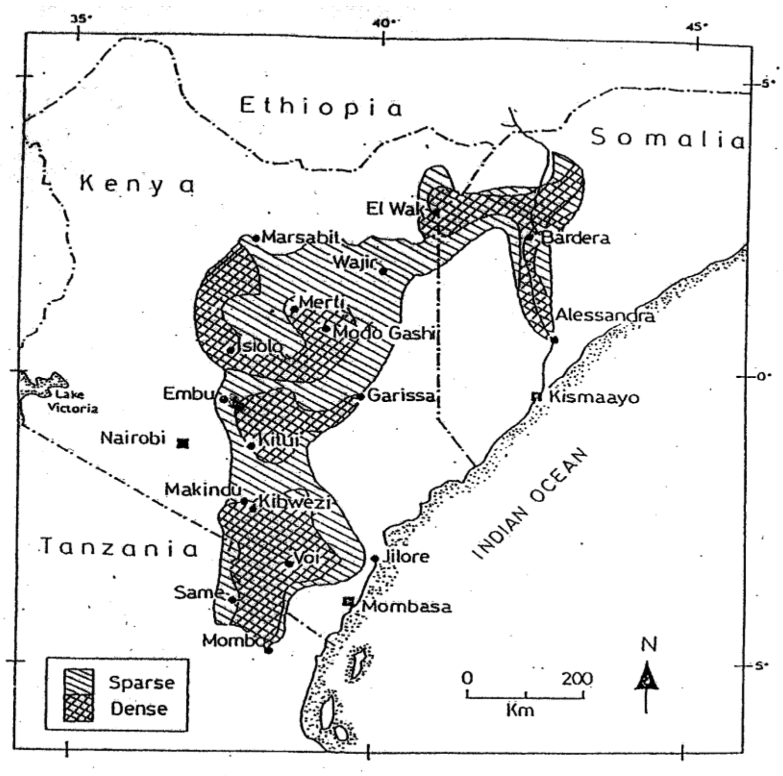

Figure 1. Distribution of *Melia volkensii* in drylands of Kenya

The natural range is characterised by dry bushland and wooded grassland, lying between 400 and 1600 metres above sea level. It is normally found in well-drained sandy clay and stony soils; although it is also found on sites classified as imperfectly drained soils (Muok, *et al.,* 2001).

In the natural stands, Melia trees of good form have been heavily exploited for timber leaving bad quality trees (Plate 1 and 2). Consequently, Melia trees of good form are only found in the farms although this could be as a result of management practices (Plate 3).

Plate 1. Stump of *Melia volkensii* tree coppicing

Plate 2. Melia trees of poor form on the farms in Mwatate

Plate 3. *Melia volkensii* tree of good form in Mutha, Kitui

Currently, there are no large-scale plantings of the species, which could be attributed to the difficulties of seedling propagation

Propagation
Seed collection processing and storage

Mature yellow fruits are collected from the crown by spreading a net, canvas or any other appropriate material under the tree and climbing the tree to hand pick the fruits or shaking the branches to release the fruits. Mature ripe fruits are depulped using a mortar and pestle. The nuts are then washed thoroughly under running water (KEFRI, 2004). Alternatively, depulped nuts are collected from goat shed where they are regurgitated during the chewing of cud.

The seeds are extracted from the hard nut by cracking the nut using either a knife and hammer or the seed extractor, a machine developed by KEFRI. The extracted seeds are then cleaned by hand sorting. However, when seed is required for subsequent seasons, it should be noted that Melia seeds are better stored unextracted to avoid significant loss of viability.

Seed germination
To improve germination, it is necessary to nip the tip of the seed, soak in cold water for 24 hours, and slit longitudinally through the inner and outer seed coats (KEFRI 2004, Milimo 1989). Scarification of seed is essential as the seed coats of *Melia volkensii* impose and maintain dormancy by not permitting embryos to absorb sufficient water and/or by mechanically restricting

radical protrusion (Milimo and Hellum 1989). Since Melia seed are sensitive to fungal attack, it is important to maintain a sterile environment during the scarification process.
After pre-treatment, seed are sown in a sterilised germination media under high temperature and humidity. In practice, such conditions are maintained under non-mist propagators similar to green house conditions. Under such conditions, germination takes 4-10 days. Pricking out is done 1 – 2 days after germination. Melia is prone to high mortality after pricking out, during seedling rearing, and even during seedling establishment in the field.

Alternative propagation methods
Farmers who do not have access to seedlings use vegetative propagation. The method entails injuring the roots to initiate sprouting of shoots from the roots. In addition, attempts to raise Melia through stem cuttings and tissue culture have been undertaken by researchers with limited success. Due to difficulties associated with raising seedlings from seeds, farmers routinely use wildings that arise from naturally dispersed seed or injured roots.

Management of planted trees
The growth of *Melia volkensii* in well-managed plots in arid and semi arid lands far exceeds those of other indigenous tree species (Kimondo 2002). Currently, there are no clearly defined management guidelines for farmers to use to manage their trees. While proper pruning of *Melia* should be done early to obtain clear boles, in practice farmers retain branches and prune them to obtain fuelwood and fodder for their animals during drought (Blomley 1994).

Uses of Melia
Melia volkensii is used for construction timber and fuelwood. In addition, the tree is used as fodder (fruit and leaves); medicine (bark), bee forage, mulch and green leaf manure (Omondi, *et al.*, 2004). It is also reported that some people use leave extracts of *Melia* on the skin of goats to control ticks and fleas. The insecticidal properties of Melia are widely documented (Mwangi 1982, Mwangi and Mukiama 1988) suggesting that the farmers' practices could be technically justified.

Way forward
Melia volkensii trees are currently heavily exploited for timber in the drylands leading to high erosion of their genetic variability. However, recent surveys have shown that some superior trees still exist in those areas that are not easily accessible. As a result, it is necessary to identify such trees and conserve their genes ex-situ. In addition, considering that the surveys have only covered a limited area in the species natural range, a more elaborate survey should be carried out to capture a large gene pool.

Observation of Melia in the nursery and field have shown differences in: bark and leaf colour; tree form; growth rates and branching habits. These observed differences require investigations to determine whether they have a genetic basis and their effect on growth. Additionally, there is need to identify more melia seed sources because selective tree cutting has progressively removed the best trees from the existing sources.

Both genetic composition and the management have generally influenced trees growth and form on the farms while those in the wild are mainly influenced by genetic composition. It is therefore recommended that selection for improvement should focus more into the natural range rather than on the farms.

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Genetic structure of Kenyan populations of *Melia volkensii* inferred from random amplified polymorphic DNA (RAPD) analysis

D.W. Odee, M.S. Runo, J. Gicheru and G.M. Muluvi

Abstract
Melia volkensii is a popular multipurpose tree species in Kenya's arid and semi arid lands (ASALs). The species has been overexploited in the recent past leading to erosion of genetic diversity. The aim of this study therefore was to assess the levels and distribution of genetic diversity of selected Kenyan populations. Nine populations were analyzed using random amplified polymorphic DNA (RAPD) markers. The levels of genetic diversity were low (H = 0.0663 to 0.1372). The populations were differentiated into two groups, eastern and coastal regions, which are also distinguished by eco-climatic conditions. The groups were also subdivided into farmland and natural populations. Higher genetic diversity was found within farmland (H = 0.1075) than in natural populations (H = 0.0690). The analysis also revealed that more variation (75.4%) existed within populations. The genetic differences observed between the regions and at sub-regional level (farmland versus natural populations) constitute important units, which should be considered for conservation, improvement and sustainable utilization of the species.
Key words: Genetic variation, conservation, Melia volkensii populations

Introduction

Melia volkensii is a multipurpose tree species in the family Meliaceae and is endemic in the drylands of Eastern Africa. In Kenya, *M. volkensii* has been overexploited over the past two decades due to its high quality, termite resistant wood. Habitat fragmentation and loss of the species natural population is also on the increase as more areas are opened for settlement. It is currently of great concern that continued overexploitation of *M. volkensii* will deplete its genetic diversity through the removal of superior genotypes, disruption of gene flow and isolation of the remaining populations.

Conservation of plant genetic diversity has recently generated a lot of interest in the tropics because of many years of mismanagement, adverse environment and socio-economic changes. Genetic diversity provides the potential for a species to adapt to changing environments, resist pests and avoid negative consequences of inbreeding. Understanding species population genetic structure is essential for planning for conservation and sustainable management (Sun *et al*., 1998).

Traditionally, provenance and progeny tests coupled with biometrical analysis of phenotypic traits have been the standard methods for describing and quantifying genetic variation in forest tree species (National Research Council, 1991). However, this approach is slow, expensive and strongly influenced by environmental effects, although suited for improvement programme. It is particularly a slow approach when the goal is to rapidly estimate the patterns and distribution of genetic variation for making decisions on conservation and monitoring of genetic resources. Recent development of molecular markers has complemented and drastically reduced the time taken in generating information required in making conservation and management decisions.

Maintenance of genetic diversity is considered crucial for long-term survival and evolutionary response of populations to changes in the environment (Hueneke, 1991). In addition, genetic erosion reduces the potential of the species improvement through selection. Knowledge of genetic variation can assist in making decisions on conservation of *M. volkensii* genetic resources. Past genetic study on *M. volkensii* was carried out by Milimo (1994) using isoenzyme analysis but was only limited to three populations namely; Mbololo, Embu and Isiolo. In the present study, the RAPD technique (Williams *et al*., 1990) was used to characterize genetic variability within and among nine populations of *M. volkensii* in Kenya.

Materials and methods

Plant material and DNA isolation

Leaf samples were collected from 10 mature trees chosen at random from each of the nine populations (Table 1). These populations occurred in either National Parks (natural populations) or farmlands. The method described by Edwards *et al*. (1991) was used to isolate total genomic DNA from *M. volkensii.*

RAPD reaction and gel electrophoresis

Amplification was carried out in a 20 µl volume reaction mix, which contained 200 mM of each of the dNTPs (Life technologies), 10x *Taq* polymerase buffer (Perkin Elmer), 3 mM $MgCl_2$ (Perkin Elmer), 0.2 µM primer (Life Technologies), 2.5 ngμl^{-1} DNA and 0.75 units of *Taq* polymerase (Gold™; Perkin Elmer). Amplification conditions were set as, 1 cycle of 15 min at 94 ºC, 44 cycles of 1 min at 94 ºC (denaturation), 1 min at 36 ºC (annealing), 2 min at 72 ºC (extension). A final 5 min extension (72 ºC) was allowed to ensure full extension of all amplified products. Amplification products were mixed with 6x gel loading dye (0.25 % bromophenol blue, 25 % Xylene Cyanol and 30 % glycerol) and separated on 2% agarose gel. The ethidium bromide stained agarose gels were visualised under ultra violet light and then photographed.

Data analysis

Amplification products were scored as presence or absence of a band. Diversity values were calculated according to Nei's unbiased statistic (Nei, 1987) using POPGENE 1.31 (Yeh *et al*., 1999). Genetic distance (*D*) between populations was generated according to Nei (1972). Cluster analysis based on Nei's genetic distance was undertaken using an unweighted pair-group method with arithmetic averaging (UPGMA; Sneath and Sokal, 1973) to generate phenograms. Analysis of Molecular Variance (AMOVA) (Excoffier *et al*., 1992) was estimated using Arlequin version 2000 (Schneider *et al*., 1997). Significance values were assigned to variance components based on the random permutation (5,000 times) of individuals.

Results

Analysis of the nine populations of *Melia volkensii* revealed 38 polymorphic RAPD markers. Levels of genetic diversity within populations ranged from 0.0663 (Galana) to 0.1372 (Kibwezi) with a mean value of 0.0946 (Table 1). Comparison of genetic diversity between populations revealed that the eastern populations had a higher mean value of genetic diversity of 0.1146 while the mean for coastal populations was 0.0697.

Table 1. The nine *Melia volkensii* populations used and the mean diversity estimates (*H)* based on 38 RAPD markers.

Population	Lat.	Long.	Altitude (masl)	Region	Population type	Diversity index (H)
Kitui	01º30'S	30º50'E	1300	Eastern	Farmland	0.1196
Kibwezi	02º20'S	38º57'E	1200	Eastern	Farmland	0.1372
Embu	00º48'S	37º55'E	1050	Eastern	Farmland	0.0957
Isiolo	00º22'N	37º35'E	700	Eastern	Farmland	0.1131
Meru	00º00'	37º36'E	1200	Eastern	Farmland	0.1074
Mbololo	03º20'S	38º28'E	1166	Coastal	Farmland	0.0718
Galana	03º32'S	37º20'E	730	Coastal	National Park	0.0663
Mwatate	03º30'S	38º30'E	900	Coastal	National Park	0.0667
Taveta	03º37'S	37º44'E	1000	Coastal	National Park	0.0740
Mean						**0.0946**

When genetic diversity was considered between farmland and natural populations, it was found that a high level of genetic diversity occurred in farmland (0.1075) compared to natural populations (0.0690). AMOVA showed significant differences (P<0.0002) between regions (eastern and coastal), between farmland and natural populations, and among populations (within groups and populations). The analysis also revealed that high variation (75.4 %) existed within populations. There was also a high component of variation (21.1%) partitioned between coastal and eastern populations. The dendrogram (Fig. 1) showed a clear split between the castern and coastal populations. Further, within the coastal populations, the natural populations (Mwatate, Galana and Taveta) formed a cluster that excluded the farmland population (Mbololo).

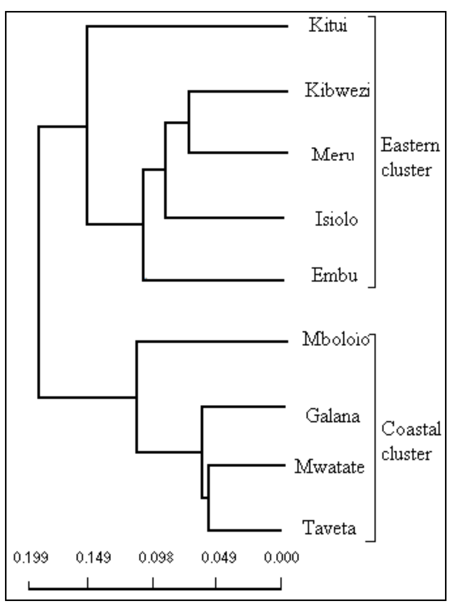

Fig. 1. Dendrogram based on Nei's (1978) genetic distance for the nine populations of *Melia volkensii* based on 38 RAPD markers.

Discussion
The mean level of genetic diversity within populations (*H* = 0.0946) shown in Table 1 was comparable to the mean level of 0.08 found by Milimo (1994) using isoenzymes in three populations (Mbololo, Embu and Isiolo) of *M. volkensii*. The range of genetic diversity (0.0663 to 0.1372) also compared favorably with those found recently by Cavers *et al*. (2003) in *Cedrela odorata* L. (Meliaceae) populations in Costa Rica (0.03 to 0.13) using amplified fragment length polymorphism (AFLP). The pattern of genetic diversity exhibited by *M. volkensii* could be a result of effective gene flow within populations.

Diversity within populations from the national parks was found to be low compared to farmland populations. This low polymorphism within National Park populations could be due to the restricted gene flow and small population size. This is consistent with the findings of Loveless (1992) and Travis *et al*., (1996) where they assert that population size influence within-population genetic variation in tropical tree species.

The present work has shown national park populations to be less diverse. Therefore, efforts should be made to conserve the remaining genepool *ex situ.* At the farm level, conservation should go hand in hand with breeding programs to exploit the existing high genetic diversity. Since the levels of genetic differentiation observed might be related to adaptive variation, structured progeny trials may be required to assess the performance of different populations in the different regions for traits of interest such as timber and fodder. In addition, fresh infusions can be carried out from the genetically diverse populations (Kibwezi and Kitui) to those areas with low genetic diversity (Galana, Taveta, Mwatate and Mbololo).

The way forward

This study identified two distinct clusters that are probably based on variation in sub-regional characteristics. All these levels of genetic differences constitute important conservation units. Therefore, the study should be extended throughout the natural distribution of *M. volkensii* to capture the existing gene pool to facilitate effective conservation, improvement and sustainable utilization.

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Survey of *Melia volkensii* plus trees in the Eastern and Coastal provinces of Kenya

D. Muchiri and J. Mulatya

Abstract

The escalating selective cutting of Melia trees of good form may be influencing negatively the genetic composition of natural stands. In realizing that superior trees are diminishing, a survey to select some superior mother trees for melia improvement and propagation was carried out in eastern and coastal districts of Kenya. From these sites, seven transects were established for tree mapping. Results of the study indicated that longer merchantable heights and good form trees occurred in Siakago, Mwatate and Ishiara transects while shorter merchantable heights occurred in Mwingi-Nuu and Kitui-Katulani transects. Overall, good formed merchantable tree heights ranged from 28% to 42% of the total tree height. Mutha-Inyali transect was the only transect that had naturally occurring trees without human influence offering opportunity for selecting genetically superior materials.

Introduction

Melia volkensii occurs naturally in drylands of Eastern Africa (Kidundo, 1997). It extends from southern Somalia to northern Tanzania (Milimo 1986). In the eastern and coastal regions of Kenya, the tree is heavily exploited for its high quality timber. Exploitation targets mature trees of good form, leaving trees of poor form. The trend is likely to worsen considering the prevailing shortage of alternative hardwood species in high potential areas. To cope with this challenge, most of the dryland afforestation projects have embarked on aggressive Melia afforestation programmes. KEFRI and its development partners particularly Belgium Technical Cooperation (BTC) and Japan International Cooperation Agency (JICA) have shown the most interest. Farmers have also been struggling to grow and manage the species using indigenous knowledge, which varies across the distribution range with limited success (Mulatya 2000).

Previous studies by KEFRI have shown that Melia is a fast growing species producing quality timber in 10 to 12 years (Kimondo 2002, Muturi et al 2003, Mulatya 2000). The growth is even faster on farm than in the wild, suggesting tremendous potential gains through domestication. A major impediment to successful domestication programme is the source of good germplasm. Unfortunately, it has been observed that the local communities in most areas have cut the best and mature plus trees for their own local use. This selective cutting of the best trees has caused the seed collectors to sample from the presumed existing superior stands.

Against this background, a survey was carried out to identify and select superior trees from the existing populations both wild and on farm to be used for the species domestication programme.

Materials and Methods

Eight survey sites were predetermined using previous reports (Mulatya 2000, Kidundo 1997) and personal experiences on Melia occurrence in Eastern and Coastal provinces. This was followed by a reconnaissance survey to confirm availability of sampling material. Thereafter, a sampling framework was developed based on the findings of the reconnaissance survey. Briefly, the sampling framework entailed laying out of the transects, development of tree score sheet characteristics and field data collection, and finally data analysis.

Laying out of the transects

Eight transects were laid out and their attributes described as detailed in Table 1.

Table 1: Survey transects and their attributes

Transect no.	Transect name	Transect attributes
1	Mutha – Inyali	Extended from Mutha to Inyali transecting through settled areas and Tsavo game reserve
2.	Kitui – Katulani	Transected through farmlands from Kitui town to Katulani market in medium densely populated area.
3.	Siakago – Embu	Stretched from Embu town through Siakago division to the Kamburu dam in highly populated farmlands where some form of management on the trees is practiced.
4.	Mwingi – Nuu	Stretched from Mwingi town through Nguuni to Nuu hill through sparsely settled areas.
5.	Kyuso – Tseikuru	Stretched from Kyuso to Tharaka through Tseikuru in a sparsely populated area next to Mitamisye game reserve.
6.	Tharaka – Ishiara	Stretched from sparsely populated areas in Tharaka to highly populated areas in Ishiara in the high altitude areas of Kanyambora
7.	Mwatate – Mtito Andei	Started from Mwatate farmlands through Tsavo national park to Mtito Andei
8	Nguuni – Ukasi	Started from Nguuni to Ukasi through a very sparsely populated area along Mwingi – Garissa road.

Development of "tree score-sheet characteristics" and field data collection

A score data sheet (appendix 1) was developed to collect data on tree and site characteristics. In each transect, eight trees were qualitatively selected from a sample of 30 trees and both tree and sites characteristics recorded in the tree score data sheet. Tree characteristics were measured using appropriate instruments such as diameter tape, height hypsometer while the tree geographical data were collected using geographical positioning system (GPS).

Data analysis

Data was analyzed using SPSS software. The mean heights, diameter at breast height (dbh), merchantable heights from 8 trees per site were calculated.

Results

Spatial distribution of the sample trees within the transects

The altitude ranges and their averages for the surveyed transects across the districts indicated little differences between sites (Table 2). Except for the hills and upper part of Embu district, the rest of the districts lay within similar altitudinal range. The range of latitude and longitudes are also provided as indicators of the spatial distribution of selected trees within transects.

Table 2: Transects and their spatial distribution within the survey sites

Trasect	**Altitude range (m)**	**Mean altitude (m)**	**Longitude range**	**Latitude range**
Kitui – Katulani	658 – 803	710		
Siakago – Embu	690 – 1180	965		
Mutha – Inyali	588 – 628	620	E038^{0}06’7’’- E038^{0}15’9’’	S01^{0}22’3’’–01^{0}51.8
Mwingi – Nuu	642 – 680	650	0 38^0 19’.12’’-0 38^0 1.4’’	00^{0}48’.5’’- 01^0 00.0
Mwatate–Mtito Andei	580 – 1000	620	0 38^0 22’.3’’- 0 38^{0}29.4’’	03^{0}17’.1’’– 03^{0}30.5
Kyuso – Tseikuru	637 – 1000	740	0 38^0 15’.5’’- 0 38^0 06.1’’	00^{0}15’.9’’– 00^{0}39.1
Tharaka – Ishiara	676 – 1110	875	0 37^0 47’.4’’- 037^{0}44.2’’	00^{0}14’.8’’– 00^{0}31.6
Nguuni – Ukasi	No superior trees were selected in this transect			

Diameter sizes

The diameters at breast height for the trees within transects presented in table 3 showed that there were great variations in diameters among trees within all transects. The biggest tree diameters occurred in Mwatate – Mtito Andei and Tharaka – Ishiara transect. The average diameters ranging from 29.6 to 35.9 cm for trees in all the transects are presented in table 4.

Table 3: The diameters at breast height (cm) of individual trees in each survey transect.

Tree no	Kitui - Katulani	Siakago - Embu	Mutha - Inyali	Mwingi - Nuu	Mwatate - M/Andei	Kyuso - Tseikuru	Tharaka - Ishiara
1	25.2	33.5	33.4	22.5	37.1	36.2	28.2
2	38.4	45.2	49.6	22.6	36.7	33.3	42.5
3	28.8	30.1	44.3	33.6	35.5	35.1	32.1
4	25.2	35.0	16.8	26	25.5	34.4	51.2
5	22.4	37.5	26.8	29.5	47.5	31.5	39.5
6	36.6	24.0	20.2	26.9	32.5	26.7	32.6
7	25.1	30.3	47.9	32.5	27.5	31.8	32.6
8	34.5	39.5	31.2	43	30.8	35.6	29
Average	29.7	34.3	33.8	29.6	34.1	33.1	35.9

Table 4: Statistical analysis of trees diameter, height and merchantable height across the transects

Transect	**Mean Dbh (cm)**	**Mean ht (m)**	**Merchantable ht (m)**	**% of Merchantable ht**
Kitui – Katulani	29.7	11.6	4.2	36
Siakago – Embu	34.3	16.6	6.9	42
Mutha – Inyali	33.8	13.6	4.1	30
Mwingi – Nuu	29.6	11.3	3.5	31
Mwatate- M/Andei	34.1	17.9	7.1	40
Kyuso - Tseikuru	33.1	13.4	3.7	28
Tharaka - Ishiara	35.9	16.3	6.4	39
Grand mean	**32.9**	**14.4**	**5.1**	
Std dev.	**7.4**	**3.1**	**2.0**	

Tree heights

There were great mean heights variations between transects and between individual trees in each transect (Table 4 and 5). The tallest trees were found in M/Andei – Mwatate, Tharaka-Ishiara and Siakago –Embu transects.

Table 5: Tree height (m) assessment for each transect within survey sites.

Tree no	Kitui - Katulani	Siakago - Embu	Mutha - Inyali	Mwingi - Nuu	Mwatate - M/ Andei	Kyuso - Tseikuru	Tharaka - Ishiara
1	11.4	15.5	15.8	9	16	12	16
2	11	18	16.3	11.5	18	15	19
3	12.3	17	15	13.5	14	16.5	13.5
4	12.7	16	10.8	12	22	12	22
5	11	16.5	13	10	21	11	13.5
6	12	16.5	12	10	18	12	15.5
7	11.5	17.5	13.5	13	18	11	17
8	11.3	16	14	11.5	16	18	14
Average	**11.7**	**16.6**	**13.8**	**11.3**	**17.9**	**13.4**	**16.3**

Merchantable heights

The merchantable heights of trees in each transect are presented in Table 4. From the table, the merchantable height ranged from 28% in Tseikuru – Kyuso to 42% in Embu – Siakago transects.

Discussion and recommendation

The survey revealed that diameter categories did not vary much among the sampled populations. However, merchantable heights differed substantially ranging from 28% to 42% of the total tree height. According to past studies (Tedd 1997), the variation could be attributed to different levels of tree management. Indeed this survey observed greater management intensities in the Siakago – Embu and Mtito Andei - Mwatate transects, where the merchantable height was 42% and 40% respectively. On the contrary, merchantable height was 28% and 30% in Tseikuru – Kyuso and Mwingi-Nuu transects respectively where trees were generally growing in the wild without any form of management. The foregoing suggests that merchantable height of Melia can be improved through management.

From the sizes of the diameters observed, which were generally small, and speculations from farmers that huge trees existed, it is recommended that a similar study is carried out to cover as much of the species ecological range as possible. The study established that there are no naturally occurring superior trees in areas adjacent to the settlement except those grown and managed in the farms. Furthermore, those good trees occurring on farms might not necessarily be genetically superior *per se* but rather could be because of good management practices by the farmers.

To validate the genetic status of good trees on the farms and particularly those identified in this survey, there is an urgent need to establish whether observed phenotypic traits are genetically controlled. For this reason, selected trees should be protected from felling until their own kinds are reproduced as trial plantations cum seed stands. It is also recommended that conservation measures be undertaken to select and conserve in-situ or ex-situ the superior genetic materials found in the wild before they are depleted.

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Appendix 1: Tree data collection sheet

1. District…………………………………………………………….
2. Division……………………………………………………………
3. Location……………………………………………………………
4. Sub location………………………………………………………..
5. Transect name……………………………………………………………
6. Ecological zone…………………………………………………
7. Altitude……………………………………………………………..
8. Latitude……………………………………………………………..
9. Longitude…………………………………………………………
10. Location of tree (a) on farm ((b) In the wild (c) Others (specify)
11. Tree No. ……………………………………………………………..
12. Dbh…………………………………………………………………
13. Height………………………………………………………………..
14. Clear bole height………………………………………………….
15. No. of branches …………………………………………………..
16. Size of branches…………………………………………………….
17. Tree health (1) Die back (2) Diseased (3) Pest
18. Deforms/Defects score…………………………………………………
    (1) Excellent (None) (2) Moderate (3) Few (4) Many (5) Extreme
19. Canopy condition:…………………………………………
    (1) Green with full canopy (2) Fruiting with full canopy (3) moderate canopy
    4) Shedding leaves (5) No leaves
20. Bole quality…………………………………………………………………….
    1) Spiral grains on bark (2) less spiral (3) No spiral bark (4) Normal plain bark
22. Benchmark of selected tree: 1) Type ………………………………
    2).Distance……………………………….3). Direction…………………………….
23. If on-farm… Yes/No Name of the farmer…………………….

An overview of *Melia volkensii* propagation at Tiva nursery, Kitui district

E. Kyalo

Abstract

Propagation of Melia volkensii has remained a challenge to foresters, farmers and all other stakeholders. Failure to achieve massive production of seedlings has constrained establishment of plantations. Kenya Forestry Research Institute has undertaken several trials on station at Tiva Nursey in Kitui district to address this constraint. Attempts have been made to propagate M. volkensii through seed and cuttings. A germination rate of 80 percent through use of seed has been achieved when seeds are subjected to the appropriate seed pretreatment. A success rate of 40 percent has been recorded in root cuttings. In both cases, maintenance of high humidity and regular spraying with fungicide was found to be crucial to avoid seedling mortality.

Keywords: pre-treatment, root cuttings, humidity

Introduction

Melia volkensii is one of the most prized trees in the semi-arid zones of Eastern and Coastal provinces of Kenya. The major attribute is that it provides high quality, durable timber within a short period of 10 years (Mulatya 2000). In the wild, Melia is heavily overexploited and currently it is largely to be found in cropland. However, undocumented surveys have shown a tremendous decline in Melia trees on farms, against the farmers' desire to plant more because of its economic importance.

Despite the potential of the species, the tree is yet to be massively propagated for plantation establishment especially by farmers. This has been due to difficulties experienced in seed extraction, germination and propagation through cuttings, when compared to other species. It is because of these reasons that KEFRI embarked on propagation studies (Milimo, 1989, Kidundo 1997) to ease production of planting materials. The recommendations of these studies have been adapted at Tiva nursery to develop protocols for massive propagation of the species. This paper highlights findings and recommendations of this adaptive research.

Propagation of Melia through seeds

A germination of 80% within 5 to 7 days and successful seedling production was achieved when the following procedures were adopted.

- Collection of fresh mature nuts (yellowish green to yellow) and depulping,
- Extraction of seeds from the nut without injury,
- Pre-treating the seed through: careful nipping, soaking in cold water overnight, slitting to break the inner and outer seed coat using a razor blade,
- Sowing seeds in sterlised or fumigated medium such as sand or vermiculite in germination chambers where ambient temperature was maintained between 30^0 to 38^0C.

Propagation of Melia through cuttings

A success rate of 40% seedling production was achieved when root cuttings were subjected to the following treatments.

- Obtaining fresh root cuttings measuring 8 to 12 cm,
- Sterilizing the cuttings and waxing the upper end,
- Inserting the cuttings in sterilised rooting media such as sand or vermiculite in germination chambers where ambient temperature is maintained between 30^0 to 38^0 C.

Attempts to establish seedlings using stem cuttings using the above procedure failed.

Discussion and recommendations

It is important that in both propagation methods, the ambient humidity is maintained high by covering the propagation chambers with polyethylene sheets.

For seed propagation, it has been observed that the seedlings should be pricked out immediately after emergence. Seedlings from cuttings should be transplanted into the pots after several flushing leaves are fully developed which takes about two weeks. To avoid post-transplanting losses, the potting media must be well drained and watering intensity well managed to avoid water logging. Seedlings should be sprayed regularly with a fungicide “Benlate”, “Bavistin”, or any known plant fungicide to avoid losses through fungal infection common with Melia.

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Melia volkensii seed extractor

J. Lugadiru

Abstract

Melia volkensii is a prized agroforestry tree in the ASALs for its durable quality timber besides other many uses. Propagation of the species is constrained by strong seed dormancy, which has to be broken to increase the rate of germination. However, the matter is compounded by the fact that seed is borne in a hard nut and its extraction poses a major challenge. A more efficient extraction tool was conceptualized, designed and manufactured in the 1990's. The machine increases the rate of seed extraction by increasing the precision of breaking the nut. For efficient performance of the machine, its parts (knife, stopper groove, adjuster and return spring) require regular maintenance. The functioning and the necessary maintenance of the extractor are described.

Key words: Seed extractor, nuts, seeds, and cracker

Introduction

Melia volkensii is an important tree species in the drylands. It provides quality timber and other products such as fodder and bee forage. Because of overexploitation trends, there has been increasing demand for seedlings. Among the factors that hinder mass propagation is seed extraction from the hard stony nut. Indeed nurseries have trouble in seed extraction where the only known option is to crack the nut using a sharp kitchen knife and a hammer. This is slow and cumbersome and leads to injuries to seed and at times even to the operator.

Against this background, the need for a more efficient extraction tool was conceptualized in the 1990s to support an expanded tree-planting programme under KEFRI/JICA social forestry training project. This led to the development of the Melia extractor. This paper highlights the machine, its operations and maintenance.

The components of the extractor

The extractor and its components are illustrated in figure 1.

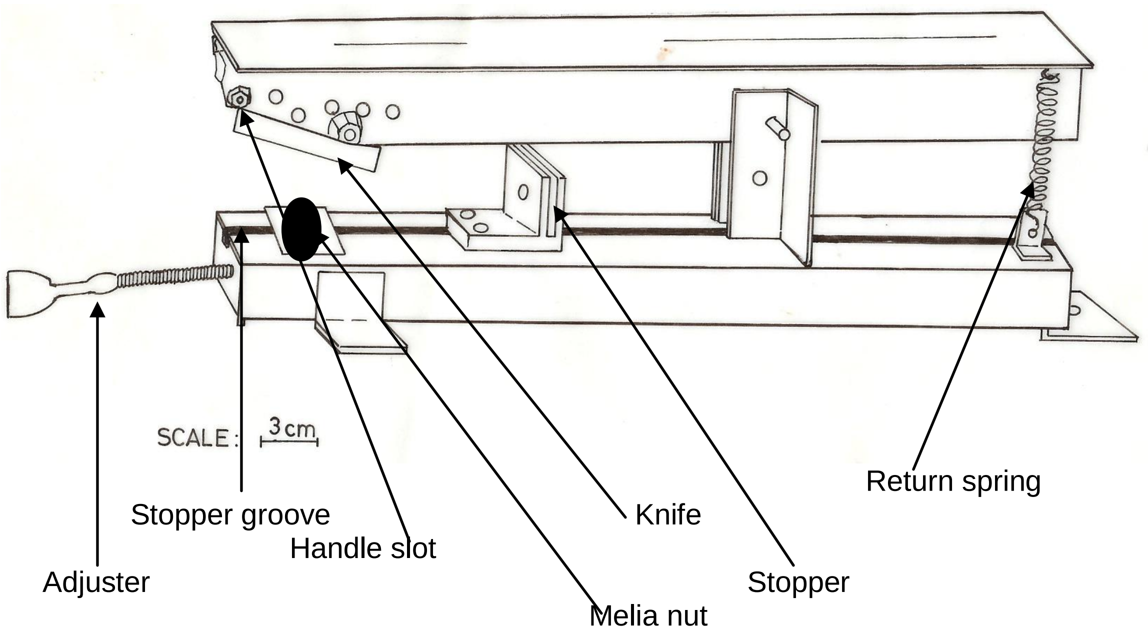

Figure 1. Melia seed extractor

Handle bar
The handle bar is inserted in the provided slot. It can be inserted from either sides of the machine depending on whether the operator is left or right handed.

Stopper
Using the adjuster, the stopper can be moved back and forth along the stopper groove. Its working position depends on the size of the Melia nuts. It is set so that the knife just cracks the nut cover without damaging the seed inside.

Return spring
The return spring pulls the knife up allowing the operator to remove the cracked nut without endangering self. In resting position, the return spring holds the knife up.

Operation
Although the machine is heavy enough to rest on a table, it is recommended to fasten it firmly to avoid shifting when operating. The following are the steps to take when extracting seeds.

- Sort nuts into uniform size classes by visual means.
- Place the nut onto the nut rest slot with nuts' long axis perpendicular to the knife (Figures 1 and 2) and adjust the knife back or forth to fit the nut size.
- Raise the knife holder and using optimal force, crack the nut.
- Gently ease out the seeds from the cracked nut

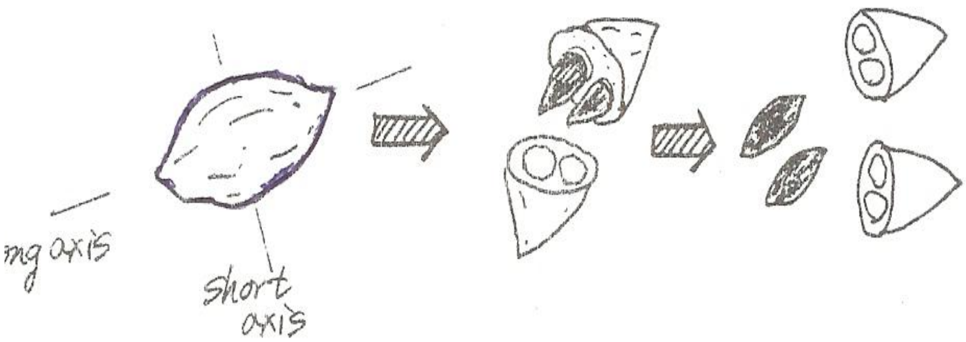

Figure 2. Melia volkensii nuts extraction process

For safety purposes, it is recommended that the machine should be operated by a single person with maximum concentration and without any other activities on the operation table.

Maintenance of the extractor
The extractor has several parts that require maintenance.

Knife
The knife requires sharpening and resetting to the appropriate angle. The process is done by unscrewing bolts that hold the knife in position and turning the knife to use the side that was away from the nut. When the whole cutting edge is blunt, the knife is sharpened uniformly and refitted.

Stopper groove and Adjuster
The stopper groove and adjuster needs to be greased for proper functioning and movements of the stopper.

Return spring
The return spring should be replaced as need arise and especially when it loses tension.

Safety while in transit
While on transit, the machine can damage the knife or even cause body injury. It is therefore recommended that the knife is unfastened from the machine while on transit.

Traditional methods used by farmers to break seed dormancy in *Melia volkensii* in Eastern and Coastal provinces of Kenya

A. Mwamburi, J.M. Kimondo and E. Kyalo

Abstract

Melia volkensii is an important timber species in the drylands of Eastern and Coastal provinces of Kenya. Despite its importance, it is a difficult tree to propagate. Technologies developed by researchers for tree propagation have received low adoption by farmers probably due to their complexity and for that reason farmers have continued to use traditional methods of breaking seed dormancy. However, these methods are not well documented to facilitate their validation and improvement. Therefore, a survey targeting 80 farmers from six districts in Eastern and Coast provinces of Kenya was undertaken to document the methods in use. In total seven methods were documented, namely: burning of the nuts; sowing the nuts in troughs; cracking of nuts; sowing of nuts in long-term beds; sowing of nuts in sunken beds; direct sowing of seeds and sowing of nuts in a seedbed. The study recommends the investigation, validation and improvement of these methods for applicability to alleviate *M. volkensii* seedlings shortage.

Key words: Traditional methods; *Melia volkensii*; seed dormancy

Introduction

The current emphasis of afforestation in arid and semi arid lands is based on the planting of high value trees and shrubs. Such trees species provide the farmers with valuable products and services to meet their basic needs in terms of food, shelter and clothing. This move has been found to act as an incentive to farmers to plant trees on their farms. For the past two decades, research work has attempted to identify such tree and shrub species, both indigenous and exotic. In most trials, *Melia volkensii* has out performed most of the other dryland species (Kidundo 1997). In Kenya, the tree is found in several districts including Kitui, Makueni, Mwingi, Tharaka, Mbeere, and Taita-Taveta (Dale and Greenway 1961). It is known by different local names such as Mukau (Kamba, Mbeere and Tharaka), Kirumbutu (Taita) and Mpenda bure (Swahili).

Melia volkensii is one of the most prized and important multipurpose tree species producing a range of useful products such as high quality timber, fodder, fuelwood and other environmental services. In areas where it naturally occurs it is common to find isolated trees left intact in croplands (Stewart and Blomley 1994).

Over-exploitation of *M. volkensii* for timber without replanting has resulted in rapid depletion of its natural supply. Attempts to propagate the species have proved to be both difficult and expensive due to seed dormancy and post germination problems. There is evidence that farmers have used other establishment practices (technologies) to raise *Melia volkensii* seedlings such as scarification through burning of the nuts. Farmers also use nuts regurgitated by goats (Kidundo 1997) to raise seedlings. However, these methods/technologies are not well documented in such a way as to provide an avenue/strategy for validation and improvement. This survey was initiated to address this felt need.

Materials and methods

With the assistance of the District Forest Officers in the respective districts, farmers with young Melia trees were identified in Kitui, Mwingi, Makueni, Taita-Taveta, Mbeere, and Tharaka districts. The selected farmers were interviewed and requested to identify other Melia growers. While traversing the study areas, the survey team also sampled other farmers with Melia trees on their farms. In total, 80 respondents were covered in the six districts. The interviews were conducted using a structured questionnaire. Farmers also demonstrated their methods although this was not applicable to all farmers due to logistical reasons such as lack of nuts. Most farmers were interviewed singly but a few were interviewed as groups of 2 to 3 farmers. The criteria used to judge the validity of the information included:

- Presence of melia trees of various ages to indicate that the farmer actually was active and interested in the tree (most farmers interviewed had over 50 *Melia volkensii* trees)
- Presence of a tree nursery on the farm.
- Observable management/establishment practices such as border or woodlot planting, pruning and tree protection.

Results

Number of respondents

The distribution of the farmers in the sample districts are shown in Table 1.

Table 1. Number of respondents per district

District	Respondents
Kitui	18
Mwingi	6
Taita-Taveta	12
Makueni	8
Tharaka	12
Mbeere	24
Total	**80**

Methods of breaking seed dormancy

The most common method of breaking seed dormancy used by farmers was scarification by burning (39 farmers) followed by splitting/cracking of the nuts (15 farmers) and sowing of nuts in troughs (11 farmers) as shown in Table 2. Burning was common in all the districts except Taita-Taveta district. The procedures applied in each of the methods are summarized in Table 3.

Table 2. Methods used by district

District	Burning of the nuts	Splitting the nuts	Sowing nuts in troughs	Others	Total
Kitui	8	4	2	4	17
Mwingi	3	1	2	0	6
Taita-Taveta	2	2	5	3	13
Makueni	2	3	0	3	8
Tharaka	5	3	1	3	12
Mbeere	19	2	1	2	24
Total	**39**	**15**	**11**	**15**	**80**

Table 3: Summary of traditional methods of breaking Melia seed dormancy

No	Method	Narrative summary	Remarks
1	Burning of nuts	• Farm residues are uniformly laid on the ground to a thickness of 10 - 15 cm. • 1 - 3 stacks of either fresh or dry nuts are laid on the residue • The nuts are then covered with another 10 - 15 cm layer of farm residue and lit	An approximate germination of 5 - 10% occurs 1 - 3 weeks after onset of rains.
2	Use of troughs	• Troughs of about 20 - 30 cm deep and 60 cm wide are dug 2 - 3 months prior to rains • The nuts are then sandwiched between two equal layers of fresh manure up to two thirds the depth • The top third is filled with soil • The trough is then covered with grass and watered thoroughly	An approximate germination of 10 - 25% is achieved.
3	Cracking of nuts	• Current year nuts are collected from goat sheds and cracked using machetes with nuts placed on either wood or stones • The exposed seeds are sown in containers at depths of 2 – 3 cm • The sown seeds are thoroughly watered once • The container is then covered tightly with polythene sheet	Germination occurs in 1 - 3 weeks.
4	Long-term beds	• Fresh nuts from goat shed are sown in a sunken bed and covered with manure 2 - 3 months before rains • The bed is watered once • The bed remains in place for 2 - 3 rainy seasons	Germination occurs every rainy season over the period
5	Sunken beds	• Fresh nuts from goat shed are sown in sunken beds of 10 - 15 cm depth and covered with manure • The beds are watered once per day	Germination occurs in about 30 days
6	Direct sowing of seeds	• Nuts are cracked to remove the seeds • 3 - 10 seeds are then sown per hole at depths of 5 - 10 cm just before rains	Germination occurs after 1-3 weeks
7	Sowing of nuts	• Current year nuts were sown in seedbed using forest soil • They were watered once a day	A germination of about 20% was achieved after 8 - 10 weeks in one nursery.

Discussions

Despite the apparent lack of planting material for *Melia volkensii*, it is evident that farmers are keen in growing the tree in their farms. The seven methods and their variations attest farmers' efforts in raising their planting material. Surprisingly, the germination results from farmers' methods were low in contrast to the methods prescribed by KEFRI that achieve up to 80% germination. The non-adoption of KEFRI method by farmers could be attributed to its complexity, suggesting that mass production of seedlings could only be undertaken in specialized nursery for the time being. Nevertheless, the methods identified with farmers require validation and refinement using experimental approaches to improve germination and develop appropriate protocols that can be used by farmers in different places.

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Vegetative propagation of *Melia volkensii*: an indigenous multipurpose drylands tree species

S.A. Indieka and D.W. Odee

Abstract
Melia volkensii is a multipurpose tree species endemic in the arid and semi-arid lands (ASALs) of Eastern Africa. Its wide scale planting has been constrained by lack of quality planting material due to problems associated with seed extraction and difficulty of propagation. In this study, two propagation techniques were tried: (1) macro-propagation using rejuvenated leafy stem cuttings from mature trees and (2) in vitro shoot multiplication using juvenile explants. In macro-propagation, success rates of 13 to 33 % were achieved using low-cost propagator, when cuttings were treated with 4-10 g/L IBA rooting hormone. Length and number of roots obtained per cutting were significantly ($P<0.05$) influenced by IBA concentration. The in vitro multiplication experiments were conducted in Murashige and Skoog (MS) basal media supplemented with BAP in combination with either kinetin or IAA. An average of 5 shoots per explant was achieved with BAP: IAA combination (0.5: 0.2 mg/L), while a maximum of 2 shootlets was achieved on BAP: Kinetin combination. Height, number of shootlets per explant and quality (harvestable shoots) were significantly ($P<0.001$) influenced by BAP: IAA combination, while height was only influenced significantly ($P<0.05$) by Kinetin: BAP combination. The study demonstrated that *M. volkensii* is amenable to propagation by rejuvenated leafy stem cuttings and in vitro multiplication.

Key words: Multipurpose tree, rejuvenation, in vitro multiplication, macro-propagation

Introduction
M. volkensii is a popular indigenous agroforestry tree species in arid and semi arid lands (ASALs) of Kenya (Tedd, 1997; Broadhead *et al*., 2003). It is fast growing, tolerant to dry conditions and is compatible with most crops, though management through root and crown pruning are recommended to minimize competition (Stewart and Blomley, 1994; Mulatya *et al*., 2002). The tree produces high quality timber, poles, beehives, fodder and pesticides extracts (Rajab and Bentley, 1988; Sharook *et al.*, 1991; Kidundo, 1997).

Despite the popularity and multipurpose nature of *M. volkensii*, its wide scale cultivation has been constrained by lack of planting material due to problems associated with seed extraction and seed dormancy (Milimo and Hellum, 1989; Stewart and Blomley, 1994). The current available methods of propagation using seed or root and stem cuttings are problematic and hence not amenable to mass production of planting materials. The methods are labour intensive, difficult to optimize and have not been able to meet the growing demand for planting materials. There is, therefore, an urgent need to develop appropriate alternative propagation techniques.

Currently there are no methods developed or reported on the application of either tissue culture or rejuvenated leafy stem cuttings for the propagation of *M. volkensii*. This paper reports on the developments of these techniques and preliminary results on the influence of surface sterilization and IBA concentration on rooting of rejuvenated leafy stem cuttings, and *in vitro* shoot multiplication using juvenile shoot tips.

Materials and methods
Macro-propagation
Six mature *M. volkensii* trees (>5 years old) were selected from three farms in Katulani sub-location, Kitui district. The trees were either root-pruned or stems cut at one metre

above the ground in order to initiate root suckers and shoot coppices. Only suckers from roots were used due poor coppicing of cut stems. Cuttings were collected from the suckers and transported to the laboratory. Two- or three- node leafy stem cuttings were prepared.

The cuttings were treated with IBA at concentrations of 0, 2.0, 4.0, 6.0, 8.0 and 10.0 g/L and used according to methods described by Hartman *et al.,* (1997) and commercial rooting powder (Seradix®, 0.8 % IBA). In experiment 1, suckers were not surface sterilized before or during preparation of cuttings. However, in experiment 2, suckers surface were sterilized with 0.2 % NaOCl for 2 to 3 minute, and then rinsed with distilled water before cuttings were prepared. The cuttings were then inserted into sterile washed sand (sterilized at 121 ^{o}C, 1.06 kg/cm^{3} for 60 minutes) in a low-cost propagator covered with 50 % shade cloth. The conditions within the propagator were 70-90 % humidity and mean temperature of 22 to 28 ^{o}C.   Treatments were replicated 5 times and randomized within the rooting bed. Each replicate had 6 cuttings. The number of surviving and infected cuttings was assessed at 15, 30, 45 and 60 days after insertion. Percentage rooting, number and length of roots per cutting were assessed 60 days after insertion. Analysis of variance and the Newman-Keuls test ($P<0.05$) were performed on all data to detect differences between treatment means.

Micro-propagation

M. volkensii nuts were obtained from Kenya Forestry Seed Centre, Muguga. Seeds were extracted, surface sterilized with 10 % NaOCl for 15 minutes and rinsed in 3 changes of sterile distilled water. The seeds were soaked overnight in 1 % NaOCl and longitudinal slits were made as described by (Milimo, 1989) and then pre-germinated in sterile moist vermiculite incubated at 28±2 ^{o}C. The germinated seeds were transplanted into potted nursery soil mixture (2: 1, soil: sand) and were raised for 3 months under glasshouse conditions with average day and night temperatures of 25 and 17 ^{o}C respectively.

After 3 months, shoot tips were harvested, defoliated and surface sterilized with 6 % NaOCl for 10 minutes. The shoot tips were then rinsed in 3 changes of sterile distilled water, re-cut into sizes of 3-5 mm and inoculated into test media. The test media consisted of Murashige and Skoog (1962) basal media (MS) and supplemented with BAP in combination with either Kinetin or IAA; BAP (0, 0.1 and 0.2 mg/L) and kinetin (0, 0.1, 0.2, 0.4, 1.0 and 3.0 mg/L), BAP (0, 0.5, 1.0, 2.0 and 3.0 mg/L) and IAA (0, 0.1 and 0.2 mg/L). Each culture tube contained 30 ml of media formulations and sterilized at 121^{o}C, 1.05 kg/cm^{3} for 15 minutes. The cultures were incubated for 30 days in a growth chamber illuminated with cool white fluorescent lamps with temperature and photoperiod maintained at 28±2 ^{o}C and 16 and 8 hr of light and darkness respectively. Each treatment was replicated 9 times and randomized within the growth chamber. Height, number of shootlets per explant and quality (harvestable shootlets) were assessed 15 and 30 days after inoculation. Data were analyzed using ANOVA. Callus formation was also scored on a scale of 1, 2 and 3 representing low, moderate and high respectively.

Results

Macro-propagation

Experiment 1 was terminated 20 days after insertion of cuttings due to fungal infection. In experiment 2, only 15 % of the total cuttings inserted were lost to fungal infection. At termination of the experiment (60 days after insertion), cuttings treated with IBA at 4 - 10 g/L IBA had rooting success of 13 - 33%. The number of roots and length were significantly ($P<0.05$) influenced by IBA concentration. Variation in form, number and length of roots within treatments were also observed (Plate 1). The best overall score on all root parameters considered was achieved on cuttings treated with 8 g/L (Table 1). Cuttings which were treated with 0 g/L IBA (50% ethanol), 2 g/L IBA and distilled water formed callus, whereas higher auxin treatments and Seradix® had swollen bases.

Plate 1. Variation in (a) length and (b) number of roots obtained on *M. volkensii* leafy stem cuttings treated with 8 and 10 g/L IBA at 60 days after insertion into the propagator

Table 1. Effect of IBA treatment on root production of *M. volkensii* rejuvenated stem leafy cutting 60 days after insertion into the propagator. Values in a column followed by the same letter are not significantly different according to the Newman-Keuls test at P<0.05.

IBA Concentration (g/L)	Root number cutting^{-1}	Root length (mm) cutting^{-1}	% Rooting
0	0**a**	0**a**	0**a**
2	0**a**	0**a**	0**a**
4	1.7**a**	52**b**	20**b**
6	0.3**a**	45**b**	13**b**
8	5.3**b**	47**b**	33**c**
10	1.3**a**	65**b**	20**b**

Micro-propagation

Growth response was observed 10 days after inoculation. All shoot tips were elongated when compared to their size during inoculation into MS media with or without growth regulators. Tall and good quality shoots were obtained when BAP and kinetin were combined. However, BAP and IAA combination induced shoot multiplication up to a maximum of 9 per explant (Plate 2) compared to 2 per explant with BAP and kinetin combination. In both combinations, most explants formed moderate callus rated at 1-2. Low BAP concentrations (≤1.0 mg/L) in combination with IAA at either 0.1 or 0.2 mg/L resulted in multiplication of shoot tips (Fig. 1). An average of 5 shoots per explant was achieved with BAP: IAA at 0.5: 0.2 mg/L.

Plate 2. *In vitro* shoot multiplication of *M. volkensii* in MS basal media supplemented with BAP and IAA at 0.5 and 0.2 mg/L.

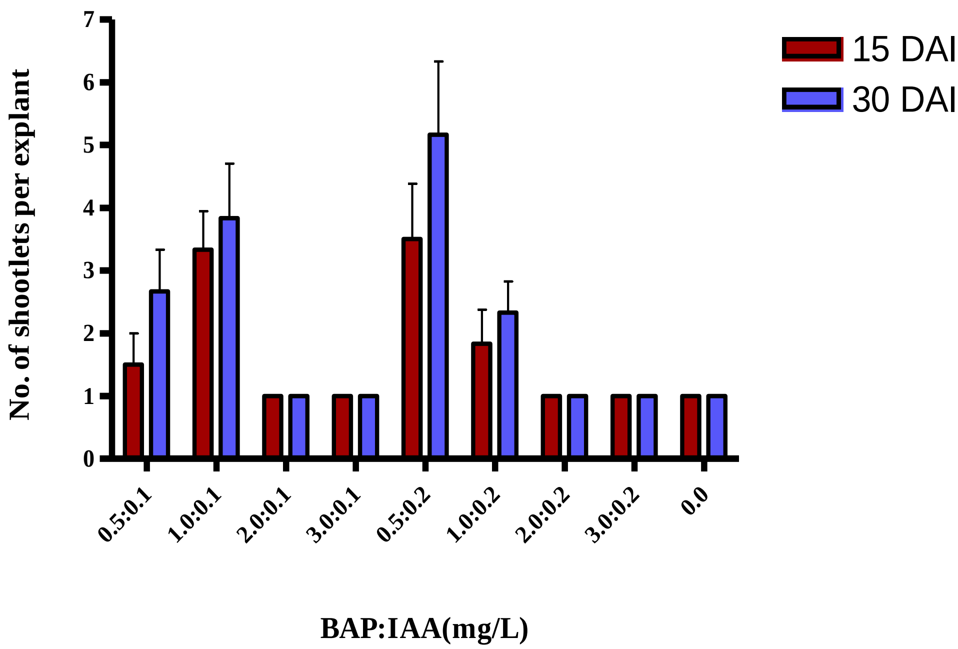

Fig 1. Effect of BAP: IAA combination on multiplication of shoot tip explants at 15 and 30 days after inoculation (DAI). Vertical bars represent standard error of means (*n* = *9*).

Height, number of shoots per explant, and quality were significantly ($P<0.05$) influenced by BAP: IAA combinations used. However, only shoot height was significantly ($P<0.05$) influenced by BAP: Kinetin combination. Increasing BAP from 0.5 to 1.0 mg/L in combination with IAA at 0.1 mg/L resulted into increase in height at 15 and 30 days after inoculation. The reverse was observed when IAA was increased to 0.2 mg/L. In both scenarios, further increase in BAP concentration reduced the number of shoots obtained per explant (Fig. 1). A similar trend was obtained with shoot quality. Increase in BAP concentration with IAA at either 0.1 or 0.2 mg/L reduced the heights of shoots formed.

Discussion and recommendations

In this study, use of rejuvenated leafy cuttings from mature *M. volkensii* trees has indicated that the method has potential for use in propagating melia. This study also confirms that juvenile tissue is more responsive to rooting hormone especially species with difficulty in rooting cuttings from mature trees (Danthu, 1992; Longman and Wilson, 1993). A rooting success of up to 33% is the highest recorded with the species to date.

Survival of cuttings in propagators was significantly enhanced with surface sterilization. Similar techniques have been applied successfully in micro- and macro-propagation of tree species such as *Acacia mearnsii* and *Ficus* species (Sascha *et al*., 2000; Danthu *et al*., 2002).

These results have clearly shown that rejuvenated *M. volkensii* leafy stem cuttings respond well to treatment with IBA. Further work is required to test the response of rejuvenated leafy cutting when treated with IAA and NAA separately or in combination with IBA. Variation in the number and length of root on cuttings may be attributed to genotypic differences since the experimental cutting materials originated from different trees. However, further studies are required to elucidate the effect of tree genotype on rooting ability of *M. volkensii* cuttings.

Micro-propagation results indicated that BAP and IAA combination was the most effective in shoot multiplication of *M. volkensii* juvenile explants. Results of this study are consistent with previous findings that demonstrated synergistic effect of auxins and cytokinins on shoot multiplications (Ndoye *et al*., 2003). However, inability of BAP: kinetin to induce multiplication contrasts with other results obtained by Babu *et al*., (2000). The kinetin: BAP results are consistent with those obtained by Ndoye *et al*. (2003) on *Balanites aegyptica* explants inoculated in MS supplemented with kinetin. Reduction in shoot multiplication due to concentrations of BAP >1.0 mg/L clearly indicates that *M. volkensii* juvenile material prefers relatively lower levels of BAP for multiplication. In addition, shoot tip elongation on MS basal media without plant growth regulators suggests that *M. volkensii* has strong apical dominance. The results on number of shoots is similar to those reported for *Azadirachta indica* (neem tree), also belonging to the Meliaceae family (Quiraishi *et al*., 2004).

The study has demonstrated that *M. volkensii* is amenable to propagation by rejuvenated leafy stem cuttings and tissue culture. Rooting experiments are therefore required to develop an *in vitro* multiplication protocol for *M. volkensii*. Further studies are recommended to optimize the protocols and open up opportunities for scaled up adoption and cultivation of *M. volkensii*.

Acknowledgements

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Performance of *Melia volkensii* at different spacing in Tiva, Kitui district

J.Kimondo and G. Ouma

Abstract

Potential gains of growing *Melia volkensii* by farmers and in public institutions is impeded by not adhering to the prescribed square spacing of 4.0 m because potential losses have not been demonstrated effectively. Against this background, a spacing trial was established at Tiva where survival and growth were evaluated in square spacings of 2.5, 3.0, 3.5 and 4.0 m. After one and half years, survival rate ranged from 69.4% in the 2.5 m to 72.8% in the 4.0 m spacing but was not significantly different. However, height and diameter were significantly different among the different spacing treatments. The highest mean height growth of 3.83 m and diameter of 6.0 cm were recorded in the 3.5 m spacing, suggesting that this could be the optimum spacing at the early growth stages of the species.

Introduction

Melia volkensii has become an important species in drylands. Previous research work has shown that melia grows fast and is therefore recommended for dryland plantation establishment (Kidundo, 1997, Tedd, 1997, Mulatya, 2000). Pilot plantation trials at Tiva have shown that optimal growth rate for dryland tree species occurs at square spacing of 3.5 m. This spacing was however increased to 4.0 m to allow mechanised weeding and over time has been adopted as a practice for establishment of Melia.

Since the year 2000, KEFRI's Kitui Centre has been promoting the planting of *Melia volkensii* in farms and public land in Kitui district. In addition, the forest department in collaboration with Integrated Natural Resource Management in Ukambani (INRMU) project has embarked on planting of melia in public forestland since 2002 using the recommended spacing. However, Tana and Athi River Development Authority (TARDA) has established pilot plantations at Masinga Dam using a lesser square spacing of 2.5m normally used for tree establishment in humid areas. Recent surveys have also shown that farmers are using close spacings for varied reasons.

This study was undertaken to evaluate and demonstrate the growth performance of melia trees planted at four different spacing treatments.

Materials and methods

The trial was established at Tiva, where the bimodal highly erratic rainfall averages from 500 to 600 mm per year. The mean annual temperatures are 24 degrees centigrade. Evapo-transpiration rate is estimated to be around 2000 mm. The soils are shallow to deep, well drained sandy clay loam. The trial site was covered by sparse bushlands with isolated *Acacia species* and *Commiphora* trees*.* Before planting, the land was cleared and deep ripped with bulldozer to enhance water infiltration. The planting holes were staked as per spacing treatments of square spacing of 2.5 m, 3.0 m, 3.5 m and 4.0 m. Each spacing treatment was replicated three times in plots of 28 m by 28 m giving rise to plots of 121, 81, 64 and 49 seedlings for respective spacings. Weeding was first done by tractor when trees were small but later oxen plough was used as trees canopy closed. The trees were assessed for survival rate, diameter at breast height and height at one and half years after planting.

Results

Survival rate ranged from 69.4% for 2.5 m to 76.6% for the 3.5 m spacing (Table 1). However, survival was not significantly different among the treatments. The highest mean height of 3.83 m was attained in the 3.5m spacing, whereas mean diameter was highest at both 3.5 m and 4.0 m spacing (Table 1).

Table 1: Percentage survival, mean height and diameter of trees at different spacing treatments of *Melia volkensii* at 1.5 years

Treatment	% Survival	Height (m)	Diameter (cm)
		Mean± se	Mean± se
2.5 x 2.5 m	69.4	3.36 ± 0.06	4.2 ± 0.1
3.0 x 3.0 m	71.3	3.38 ± 0.08	4.4 ± 0.1
3.5 x 3.5 m	76.6	3.83 ± 0.09	5.0 ± 0.1
4.0 x 4.0 m	72.8	3.70 ± 0.11	5.0 ± 0.2

Discussion and recommendations

Whereas survival at this stage is within acceptable levels for this mode of tree establishment, there is room for improvement if the unanticipated mortality agents (animals, handling, and fungal infections) were addressed. With respect to growth, this trial has clearly demonstrated that the spacing of 3.5m could be optimal. This is consistent with other studies carried out on other dryland species such as *Senna siamea* and neem under similar conditions. As the rotation age of the species is about 12 years, it is recommended that the trial is maintained and monitored over the entire rotation period.

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A review of *Melia volkensii* tree - crop interactions in eastern Kenya

J.M. Mulatya

Abstract

Melia volkensii is used for timber production in eastern Kenya. On farms, the tree is planted along the boundaries; line plots, and as isolated trees on farm where it is often intercropped. The tree – crop interaction is poorly understood and studies were undertaken to assess effects of shading and root competition on crop yields in Kitui, Mbeere, Machakos and Kibwezi. The results indicate that melia trees compete for resources with crops leading to yield losses of up to 50% because of canopy shading and root competition. The effects of shading alone were found to suppress crop yields at rates greater than that caused by 50% artificial shading. Crop yield decrease away from the tree while soil moisture depletion also followed a similar trend, suggesting that the yield loss could partly be attributed to competition for water by trees. This is corroborated by yield increases when melia trees were canopy and root pruned
.

Keywords: *Melia volkensii*, competition, maize yields, management

Introduction

Melia volkensii is becoming an increasingly important tree in the drylands of Kenya because of its high value and termite resistant timber (Mulatya and Misenya, 2005). The species is drought tolerant with rapid growth usually acquiring good form when properly managed (Tedd, 1997; Mulatya, 2000). A survey in Mbeere district indicated that farmers also treasure it as animal fodder. This has accelerated its planting within farmlands.

Farmers believe Melia has no negative effects on crops when intercropped. In the past, these sentiments were shared by pioneer agroforesters who advocated positive tree – crop interaction based on trees ability to recycle nutrients, particularly in the humid areas. However, cumulative scientific evidence shows that, as a principle, there is negative tree – crop interaction because of above and below ground competition. This competition could be more severe in drylands where soil moisture is limiting. This paper reviews studies conducted on Melia crop interaction in the drylands of eastern Kenya to guide on farm tree management.

Reviewed studies

Study 1: Shading effects of different melia provenances on maize yield

The broad of objective of this study was to evaluate the shading effects of Melia on maize yields. The specific objective tested Melia provenance variations in the aforementioned parameter. Experimental plots were set in Machakos, ICRAF station using line plots of 21 trees for each of the 4 provenances. Within the line plots, trees were spaced at 2 m and 30 m between the plots. Controls of 0%, 25% and 50% shading intensity were also used and the treatments replicated 4 times. To isolate the shading effects from below ground competition, the trees used in the shading experiment were root pruned using trenches of 30 cm depth and 50 cm away from the line plots on both sides of the rows. For maize plantings, 6 m by 6 m-square sample plots were laid out with the line plot running through the middle and maize crop established.

Maize cobs were harvested from 30 randomly selected plants in each sample plot and their yields expressed on per hectare basis.

Results

Maize yields were reduced by the shading effects of all Melia provenances to an extent even beyond 50% artificial shading intensity (Table 1). Least shading effect was found with Ishiara provenance although it was not significantly different from the others.

Table 1: Comparison of maize grain yields (ton ha^{-1}) between *Melia* provenances and controls (0%, 25%, 50% shading intensity) plots at age 3 years in Machakos

Source of variation	Maize yield (ton ha^{-1})
0% shading	1.9[a]
25% shade	1.7[a]
50% shade	1.6[ab]
Ishiara	1.3[bc]
Kibwezi	1.2[c]
Kitui	1.1[c]
Siakago	1.1[c]

Values with different letters are significantly different ($P \leq 0.05$).

Study 2: Root effects of different melia provenance on maize yield

The objective of this study was to evaluate the root effects of Melia provenances on maize yields and soil moisture absorption. The layout was as in study 1 above, except there was no root pruning. The maize yields were measured at 1, 3, 5, 7, 9, 11, 13, and 15 meters from the tree line. Access tubes were inserted to the ground up to depth of 1.5m at perpendicular distances of 1.5m and 6m away from the tree line. Volumetric soil water content (VSWC) which is an expression of the amount of water present in the soil as a fraction of soil field capacity was determined at depths of 25cm, 45cm, 65cm, 85cm 105cm and 125cm using neutron probe.

Results

Maize yields increased away from the tree (Fig 1). At age 3 years, provenances effects on crop yields were indistinct although Ishiara provenance had the least suppression effects.

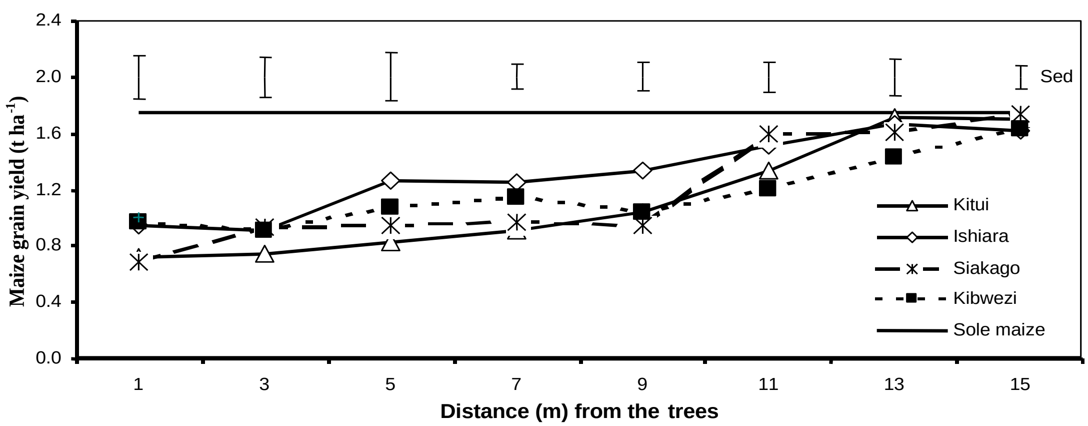

Figure 1. Relationship between maize yields and distance from the melia trees at age 3 years at Machakos.

Compared to maize, melia extracts more water from the soil at all depths up to 1.5 m away (Figure 2a). As you move away from the tree, the effect of melia diminishes up to a depth of about 100 cm down the soil profile (Figure 2b). Among provenances, there were no differences in the way they extracted water except the Kitui provenance at 125cm depth (Figure 2a).

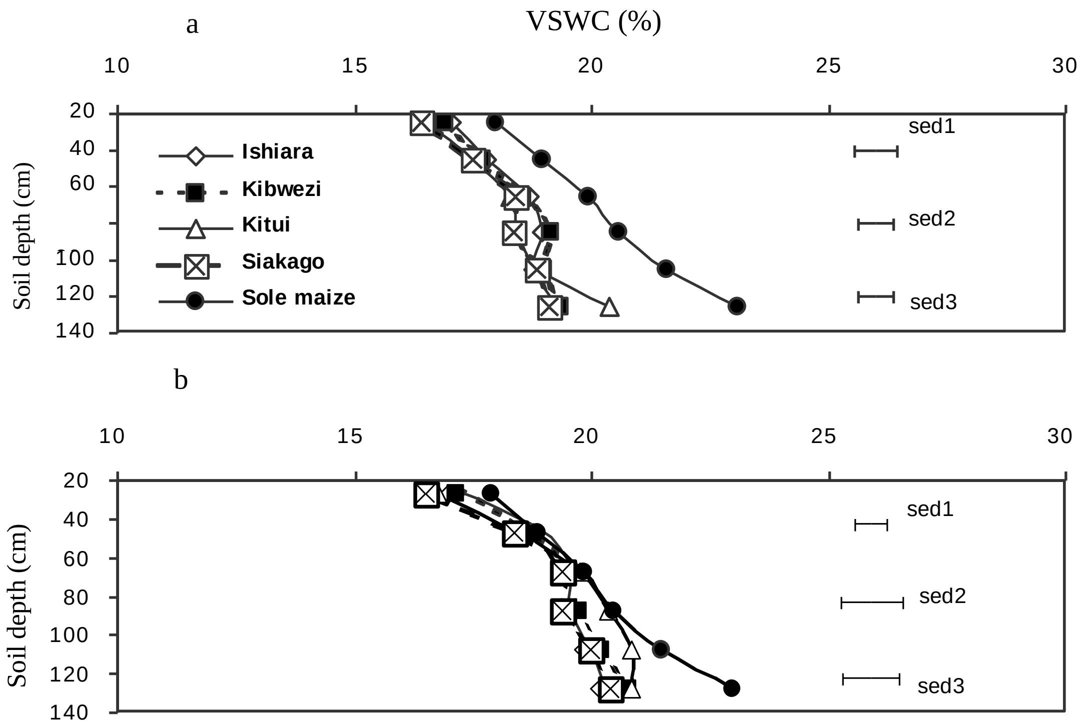

Figure 2. VSWC in the plots containing *Melia* provenances and in control plots vertically into the soil profile **a)** 1.5 m and **b)** 6.0 m from the tree rows during maize grain formation stage. sed 1, sed 2 and sed 3 are standard errors between means when comparing treatment at corresponding depths.

Study 3: Effects of different management protocols of melia on maize yields

The objective of the study was to evaluate the effects of crown and root management on maize yield. This experiment was conducted on farm where isolated trees were selected and the following treatments applied:

i. Crown pruning where tree canopy was reduced by 90%
ii. Root pruning where lateral roots were cut up to a depth of 30 to 50 cm, at a distance of 0.5m away from the tree.
iii. Crown and root pruning, a combination of (i) and (ii) above.
iv. A control of unpruned for both crown and roots.
v. A control without trees (maize only)

Maize yields were sampled at 1, 3, 5, 7, 9, 11, 13 and 15 meters away from the tree, using 10 maize plants nearest to every sample point.

Results

Under the melia tree management, where pruning of both canopy and roots were carried out, results indicated that both severe canopy pruning and root pruning improved crop yields within intercrop significantly compared to unmanaged trees (Figure 3). However, the management did not have significant effect. The combined crown and root pruning doubled the yields as close as 1 m to the tree. However, even with the management, the yields were still significantly lower (less than 50%) than where there were no trees. It seemed also that isolated effects of root and crown management on yields were similar but lower than their combined effects.

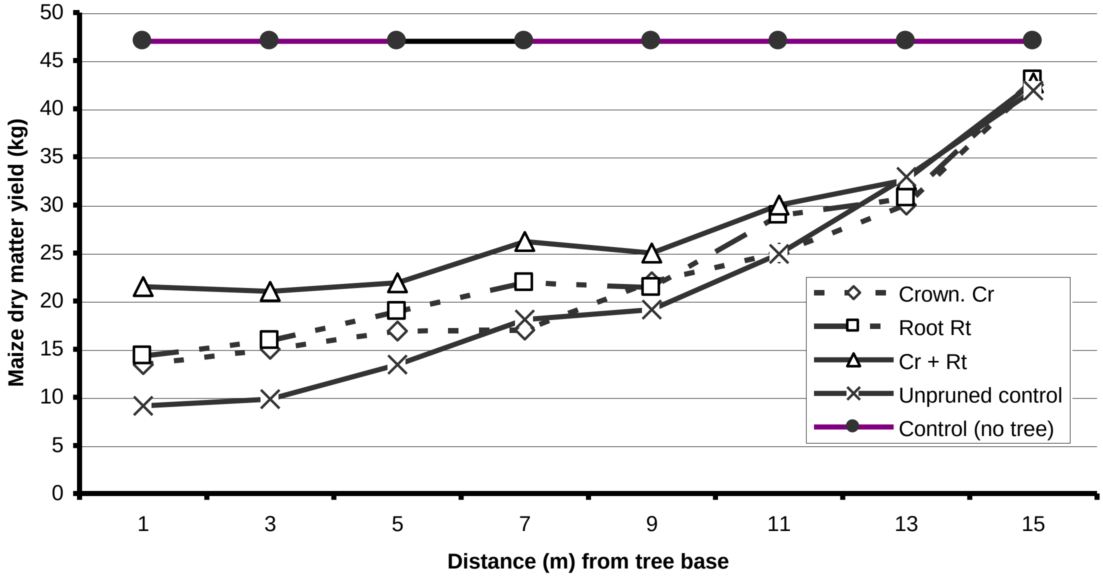

Figure 3. Comparisons of maize yields from managed and unmanaged melia trees on farmers fields at Kitui and Kibwezi

Discussion and conclusions

Results of these studies have clearly showed that melia, regardless of provenance competes with crops through canopy and root effects. Nevertheless, there is room for significant improvement of crop yields through tree management. Severe crown pruning and moderate lateral root pruning could increase yields by more than 100%.

Unpublished data have also shown that the competitiveness of Melia is comparable to other agroforestry species such as *Grevillea robusta*, *Senna siamea*, and *Gliricidia sepium* (appendix 1). For the case of melia, the anticipated values are greater than for the aforementioned species, justifying why the species should be promoted as a major agroforestry species in the drylands. However, where land is not a constraint, it is recommended that melia should be grown in woodlots as a monoculture.

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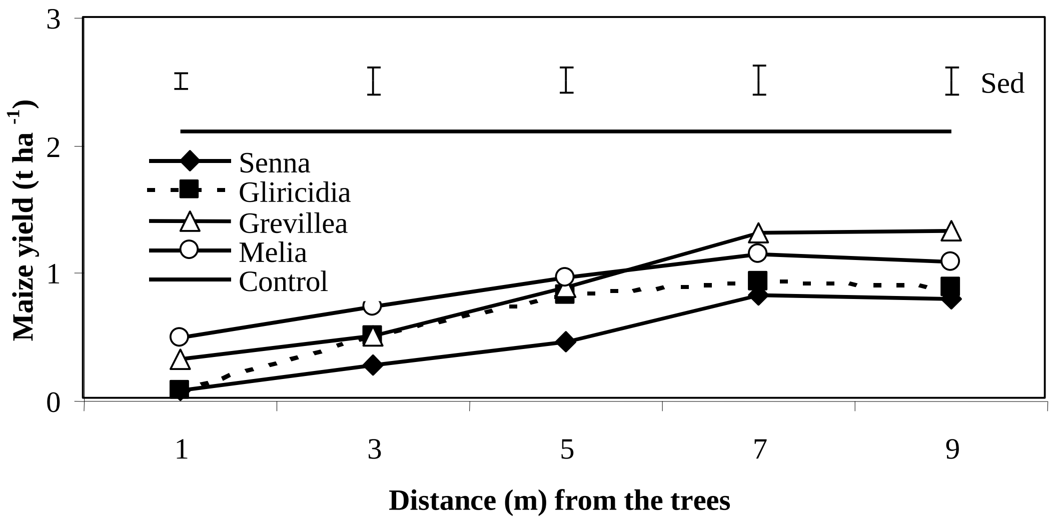
Appendix 1: Relationship between maize yield and distance from the trees for different species at age 4 years at Machakos



Rapid appraisal of management and utilisation of *Melia volkensii* by farmers in Kibwezi, Makueni district

P. Juma, D.K. Musya, T. Misenye, J. Katiku and P. Matieka

Abstract

Melia volkensii is an indigenous multipurpose tree species endemic to sub-humid and semi-arid areas of Kenya, Somalia and Tanzania. This species is a potential plantation and agroforestry tree species in semi-arid areas. However, it has not been widely planted because seedling production and other management protocols are not yet sufficiently developed. This work was initiated to look how melia fits into the on farm activities and how it interacts with food crops, livestock, wild animals as well as its management regimes in Kibwezi. The results obtained indicated that the small-scale farmers could optimize the maximum utility of *Melia volkensii* by improving its management on farm than growing it on fallow bushes.

Key words: *Melia volkensii*, management, utilization, farmers

Introduction

In the past, agroforestry in Kenya had relied heavily on a few exotic species that were selected for their fast growth and adaptability in the high potential areas. However, some of these species are not suitable for semi arid areas resulting into low productivity. The future of sustainable agroforestry in dryland areas will depend on suitable indigenous tree species such as *Melia volkensii*, which are well adapted to the local environmental conditions (Kidundo 1997). Promotion of such indigenous species have however been hampered by lack of information about their propagation and management practices. Unlike the scientists, farmers have a wealth of indigenous knowledge, which they have used over the years to establish and manage melia trees on farm. This rapid appraisal was therefore carried out to document the farmers' practices in melia management. It is anticipated that the information gathered would provide baseline inference for further scientific intervention.

Procedure used

An excursion was undertaken in the melia growing areas of Kibwezi and discussions held with farmers. Field observations were also made and inferences drawn.

Results

Propagation methods used by farmers included use of seeds to raise seedlings and injuring the roots to promote suckering. Farmers also propagate melia through coppicing. For production of healthy seedlings, it was inferred that pricking out should be done as soon as the germination commences (2 - 3 days after germination) and the potting medium should have high sand content. The potted seedlings should be kept under shade for at least 2 weeks after transplanting while seedlings in the nursery should be watered sparsely (once a day).

It was also observed that the management of melia has been integrated into the farming system (Table 1). From the table, the critical management operation of pruning is undertaken just before the rains to reduce tree – crop competition and improve timber quality. In addition, pruning is undertaken during dry season to provide fodder. The other inferred management practice is tree weeding which occurred when crops are weeded particularly in tree-cop interactive systems.

Table 1: Annual calendar for integrated melia – crop system in Kibwezi, Makueni district

Activities	Months											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Partial leaf fall												
Planting												
Prune for timber & crops												
Flowering												
Rains												
Prune for fodder												
Weeding												
Watering												
Land preparation												
Terracing, fencing,												
Tractor ploughing												
1st season planting pegionpea,maize												
Cowpea & beans												
1st & 2nd weeding of cowpea,beans												
3rd weeding of maize												
2nd seasonplanting maize,beans,cowpea												
1st & 2nd weeding beans & cowpea												
Harvesting beans & cowpea												
Harvesting maize												
Harvesting Pegionpea												
Land preparation cutting pegionpea												
Terracing												
Rains												
Land preparation, burning,digging, fencing												
Land preparation												
Planting												
Weeding												
Harvesting												

Farmers visited during the excursion mentioned various uses. The uses are summarized in table 2. The uses preferences varied from one locality to another.

Table 2: Percentage of farmers indicating the various uses of melia in different sites of Makueni district, Kenya

Ranking use	Kibwezi	Mikuyuni	Utiithi	Ngwata	Kyumani
1. Timber	70	5	10	10	5
2. Poles	15	10	15	50	10
3. Fodder	20	10	30	20	20
4.Wood carving	10	10	40	30	10
5. Medicinal	15	30	20	15	20
6. Beehives	20	10	20	40	10
7. Mortar	-	20	50	20	10
8. Fuel wood	20	20	15	30	15
9. Windbreak	5	15	10	50	20
10. Shelter	10	20	20	20	30
11. Boundary planting	35	15	20	15	15
12. Soil erosion	15	20	25	10	30
13.Home gardens	10	10	10	20	50

Discussion and Recommendation

This appraisal has revealed a highly developed melia-crop integrated management system by farmers. However, these management systems need further verification using well-designed experiments to quantify effects of tree-crop interaction. Trees should be managed for desired products.

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Melia volkensii growth in the southern drylands of Kenya

J. Mulatya and T. Misenya

Abstract

Melia volkensii is an important timber tree in drylands. Among many other species used in the dryland afforestation programmes, Melia volkensii is reported to grow faster than other species and farmers easily accept it. For these reasons, Melia was therefore chosen as the key species for comparison with others to ascertain its growth superiority in the drylands. Three trials of different ages established at Machakos Kibwezi and Kitui were used in this evaluation. The results of volume growth comparisons of melia with Grevillea robusta and Senna spectabilis showed that melia growth exceeded that of the two species by 40% and over 100 % respectively. Similarly when compared with other dryland species at Kitui, Machakos and Kibwezi trial sites, melia growth was significantly greater (p = 0.05) across the sites. Within the melia provenances, the Siakago and Kitui provenances outgrew those from Kibwezi and Ishiara. Generally, melia was shown to be superior in growth than other dryland species.

Key words: *Melia volkensii*, drylands, growth, sites.

Introduction

One of the most useful species in drylands is *Melia volkensii* (Gurke) which provides several products such as timber, fodder, pesticide, poles and woodcarving (Stewart and Blomley, 1994). The species grows naturally across the drylands of eastern, northern and coastal areas of Kenya (Milimo, 1989; Mulatya, 2000). Afforestation programme in drylands have promoted tree species such as *Eucalyptus camaldulensis*, *Grevillea robusta*, *Prosopis juliflora*, *Senna siamea*, *Acacia polycantha* and *Brachyleana huillensis*. However, recent surveys have shown a higher preference for melia by farmers who believe that Melia grows faster than the promoted species (Mulatya *et al*., 2002; Kidundo, 1997; Tedd, 1997). This study was undertaken to compare the growth performance of Melia with other tree species in selected sites. In addition, Melia provenances were evaluated for growth performance variations because of its wide distribution in Kenya drylands. Three trials established at Machakos, Kibwezi and Kitui at different times were used in this study.

Methods

In Machakos, three species (*Melia volkensii, S. spectabilis and G. robusta*) were planted in line plots of 24 trees per species at spacing of 2.5 m within rows and 10 m between rows. These were replicated in three randomized blocks. In addition, a trial of four Melia provenances (Ishiara, Kitui, Kibwezi and Siakago) was established using the same design although the number of seedlings used per line plot was 21.

In Kibwezi, 5 species (*Melia volkensii, Commiphora baluensis, Olea europea, Brachyleana huillensis* and *Dalbergia melanoxylon*) and four Eucalyptus hybrids (796, 584, 785 and 167), were planted in line plots of 6 trees per species at spacing of 3 m within rows and 10 m between rows. These were replicated in three randomized blocks. In Kitui, eight species (*Melia volkensii, Acacia polycantha, Croton megalocarpus, S. siamea, S. spectabilis, G. robusta, Eucalyptus camaldulensis* and *Prosopis juliflora*) were planted in plots of 9 trees per species at spacing of 3 m by 3 m and replicated in four randomized blocks.

Before establishment, all plots were tractor ploughed. The experimental plots were maintained through clean weeding except in Kitui where trees were spot weeded and the rest of the plot slashed.

Measurements were carried out on both diameter at breast height (dbh) and tree height using diameter tapes and height measuring rods respectively. In Machakos, where trees were big, the volume was derived using height and dbh, and species and provenance performance compared using this parameter. Data was analysed for variance (ANOVA) of growth parameters between treatments.

Results:
At age of 4 years, the volume of Melia exceeded that of other species (Figure 1).

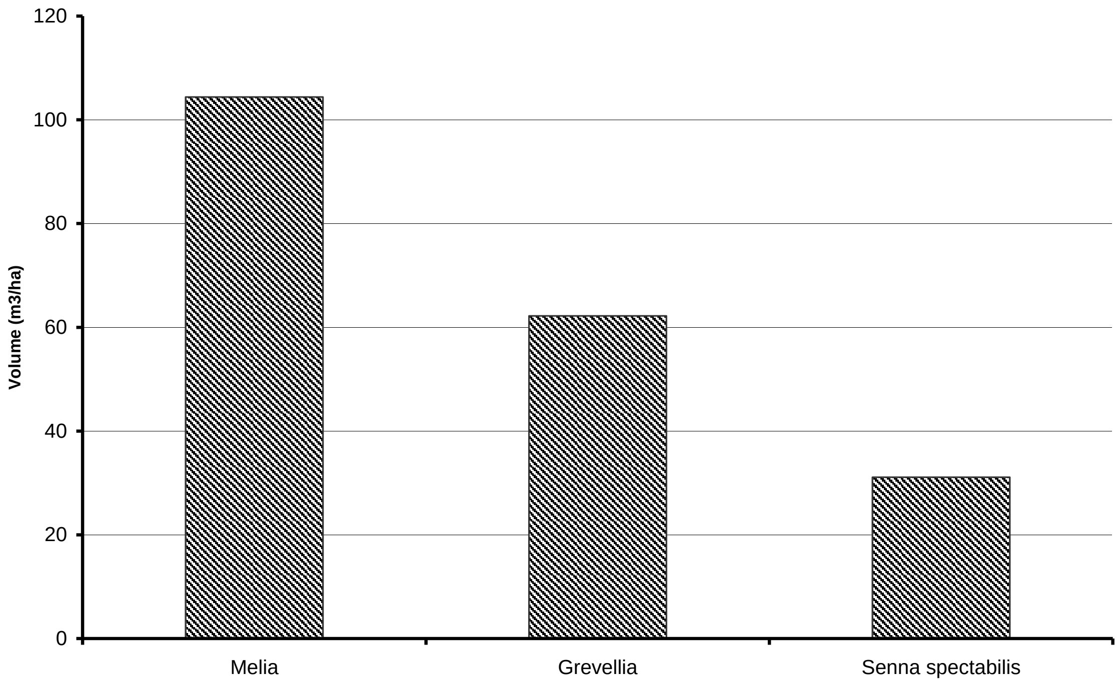

Figure 1: Volumes of *Melia volkensii*, *Grevillea robusta* and *Senna* spectabilis at Machakos at age 6 years.

At Kibwezi site, *Melia* growth was superior to those of other species. It overshadowed the fastest growing exotic species such as eucalyptus (Figure 2). Other indigenous species such as *Commiphora baluensis, Olea, Brachyleana* and *Dalbergia melanoxylon* had up to 60% less diameter growth than melia.

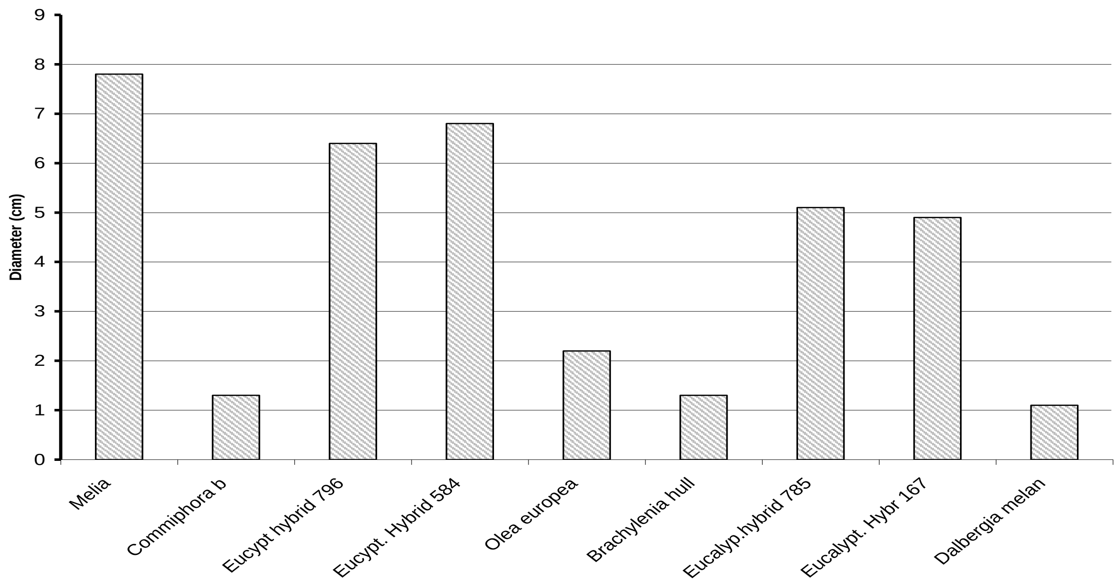

Figure 2. Diameter of melia and other species at Kibwezi at age 2.5 years

At age five years, Melia growth was at least 40% greater than that of the other indigenous species while *E. camaldulensis* was second best, growing at 30% lower than melia (Figure 3).

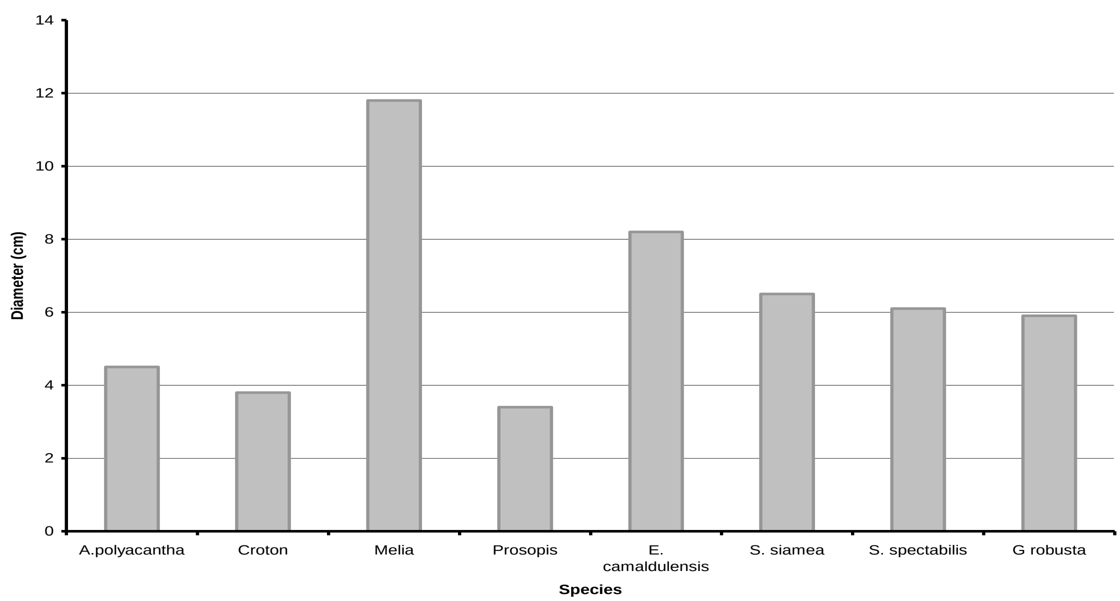

Figure 3: Diameter growth of eight dryland species at age 5 years in Kitui

While comparing the Melia diameter growth of trees originating from different sites/provenances, results indicated that the Siakago and Kitui provenances had greater diameter growth than those of the Kibwezi and Ishiara provenances (Figure 4).

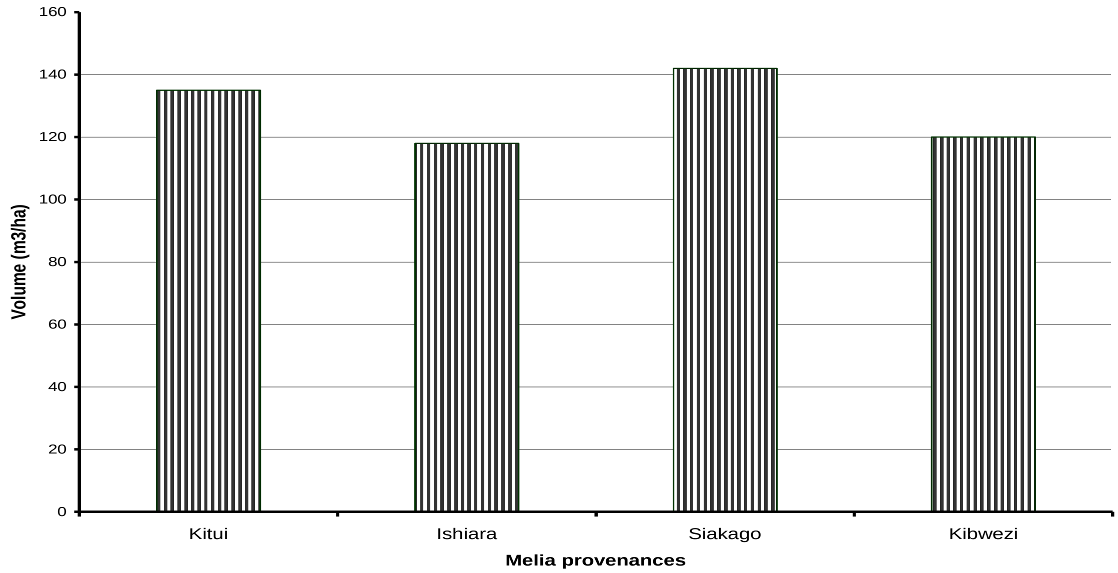

Figure 4: Volume of melia provenances at age 6 in Machakos

Discussion and recommendations

In conformity with farmers' beliefs, trials in this study have demonstrated the superior growth of *Melia volkensii* compared to both exotic and indigenous species that are commonly grown in the drylands. Indeed its growth exceeded that of fast growing exotic species such as *Eucalyptus* and *Senna*, and even indigenous species like *Croton megalocarpus* and *Acacia polycantha* commonly promoted by researchers and extension agents.

Substantial growth variation was observed in 4 provenances that are not geographically widely separated. For instance, Melia originating from Siakago (Embu) and Kitui had superior growth qualities than those from Kibwezi and Ishiara. It is recommended therefore that further studies be undertaken to optimize its growth through selection, expanded provenance trials and breeding from across its ecological range.

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Appraisal of *Melia volkensii* diseases and their control in Makueni and Kitui districts

J. W. Njuguna, L. Mwangi and L. Gibera

Abstract

Promotion of *Melia volkensii*, an increasingly important timber species in drylands, has suffered from recent incidences of diseases both at the nursery and in the field. An appraisal was undertaken to evaluate the status of Melia diseases and possible control measures. Results obtained revealed that Melia diseases were associated with Fusarium spp. *Colletotrichum* sp, *Alternaria* sp, powdery mildews and *Phomopsis* spp. A combination of two fungicides, Lindane and Benlate seemed to reverse the symptoms of rots and cankers especially at the initial stages.

Key words: *Melia volkensii*, diseases, disease control

Introduction

Melia volkensii Gurke is an indigenous tree species found in the arid and semi arid lands of Kenya. Its timber is known to be termite resistant and compares favorably with that of *Ocotea usambarensis* and *Vitex keniensis (*Kidundo, 1997; Blomley, 1994). Leaves and twigs are used for fodder, while bees utilize its flowers in honey production. Leaf extracts are used as insecticide against ticks and flea control though their efficacy is yet to be proven.

It is generally believed that indigenous tree species such as *Melia volkensii* are less vulnerable to diseases and pests because they have evolved alongside their natural enemies. Contrary to this belief, farmers have increasingly reported incidences of Melia disease attack in the field. There are also incidences of high post germination mortality in the nurseries. This appraisal was therefore conceived to evaluate the status of Melia diseases in nurseries, plantations and in farmers' fields.

Materials and methods

A survey on Melia diseases in the nursery, on-farm and on-station trials and in plantations was carried out between May 2003 and April 2004. During the survey, diseased plants were identified, disease symptoms recorded and plant materials sampled for laboratory analysis. In the laboratory, pathogens were cultured, isolated and identified using standard procedures. Once the pathogens were identified, they were exposed to healthy seedlings to determine their virulence. In subsequent surveys, diseased trees were sprayed with known fungicides to test their effectiveness in fungal control.

Results

In the nurseries, the disease symptoms revealed by the survey included wilting, leaf necrosis (yellowing of leaves) and root collar rots (damping off). Some of these symptoms are shown in plate 1.

Plate 1: A) healthy seedlings, (B) early infection and chlorosis, and (C) dead seedling.

The commonly encountered symptoms both on-farm and on-station included wilting, weak seedlings, severe chlorosis, powdery mildews, damage from browsing and water logging, root collar rots, stem cankers, stem breakages, diebacks and gummosis (production of a yellowish brown resin). Some of these symptoms are shown in plate 2.

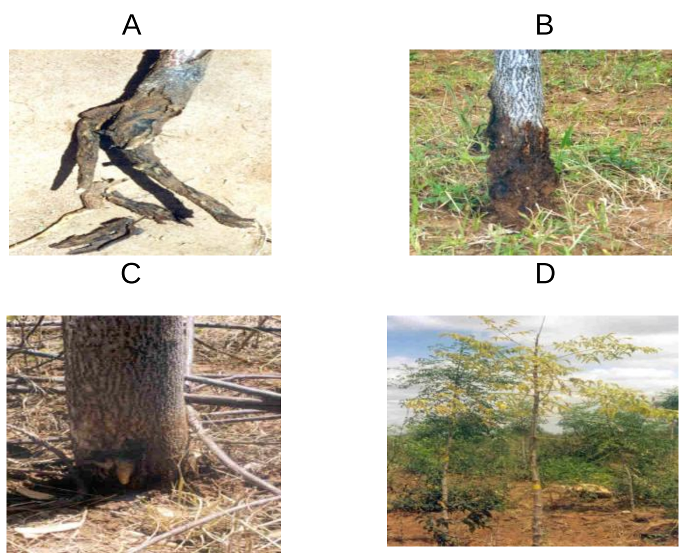

Plate 2: Root collar rot (A), Cankers (B), Gummosis (C) and Chlorosis (D)

Four major groups of fungi; *Fusarium, Colletotrichum*, *Phomopsis and Botryosphaeria* species were isolated from the diseased materials (Table 1). Two types of *Fusarium* species were consistently isolated from the root collar rots, stem cankers and wilts on *M. volkensii* seedlings. One type was thought to be *Fusarium oxysporum*. In some cases, a *Botryosphaeria* species was isolated from the cankers.

Table 1: Pathogens isolated from the different parts of *Melia volkensii*

Plant Part	**Symptoms observed**	**Pathogen**
Stem	Root collar rots and Wilts	*Fusarium* species
	Stem cankers	*Botryosphaeria* species
	Powdery mildews	Unidentified mildew fungus
Leaves, shoots	Blights	*Alternaria* and *Colletotrichum* species
Tips and branches	Dieback	*Phomopsis* species

On pathogenicity tests, only fusarium out of the other fungi caused symptoms on the inoculated seedlings. The symptoms included necrotic spots around the points of infection, which progressed into rots. The infected seedlings showed chlorosis followed by wilting and death. Results from the other four fungi (*Colletotrichum, Phomopsis, Alternaria and Botryosphaeria*) were not satisfactory because they were interfered with during watering. Tentative results from ongoing fungal control tests using benlate and lindane showed progressive recovery in some trees.

Discussion and recommendation

The results from the appraisal have shown that a host of fungi can affect melia. The attack occurs right from the seed, in the nursery and on mature trees in the field. This is contrary to the common believe that trees species with insecticidal and fungicidal properties are resistant to disease attack. Results showed that the diseases could be controlled using commonly available commercial fungicides. Since the results are based on appraisal, the results can only be treated as interim until further data from empirical studies is availed.

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Acknowledgements

Special thanks to; the Directorate KEFRI, for availing funds for the study; KEFRI staff at both Muguga and Kitui for their active involvement in the design of the project, facilitating and participating in field surveys, laboratory isolation and identification of the pathogens and to the conference task force for editing this paper.

On farm socio-economic survey of *Melia volkensii* in Kitui and Mbeere districts, Kenya

J.M. Mulatya

Abstract

Competition between *Melia volkensii* and crops is a major concern in dryland agroforestry. Socio-economic survey was therefore carried out in Kitui and Mbeere districts to gather information on farmers' knowledge and management about melia growing and its presumed effects on crops. Results showed that 40% of farmers believed that Melia volkensii does not compete with crops, while 30% believe that it competes when unpruned and 30% believed it competes. In both districts, tree establishment was by use of transplanted wildlings, root suckers and seedlings. Generally, majority (>70%) of farmers managed their trees. The standing trees were valued at Ksh. 1770 on average in the two sites but more valued at Mbeere than in Kitui. However, when converted to timber a single tree fetched 300% more than a standing tree.

Key words: *Melia volkensii*, competition, economic potential, management

Introduction

Melia volkensii occurs naturally in eastern, northern and coastal regions of Kenya. Depending on site factors like rainfall, altitude, and soil types, Melia can attain a height of 10 – 30 m. Melia has many desirable qualities that entice farmers to grow it. For instance, Stewart and Blomley (1994) describe some of these benefits as timber, poles, firewood, fodder, handcraft, pesticide and beehives. Overexploitation of the species in its natural stands has led to a drastic decrease in its products from the wild. Domestication is therefore the only mitigation measure to ensure sustainable supply of Melia products. Unfortunately, farmers are intercropping the tree with their crops paying little regard to its negative impacts on crop yields.

Against this background, a socio-economic survey was conducted within farms in Kitui and Mbeere districts to discern farmers' knowledge about Melia – crop interaction and evaluate its economic role in the farming systems.

Materials and Methods

The Kitui sites had annual rainfall of 600-700 mm, situated at an elevation of 1300 to 1400 m above sea level (asl) while the Mbeere sites were situated at 1400 to 1800 m asl with annual rainfall ranging from 830 to 1260 mm.

Combined Farm Systems Research (FSR) and Rapid Rural Appraisal (RRA) methods were used where structured questionnaires were administered to obtain data from farmers. The questionnaire was structured to capture the following data: household and farmers' general conditions, tree establishment, tree management, tree-crop interaction, marketing and constraints of growing Melia. The farmers interviewees were selected randomly considering gender balance, from among those who had trees on their farms.

Tree pricing was done on standing trees. The value of sawn timber was estimated by considering the number of doorframes that could be obtained from the tree log. The doorframe unit area is 10 x 6 cm at the cross section and 2 m length. The survey data of different variables was quantified and information from the questionnaire coded and analyzed for descriptive statistics, using appropriate procedures of Statistical Package for Social Science (SPSS) program.

Results

In total, 20 and 12 households were sampled from the Kitui and Mbeere districts respectively. The attributes of the sampled households are shown in appendix 1.

Farmers' knowledge on Melia is shown in Table 1. On average, there were fewer trees in Mbeere farms (133) than in Kitui farms (149) per household. The average prices of standing mature trees were greater in Mbeere (Ksh. 2700) than Kitui (Ksh. 840). The average rotation age for melia in both sites is about 10 years. On tree crop interactions, there was no clear knowledge on the effects of trees on crop productivity. In both areas, the respondents who indicated that trees compete or do not compete were equal with 30% and 40% respectively. However, majority agreed that melia trees need protection from browsers.

Table 1: Farmers knowledge on Melia trees in Kitui and Mbeere, districts of Kenya

Variable	Kitui	Mbeere
% households saying *Melia* competes with crops	25	30
% households saying *Melia* does not compete with crops	40	40
% households saying if *Melia* is pruned, no competition	30	30
% households saying *Melia* improves crop yields	5	0
Average number of *Melia* trees on farm	149	133
Average standing *Melia* tree price (Ksh.)	840.50	2700.60
Average rotation age of *Melia* tree	8.8	9.1
% households depending on farming only income	55	50
% households saying *Melia* needs protection from browse	80	58.3
% households saying *Melia* has no problems	10	41.7
% households saying *Melia* can become a weed	5	0
% households saying *Melia* needs watering	5	0

Results of melia survey on farms (Table 2) indicated that most of the farmers used either natural regeneration or transplanted saplings for their tree establishment. Majority of the farmers (70 - 100%) in both districts managed their trees but overall, Mbeere farmers practiced more desired tree management than the Kitui ones. Majority of trees were found isolated on farms.

Table 2: Frequency of on farm tree establishment and management in Kitui and Mbeere districts

Variable	Site	
	Kitui	Mbeere
Plant type		
% households using nursery raised seedlings*	5	0
% households using root cuttings	0	8.3
% households using natural regeneration	70	50
% households using sapling transplant	25	41.7
Management practices		
% households pruning trees	95	100
% households thinning trees	70	100
% households coppicing trees	70	100
% households pollarding trees	5	16.7
% households doing all management practices to their trees	15	25
% households doing none of the practices to their trees	5	0
Planting pattern		
% households planting as woodlot and close spacing	10	8.3
% households planting in boundaries	5	16.7
% households planting in contours or lines	5	8.3
% households planting as isolated trees in farms	70	58.3
% households planting in any combination of above patterns	10	8.3

* Seedlings were not available.

Figure 1 indicates the typical relationship between the age of trees and value of both standing tree and sawn timber derived from the means of 5 trees for every age. Trees of more than 10 years fetched at least Kenya shillings 2000 on the farms. However, when converted into timber beams, the price increased by more than three times (>300%).

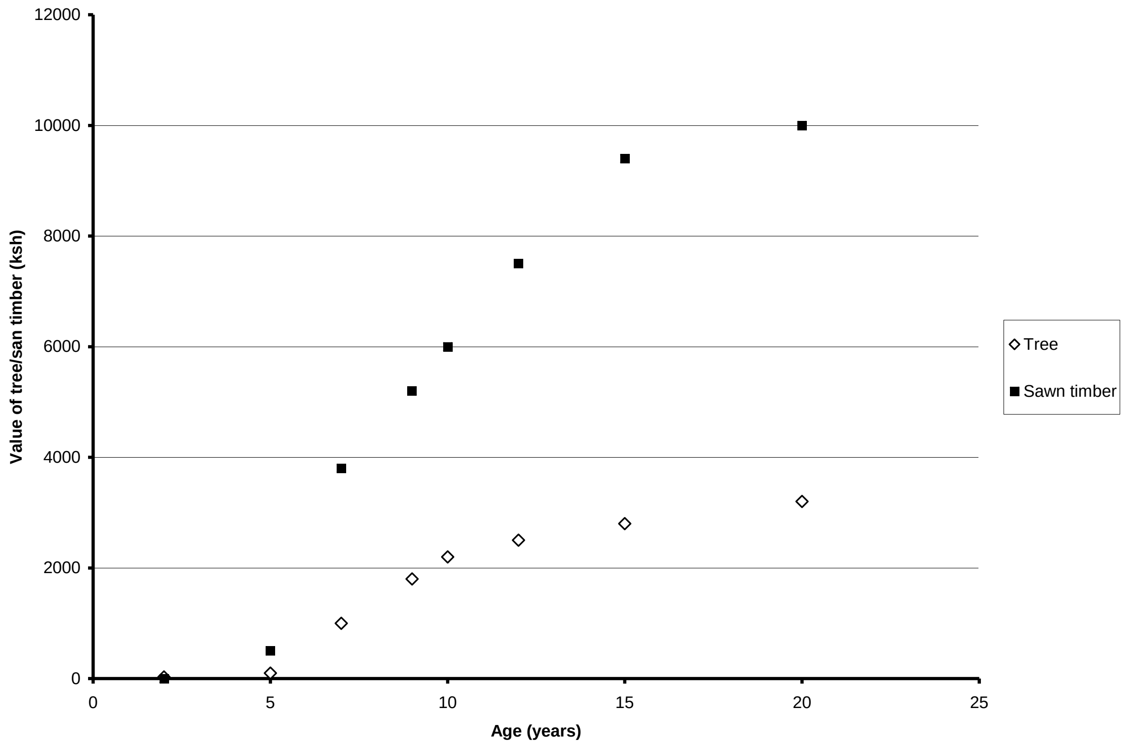

Fig 1. Combined average values of standing trees and their sawn timber at various ages from Kitui and Mbeere district

Discussion and conclusion

The study has shown almost half of the respondents think Melia does not compete with crops. This is contrary to the recent scientific findings where Melia has been shown to compete significantly with crops (Mulatya *et al*., 2002).

There are also other respondents who believed that Melia does not compete when pruned although another paper in this proceeding reveal that pruning can only lower the level of competition (Mulatya and Misenya, 2005). Nevertheless, it is probably because of the farmers' belief that an elaborate on-farm tree management practices has been developed in both sites. From the results, these management practices appeared more developed in Mbeere than in Kitui. The high selling prices (Table 1) and the small land holdings in Mbeere (Appendix 1), could probably explain the higher intensity of management practices.

Melia plays an important economic role in the farming systems in the drylands (Appendix 2) and appears to produce timber in a short rotation (figure 1). These tangible benefits could be the underlying reasons why farmers overlook its competitiveness. There is therefore an urgent need to demonstrate optimal Melia production system incorporating the scientific knowledge generated.

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Appendix 1: Characteristic of households in Kitui and Mbeere districts in semi-arid Kenya.

Variables	Kitui	Mbeere
Total number of households	20	12
% Male headed households	90	83.3
% Female headed households	10	16.7
Average land holding (hectares)	13 (8.5)	4.7 (1.8)
Average cultivated land (hectares)	8.2 (6.1)	3.4 (0.97)
Average land under fallow (hectares)	4.8 (3.02)	1.3 (0.61)
% household owning land	95	100
% household not owning land	5	0
% households depending on farming and business income	35	25
% households depending on both farming and salary	10	25
% households spending income on timber and poles	60	75
% households spending income on timber + poles and food	40	16.7
% households male planting trees only	10	0
% households female planting trees only	10	0
% households both male and female planting trees	70	91.7
% households with trees planted by none**	10	8.3
% households with male alone pruning and felling trees	85	82.4
% households with female alone pruning and trees	5	8.3
% households with both sexes pruning, felling and thinning of trees	10	8.3

Values in brackets are Standard deviation of means

Appendix 2: Economic importance of *Melia volkensii* in semi-arid Kenya

Variable	Site	
	Kitui	**Mbeere**
Uses		
% households using *Melia* timber and poles	100	100
% households using *Melia* for firewood	75	75
% households using *Melia* as fodder	25	33.4
% households using *Melia* for other needs*	15	8.3
Marketing products		
% households using *Melia* products for self consumption	25	33.4
% households selling *Melia* in local markets	70	50
% households selling *Melia* outside their markets	5	16.7
% households rating *Melia* as best timber locally	75	81.9
% household earning more from sale of tree products than from sale crops	30	42
% households preferring *Melia* timber to exotics	85	66.7
Other farm income		
% households selling maize alone	5	0
% households selling beans alone	15	16.7
% households selling maize and beans	20	25
% households selling mixed crop and fruits	60	58.3

* Other needs include; beehives, pesticides, pods

Growth and yield models of *Melia volkensii*

A. M. Maina

Abstract

Growing melia (*Melia volkensii*) has been adopted on the farms in semi-arid areas of Mbeere, Kitui and Taita-Taveta districts among others but there are no guidelines for assessing the tree volume. This study was undertaken to develop and test models that can be used in assessing growth and yield of Melia. Four volume models were tested by regressing diameter and heights on tree volumes from 139 trees. A growth and yield model was developed by regressing stand age, dominant height, and density index on estimated stand volumes from 146 temporary sample plots. Individual tree volume and stand yields were best predicted using log transformed linear models. For individual tree volume, the model was:

Log vol = 0.343988+log2.472919dbh+Log0.702275ht

while for yields, the model was:

Log Vol=-0.4626681.10215(1/Age)+0.110992ht+0.230412logSDI.

The analysis of the mean and current annual increments revealed that the biological rotation age for the species to be 11 years.

Key words: Melia, volume model, yield model

Introduction

Accurate estimation of tree volumes is important for planning purpose. There is therefore need to develop a criterion upon which to base the estimation of the tree product. In cultivated semi-arid areas, farmers with large tree crop based operations are reported to generate higher and more stable incomes than those dependent on food crops alone (Tyndal, 1996). It is probably because of this reason that melia is largely intercropped in parts of Eastern and Coastal provinces. In these areas, farmers consider melia to be a fast growing drought tolerant tree species. Melia may therefore, have potential for maximizing land productivity and farm incomes. Unfortunately, there are no management tools for guiding management decisions and evaluation of the productivity of the trees. The main aim of this study was to develop and test standard volume equations, growth and yield models that could be used to estimate productivity of melia.

Study Area

This study was undertaken in Mbeere, Kitui, and Taita-Taveta districts. Mbeere and Kitui districts are situated in Eastern Province of Kenya while Taita-Taveta district is in Coast Province, all in agro-ecological zones IV to V but patches of agro-ecological zone III are also found. Maximum temperatures range between 25 - 32^{0}C and minimum temperatures between 15 - 20^{0}C. Altitude ranges between 500 - 1000 m above sea level. Rainfall is bi-modal ranging between 500 - 900 mm annually; it is poorly distributed and occurs with high intensity. The short rains (October - December) are more reliable for crop production than the long rains (March - June). Soils are classified as, light red soil (acrisols), deep red soil (luvisols), murrum (ferrisols), and black cotton soil (vertisols).

Data Collection and Analysis

Log measurement and volume prediction

Data from felled trees was used for the construction of volume estimation models while data for growth and yield prediction was obtained from temporary sample plots. However, it was not feasible to get good melia tree stands for volume estimation in Kitui and Taita-Taveta districts because it was a good cropping year and farmers were not keen to dispose their trees. All the measurements were therefore based on trees from Mbeere district.

Sample trees were felled and base diameter measured together with diameter at 0.5 m and 1.3 m height of each tree. Other diameters along the length of the bole were taken at intervals of 1 meter from the stump to estimate sectional bole volumes. For each tree, diameter was measured up to the 10-cm diameter that was considered as the merchantable limit. For all the tree branches and pole from the 10-cm diameter limit to the tip, length was measured together with diameter at the mid-length. Diameter measurements were taken using diameter tape and a linear tape used to measure length. Total height of each tree was obtained by adding totals for all the sections. Total wood volume was obtained by adding bole volume to branch volumes. The common log volume equation (Smalian's formula) was used to obtain the sectional log volumes from felled trees.

$$Volume=L\ (g_l+g_s)/2,$$

where, L = log length,

g_l = sectional area at large end of log,

g_s = sectional area at small end of log.

The calculated volumes were regressed against the measured diameter and height. Four volume prediction models were fitted. These were:

Model 1: $Vol = b_0+b_1dbh^2+ b_2ht+b_3dbh^2ht$,

Model 2: $Vol = b_0+ b_1dbh^2ht$,

Model 3: $Vol = e^{b0}dbh^{b1}\ ht^{b2}$

Model 4: $Log\ vol = b_0 + b_1logdbh+b_2Loght$

For easiness of diameter measurement, calculated volume was regressed against diameter, to establish a local volume equation using the model:

$Vol = b_0dbh^{b1}$

Stand growth and yield data

Data for growth and yield modeling was collected from 157 randomly selected temporary plots in different melia stands of different ages (1 to 15 years) within the three districts. Sample tree stands were identified and selected using the following criteria: even aged, non-thinned, non-pollarded, and single species stands. Within the selected stands, the following measurements were taken; diameter at breast height of all trees, dominant height, and size of the plot. The size of plots ranged from 0.05 ha to 0.5 ha. Age of the stand was obtained from records and history of the production period.

A total of 146 sample plots were used for model construction and 11 for validating the model. Stand density index was derived from size of plot, quadratic mean plot diameter and number of trees per plot using Reineke (1933) equation,

$SDI = N(10/qmdbh)^b$.

Where SDI = stand density index
N = number of trees per plot
qmdbh = quadratic mean plot diameter at breast height
b = coefficient.

The developed volume estimation model was used to calculate temporary sample plot volumes using plot mean diameters and dominant heights. Farmers use different spacing between trees when establishing melia stands and this makes density an important variable in the selection of the model. The variability of densities in the farms and use of temporary plots therefore limited choice of the model to Mackinney and Chaiken (1939) model below:

$$\text{Log Vol.} = b_o + b_1A^{-1} + b_2S + b_3\text{LogSDI}$$

Where A = age of the stand
S = dominant height
SDI = stand density index, and
b's = coefficients.

The guide curve method using Schumacher (1939) model was used to construct site index anamorphic curves. The model assumes a family of curves of the form:

$$ht = b_0e^{\,b1(1/A)}$$

this was linearized as:

$$\text{Lnht} = \text{Lnb}_0 + b_1(1/A).$$

Where, ht = dominant height attained at a reference age,
b_o and b_1 = are model coefficients,
e = base of natural logarithm, and
1/A = reciprocal of age

The use of dominant height rather than site index has the advantage in that it can be measured rather than predicted and therefore avoids estimation errors in the model

Results and discussions

Volume estimation models:

Results of the regression analysis yielded the following output for respective models:

Model 1: $Vol =-0.006936+5.052431dbh^2+ -0.01051ht+0.365802\ dbh^2ht$,

$r^2= 0.858$, std. error = 0.218

Model 2: $Vol = 0.031304+0.635297dbh^2ht$,

r^2 0= 0.846, std. error = 0.226

Model 3: $Vol = e^{0.782806}\ dbh^{2.4717}\ ht^{0.705511}$,

$r^2= 0.970$, std. error = 0.235

Model 4: Log vol = 0.343988+log2.472919dbh+Log0.702275ht,

$r^2= 0.971$, std. error = 0.10114

All the standard volume equations gave high r^2 (coefficient of determination) values and low standard errors but model 4 gave the best estimation of the tree volumes. This is consistent with findings of Higuchi and Ramm (1985) where the same model gave the best estimate of dryland tree volumes in South America.

Fitting of the local volume function yielded the following relationship:

$$Vol = 22.617dbh^{2.9029}$$
$$r^2 = 0.965$$

Considering that r^2 values for Model 4 and the local volume function only differ slightly and given the enormous task of height determination, it is recommended that the local volume function, which only requires diameter measurement be used to estimate the Melia tree volumes.

Growth and yield model

Site index

Analysis of data from Mbeere, Taita-Taveta, and for all the sites combined (including Kitui) showed the following site index values: a) for Mbeere district, b) for Taita-Taveta district and c) for combined values for all district.

a): $\ln ht = 2.763069 - 0.19472(1/A)$, $r^2=0.8775$, std.error =0.1013
b): $\ln ht = 2.7891 - 2.46977(1/A)$, $r^2=0.7740$, std.error=0.1464
c): $\ln ht = 2.7517 - 2.26096(1/A)$, $r^2=0.7693$, std.error=0.1878

The model coefficients showed that growth in Mbeere district was superior and that model variables explained 88 % of variation compared with 78 % in Taita-Taveta and combined sites. Dominant tree heights also showed superior growth in Mbeere district and lowest for combined sites (Fig. 1). Apparently, the depression of the combined sites curve suggests the performance of Melia trees in Kitui district was inferior.

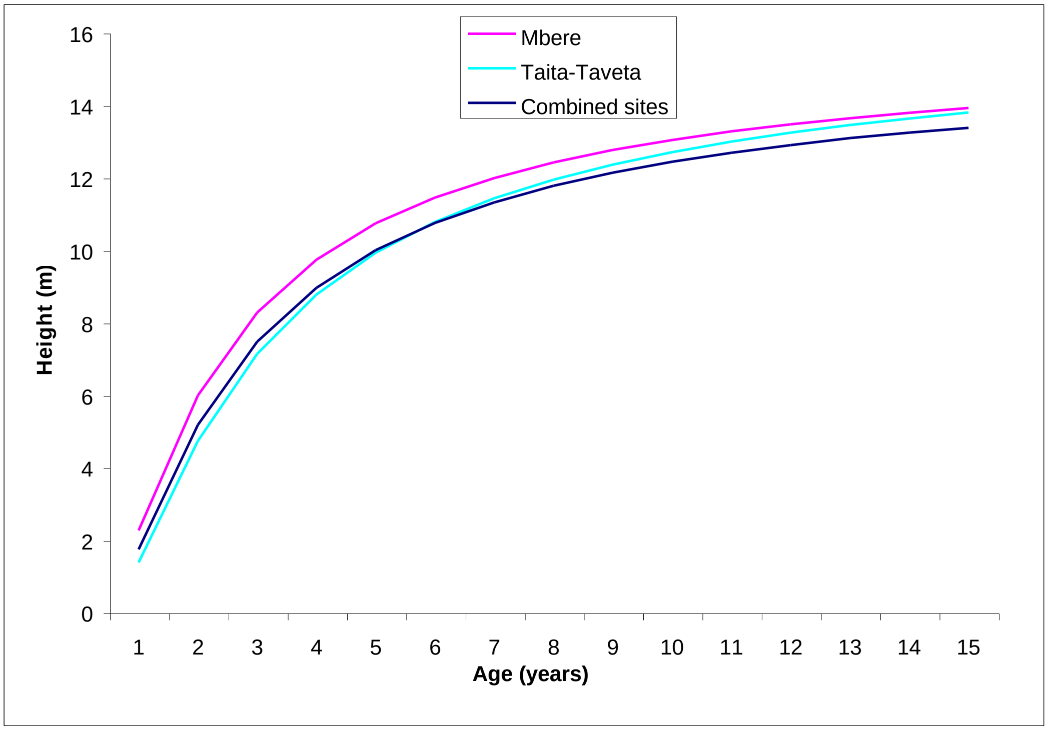

Figure 1. The relationship between height and age

Variable density growth models

Analysis of stand variables showed the following growth and yield model coefficients:

Log Vol=-0.462668-1.10215(1/Age)+0.110992ht+0.230412logSDI,
r^2=0.9860 and std. error =0.1014

The model explained the relationship between growth variables fairly well. The growth model can provide input to forest management regarding even aged stands but the projection period and the level of stand detail may vary with site. The main factors that govern yield are genotypic characteristic, productive capacity of the site, stocking level, and silvicultural treatment given to the crop. The model can be used to estimate growth and yield for different densities when the model coefficients are appropriately determined.

The combined sites biological rotation was realized at 11.0 years when CAI was 24.56m^3 and MAI was 26.41 m^3 (Figure 2).

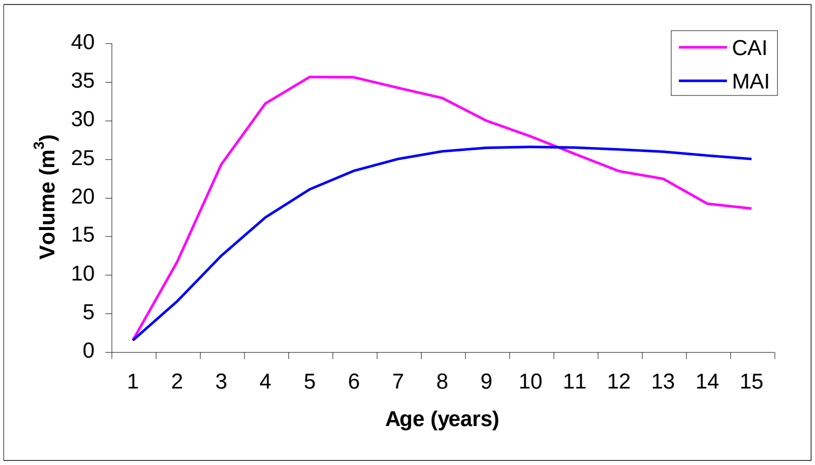

Figure 2: Relationship between stand volume and age of trees for combined sites

Conclusions and recommendations

The standard volume models can be used to estimate melia tree volumes with accuracy when height is easy to measure. However, farmers/timber dealers could use the local volume equation, which requires only diameter as the variable, but it is necessary to compile volume tables to ease conversion. In addition, growth and yield models can be used to project yield in farm planning provided the independent variables (age, density and site index) are known. However, the model does not provide size-class information that is needed to evaluate various utilization options and therefore it cannot be used to analyze a wide range of stand treatments.

It is therefore recommended that the developed growth model be used with appropriate site indices. There is also need to investigate the optimum spacing that can realize maximum productivity in different locations. Additionally, appropriate pruning and thinning regimes should be investigated to improve total wood production and quality.

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Identified information gaps for research to support massive planting of *Melia volkensii*

Theme	Emerging issues for further research
Genetic Diversity, Improvement and Conservation	- Genetic diversity and delineation of provenances - Selection of superior trees for genetic improvement (tree breeding) - Establishment of progeny trials - Conserve in-situ and establish ex-situ conservation stands
Propagation	- Current mass propagation methods using seeds are only feasible on station and there is need to simplify the production protocols for adoption by wider stakeholders. Studies are also required to develop alternative propagation methods. - Improve existing local propagation methods or practices - Develop and refine protocols on macro and micro propagation of Melia to raise the success rate of rooting the stem cuttings from the current 33% achieved - Undertake studies on post-germination seedling management - Determine appropriate storage conditions for maintaining high viability of Melia seeds - The seed extractor has eased seed extraction but it could be improved through automation especially in seed sorting and cracking
Management	- Generate empirical data over the whole rotation period on economic returns of growing melia at different silvicultural regimes for different end uses - Undertake further work to determine growth and economic worth of melia as compared to emerging species such as eucalyptus hybrids. - Volume tables for Melia per site classification are needed for ease of farm planning
Utilisation	- Determine the wood properties of Melia timber from trees harvested at different ages

Emerging issues for immediate consideration and upscaling

Theme	Emerging issues for promotion
Development and technology transfer	- Due to intricacies of Melia propagation, KEFRI should embark on massive seedling production in Kitui and Kibwezi to meet the escalating demand. - The seed extractor should be protected through patenting - Establish demonstrations plot to: 1. Reveal the levels of Melia negative impacts on crops because of competition under different management regimes 2. Reveal profitability of growing Melia under different tree crop management 3. Assist in making informed decisions on whether to grow Melia as a monoculture or intercropped. - Develop interim guidelines for on farm tree management

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