ENHANCING PROPAGATION OF *MELIA VOLKENSII* GÜRKE (MUKAU) TO INCREASE TREE COVER IN MWINGI DISTRICT, KENYA.

MFAHAYA, NAFASI WAMBUI
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DECLARATION

I Nafasi Wambui Mfahaya, hereby declare that this thesis is my original work and has not been presented for a degree in any other university

Signature---------- Date 9/12/2008

Nafasi W. Mfahaya (BSc. Forestry)

N50/7325/2001

This thesis has been submitted for our examination with our approval as university examiners.

Signature---------- Date. 9/12/2008

Prof. James B. Kung'u

Department of Environmental Science of Kenyatta University.

Signature---------- Date. 10/12/2008

Dr. Theresa C. Aloo

Department of Environmental Science of Kenyatta University

DEDICATION

This work is dedicated to my family; My father, **Mfahaya Djuombe**, My late mother, **Mariamu Murikira,** My children**, Omari Mwangi, Mfahaya Jumbe** and **Khadija Nyambura,** My supportive sisters, **Koko Waithera** and **Khadija Wanjiru,** Above all, to my husband**, Nuru Omari** for his amazing capacity to Love and Care.

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DEFINITION OF STUDY TERMS

Deforestation	This is loss in tree cover within a particular forest or through felling of trees for various end uses like wood fuel, woodcarving and building poles.
Natural Resource	The raw unprocessed material obtained from nature like forest, water, soil and air.
Afforestation	Planting of trees where originally there was none.
Reforestation	Replanting of trees where it has been clear felled
Multi Purpose Trees	Trees whose different sections are useful to the owner.
Dormancy	Physiological state in which a seed predisposed to germinate does not, even in the presence of favourable environmental conditions.
Drupe	A stone fruit such as a plum, the pericarp fleshy or leathery contains a stone with one or more seeds inside.
Seed coat	Protective outer layers on a seed derived from the integuments of the Ovule; when the two coats are present the thick tough outer coat is the testa and the thin inner coat is the tegmen.
Germination	The emergence and development from the seeds embryo of those essential structures which are indicative of the seeds capacity to produce a normal plant under favourable conditions (Willan, 1985)

ACRONYMS AND ABBREVIATIONS.

ASALs	Arid and semi arid lands
CRBD	complete randomized block design
DBH	diameter at breast height
FAO	Food and Agriculture Organization.
H_2O_2	Hydrogen peroxide
KEFRI	Kenya Forest Research Institute
LSD	Least significance difference
IBA	Indole Butyric acid
NAA	Naphtyl acetic acid
◦C	degrees centigrade
‘	Minutes
H_2SO_4	Sulphuric acid
HNO_3	Nitric acid
IAA	Indole 3 Acetic Acid
IBA	Indole Butyric Acid
UNEP	United Nations Environmental Program
ISTA	International Seed Testing Association.
OMNR	Ontario Ministry of Natural Resources.
RCD	Root Collar Diameter.
GenStat	General Statistics.

ABSTRACT

Kenya's arid and semi arid lands (ASALs) represent 80% of total land area. The natural resources of ASALs are being degraded rapidly. The crisis has been aggravated over the last three decades by repeated drought and inappropriate land use practices, as a result of rapid population increase of people and livestock. This has resulted in clearing of forests for agricultural production and settlement, cutting of trees for charcoal production for both home and commercial purposes. Afforestation in ASALs has been emphasized to ensure a sustainable management system, which will contribute towards poverty alleviation. One of the highly valued multipurpose trees in ASALs, which has been recommended for planting in Kenya, is *Melia volkensii* Gürke (Meliaceae). The wood from the tree is durable and resistant to termite, the leaves and fruits are used as fodder for livestock in the dry season; the flowers also provide bee forage and are used as tick, flea and fly repellant. Branches act as a source of fuel. Propagation of *Melia volkensii* Gürke is difficult and requires careful handling for optimal germination in the nursery. Development of an appropriate vegetative propagation technique through use of cuttings is of highest priority for production of large amount of planting material. This research study was carried out at Nuu tree nursery in Mwingi district to investigate seed germination and rooting of cuttings. Seeds were subjected to 6 different pretreatments against the control. Soaking seeds in 10% sulphuric acid for 10,30 and 60 minutes and nicking followed by soaking seeds in 10% sulphuric acid for 10,30 and 60 minutes respectively. Cuttings obtained from three different sections (bottom, middle and top) of the stem were subjected to different hormones concentrations of 0.5% Indole butyric acid (IBA), 0.33% of IBA and 0.11% IBA. Seedlings were also subjected to different watering regimes so as to get the best quality seedlings. 100 seedlings were used per replicate for four watering regimes, normal watering, 2.5, 5.0 and 10 litres. Nicking followed by soaking in 10% sulphuric acid for 10 minutes gave the highest germination percent (53.33%) and soaking in 10% sulphuric acid for 60 minutes gave the lowest (6.67%). Cutting from the bottom section had the highest rooting percentage and use of 0.33% IBA was the best. Watering on alternate days using 10 litres four times in a week gave the best quality seedlings. Success in nursery production through vegetative production will open an opportunity to successful plantation establishment of *M. volkensi*i.

CHAPTER ONE: INTRODUCTION

1.1. Background Information

The world today is experiencing unsustainable exploitation of natural resources which has led to land degradation, water and air pollution which if unchecked will sooner or later affect negatively the survival and welfare of human beings. Each region, area and locality, therefore requires devising management measures suited to their peculiarities. This will lead to a sustainable natural resource management system, which will eventually contribute to the global objective of poverty alleviation.

Afforestation in arid and semi arid lands (ASALs), is one intervention towards achieving sustainable land use. Sub- Sahara Africa, has an estimated population of more than 75 million people, 62% of the population occupy agriculture zone, 15% in urban towns and 23 % occupy arid and semi arid lands (UN, 1993). The people living in ASALs are affected or threatened by desertification (Baumer, 1990).

In Kenya, areas designated as arid and semi arid lands (ASALs) are fragile dry land ecosystems covering 80% of total land area and host 25% of the population, 60% of livestock and over 65% of wildlife (Odera and Kuusipalo, 1993). ASALs are characterized by poor agricultural productivity and high incidence of poverty. The threats to livelihoods of the inhabitants in ASALs are real and call for practical remedial action so as to improve the livelihood conditions of the inhabitants.

Planting of high value trees and shrubs may provide the farmers with a variety of products and services to meet their basic needs like food, shelter, fuel and other financial and non financial services.

One of the high value multipurpose tree species in the ASALs is *Melia volkensii* Gürke. In areas where it naturally occurs, it is common to find *M. volkensii* Gürke left standing in cropland during land clearing for agricultural activities. *M. volkensii* is used for timber as its wood is durable and termite resistant (Stewart and Bloomley, 1994). The timber is compared to Meru Oak (*Vitex keniensis*) and camphor (*Ocotea usambarensis*) in terms of strength (Bloomley, 1994: Stewart and Bloomley, 1994). The wood is used in making accoustic drums, door and window frames and shutters. During the dry season, the leaves and fruits are used as fodder for livestock (Tedd, 1996). The flowers also provide excellent bee forage (Salim *et al*, 1998) and can be made into powder and used as an insect repellant (Rajab and Bently, 1988a). Branches are also a source of fuel.

M. volkensii is important to people of ASALs as it provides quality timber, fodder for their animals and fuel wood. Despite the importance of *M. volkensii* to ASALs, its exploitation without replanting has resulted in rapid depletion of this species. The difficulty has been and still is in germinating *M. volkensii* seeds (Milimo, 1989). Normal germination produces low percentage of seed germination. Optimal germination is labour intensive as it requires seed extraction from the endocarp, followed by seed pretreatment of soaking the seeds overnight. Farmers, in their effort to improve germination feed seeds to goats however; it is difficult to control the genetic quality. Large scale planting of the species is thus hampered by lack of quality seedlings.

Development of an appropriate propagation technique of *M. volkensii* Gürke should be given priority for plantation forestry. So as to ensure desired genetic qualities are captured, vegetative propagation could be used. This technique allows an exact copy of the genome of a mother plant to be produced in the new plants, which may otherwise be diluted when using sexual propagation.

1.2. **Statement of the Problem**

In Kenya, there is an urgent need for tree planting to satisfy the population's demands for forest goods and services. The high demand is attributed to high population growth rate especially in urban areas. The high demand for wood fuel energy has resulted in high prices of other energy services. Afforestation schemes using exotic trees such as *Eucalyptus* rather than indigenous species have been costly on economic analysis anticipating a more rapid return on investment. Despite the efforts, the schemes have not been of great success (Tchoundjeu, 1996).

The use of indigenous species is an alternative to the problem as they are more compatible with crops and would also improve the ecological stability (Yirdow, 2002) of our environment. *M. volkensii* is an indigenous species that has been utilized for agro forestry purposes in arid and semi arid lands. However germination of the seeds without any pretreatment is usually difficult and some farmers try to address this problem by using seeds that have been dropped in goats manure. The germination rate has been found to be low, about 2% (Teel, 1984). The current method used to break the seed dormancy involves (i) Extracting seeds from stony endocarp (ii) Breaking of the caruncle of the micropopyle end (iii) Seed surface sterilization in mixed solution of sodium

hypochlorite for 30 minutes (iv) Soaking the seeds in clean water for 6 hours and (v) Cutting the seeds longitudinally through the integument. The process is successful but tedious and may not work for large-scale production of seedlings.

In vegetative propagation, multiplication of genetically desired characteristics (such as good straight boles for timber, wood for log hives) in plants within a short period can be a success, as the technique aims at the identical reproduction of plants with desirable features such as superior quality of trees. It is less expensive and easy to handle as compared to seed pretreatments.

Damping-off disease in *Melia volkensii* is also a major threat to survival of seedlings in the nursery. Damping-off generally refers to sudden plant death in the seedling stage due to toxic materials in the soil, excess or deficient soil moisture, seed defects, temperature extremes, toxic gases in the air, etc. A correct diagnosis is the key to effective control measures. Normally, however, cool wet soils favor development of the disease (Pfleger and Gould, 1994). Damping-off fungi kill frequently germinating seeds before they emerge from the ground, which accounts for low number of seedlings being produced in the nurseries. This calls for need of getting appropriate moisture level to reduce incidence of damping-off.

There is therefore need to come up with the most effective pretreatment in seed germination and identify the best section of the tree from which to obtain cutting for

rooting. There is need also to obtain the most appropriate hormone concentration and come out with the best watering regime for the seedlings in the nursery.

1.3 **Research Objectives**

The main objective of this research was to develop the most desirable method for propagating *M. volkensii.*

Specific Objectives

1. To determine the best pretreatment for *M. volkensii* for maximum germination percentage.

2. To determine branch cuttings of which section of the stem that will give the highest rooting percentages.

3. To determine the best rooting hormone concentration to be used in cuttings for *M. volkensii* rooting.

4. To determine the best moisture level for maximum growth of *M. volkensii* seedling in the nursery with the other environmental conditions being constant.

1.4 **Research Hypothesis**

The research was guided by the following hypothesis

1. Nicking followed by soaking seeds in 10% concentration of sulphuric acid for 10 minutes will give the highest germination rate of *M. volkensii* . The soaking will allow the micropopyle end to open.

2. Rooting hormone 0.5 Indole Butyric Acid (IBA) will give the highest rooting rate on *M. volkensii* cuttings.

3. The branches from the bottom section of the *M. volkensii* stem will give the highest rooting rate.

4. Watering 100 *M. volkensii* seedlings with 10 litres of water four times a week will give the highest survival and good quality seedlings. The other environmental conditions being constant.

1.5. **Significance of Study.**

Over exploitation of *M. volkensii* for timber without replanting has resulted in rapid depletion of the tree species. Propagation of *M. volkensii* for a long time has been hampered by low seed germination from the seeds. Seed dormancy, has contributed to the low seedling production in tree nurseries. Though researchers have developed a technology to overcome germination problems of *M. volkensii*, improvement is required to make it less time consuming and practical for adoption by farmers and nursery operators. Effective method of breaking the seed dormancy of *M.volkensii* can be a major breakthrough for using seeds for seedlings production.

Propagation of *M. volkensii* through vegetative propagation may be a viable possibility (Milimo, 1989). There is also need to collect and conserve the genetic diversity of these species (Jama *et al*, 2003). Thus it is important to determine the best section of obtaining the cuttings and the best hormone concentration.

Damping-off is a function of soil contamination, physical fertility, soil temperature and moisture. It is very common on *M. volkensii* seedlings in the nursery and causes high seedling mortality. This can be avoided if appropriate moisture level is known for the seedlings so as to avoid the damping-off disease.

CHAPTER TWO: LITERATURE REVIEW

2.1. **Plantation Forestry**

Due to population pressure, soils, forests and woodlands in ASALs are in a state of degradation since the natural vegetation has to be cleared to give way to crop production. The Government has targeted the ASALs areas as its priority in agriculture development and afforestation programs through farm forestry (Government of Kenya Development Plan, 1995). Farm forestry, is planting of trees outside gazetted forests such as in private farms, trust lands or communal lands. It promotes tree growing for browse, fodder, shade, living fences and windbreaks (Milimo *et al*, 1992).

The use of exotic species in ASALs has been preferred until recently when it became a government policy in Kenya to promote the replanting with indigenous species. Kimondo (1991) reports that, when comparing results of 58 exotic and indigenous tree and shrubs species at Loruk (Kenya), exotics were superior in height growth but had poor survival rate with only three out of 15 species achieving greater than 80% survival, compared with nine out of 12 of the indigenous species. Of the indigenous species tested the height and survival of *Acacia seyal* and *Melia volkensii* were acceptable (Kimondo, 1991; Milimo *et al*, 1992). Afforestation schemes using exotic trees such as *Eucalyptus* rather than indigenous species have been costly on economic analysis anticipating a more rapid return on investment. Despite the efforts, the schemes have not been of great success (Tchoundjeu, 1996).

M. volkensii whose common name is Mukau (Kamba language) is an indigenous species that has been utilized for agro forestry purposes in arid and semi arid lands. Mukau is an

important source of wood (firewood, poles, posts, timber), non-wood products (fruits, medicines, fodder) and maintaining soil fertility (Njenga and Eckert, 1990) through heavy leaf fall (Kimondo, 1992), which disintegrates and improves soil nutrients. Farmers consider *Melia volkensii* to be a weaker competitor and thus compatible with agricultural crops (Tedd, 1996; Kidundo, 1997). Although propagation by seed is the main method of plant multiplication, availability of quality seed is a major constraint affecting planting (Milimo, 1994). Propagation of this species has been hindered by poor germination of seeds.

2.2. *Melia volkensii* Gürke (Mukau).

2.2.1. Distribution.

Melia volkensii is endemic to arid and semi arid zones of East Africa from southern Somalia through eastern Kenya and south to Tanzania (Beentje, 1994; Bloomly, 1994). The tree has been reported to grow in areas between altitude of 100m to 1700m above sea level and a mean annual rainfall of 300mm to 800mm. Three soil types are arbitrarily distinguished principally according to physical characteristics (Abeele *et al*, 2005). These are sandy soils, clays and shallow stony soils. Normally it is found in well-drained sandy clay and shallow stony soils in Tharaka Nithi and Isiolo districts in Kenya (Milimo, 1994).

Good drainage appears to be a common characteristic among most of the soils within the range of *M. volkensii* although a few sites classified as imperfectly drained have been observed in parts of the range of Meru, Kenya (Milimo *et al*, 1992).

2.2.2. **Botanical Description**.

Melia volkensii is a deciduous tree with mature trees growing from 6m to 20m in height with a diameter of up to 25cm at breast height. The bark is reticular flaking, grey while the leaves are light bright green with sub opposite leaflets, 3-7 pinnae with entire or serrate margins. The fruit is a 2.8-4 cm long, ovoid drupe (Beentje, 1994). Each fruit may have one to five seeds that are enclosed in a thick bony endocarp as the fruit matures.

2.2.3. **Seed, Flowering and Fruit Development**.

The seed is the reproductive unit, which develops from an ovule. Seed development is initiated by fertilization, which is preceded by pollination. Literature on pollination is scarce but bees visit the flowers, which is an indication of insect pollination (Salim *et al*, 1998). The tree flowers as early as 2-3 years after establishment. The flowers are white dense headed pinnacles, inflorescence with stellate hairs, petals 5-7mm long (Bentje, 1994). Flowering and fruiting do not follow a seasonal pattern, but can be two to three times per year or continues depending on site conditions. Fruits, however even on the same branch, can be at very different stages of maturity (Milimo, 1994; Muok *et al.*, 2000).

Fruits normally ripen 12 -13 months after the time of flowering. Mature fruits can be collected nearly all year round. As a deciduous tree it sheds leaves twice a year, early each dry season. On cultivated land, *Melia volkensii* trees retain their leaves longer into the dry season (Bloomly, 1994). Fruits at different stages of development occur on the same tree making it difficult to differentiate mature fruits except for the colour, which turns from green to yellow when mature.

2.2.4. **Dispersal of Seeds**.

Animals including giraffe, Kudu and goats eat the fleshy fruits and act as the main dispersal agents apart from human beings. When the animals feed on the fruit, the seeds are protected by hard seed coat or endocarp, and these passes unharmed through the digestive tract and are deposited in the droppings at a considerable distance from the point of consumption (Kimondo, 2005).

2.2.5. **Germination of Seeds.**

The seeds are oval, about 2cm long and 0.5 cm wide. At one end is an appendage called caruncle. Wildlings are usually planted on farms, with a survival of over 70 % especially during good rains. Coppicing is encouraged as they grow faster than seedlings. There is limiting literature on grafting, stem cutting or layering for *Melia volkensii* suggesting that little work has been done on it (Muok *et al.*, 2000).

Germination consists of three overlapping processes mainly (i) Absorption of water by imbibition, causing a swelling of the seed and eventual splitting of the seed coat, (ii) of stored food and translocation to growing regions (Reid, 1972), (iii) Cell enlargement Enzymatic activity and increased respiration and assimilation rates which signal the use and divisions resulting in emergence of radicle and plumule (Krugman *et al.*, 1974). *Melia volkensii* Gürke seeds, which have been extracted and scarified, germinate after seven days. Before sowing it is recommended to soak seeds in water for 18 hours (Turnbull, 1975b).

2.2.6. **Seed Dormancy**.

Dormancy preserves the seed against temporarily unsuitable conditions such as may occur during the period between seed collection and planting. It also provides an insurance against the loss of viability during transport and processing which can easily occur in non-dormant seeds in less than ideal conditions (Willan, 1985). There are two main types of dormancy, namely a) Embryo dormancy where the embryo is morphologically under developed. This type of dormancy is not common in the tropics, b) Seed coat dormancy where the seeds have cutinized seed coat that completely prevent the imbibition of water and sometimes also the exchange of gasses. It occurs frequently in species adapted to dry conditions.

Although propagation by seed is the main method of plant multiplication in Africa, availability of quality seed is a major constraint affecting planting (Milimo *et al.*, 1992). Pretreatments become necessary to obtain a rapid and uniform germination (Willan, 1985). Experimental trials that have been tried on seed extraction, germination treatments and reduction of post emergent damping-off all show that germination treatments improved germination (Muok *et al.*, 2000).

2.2.7. **Seed Pretreatment Methods**.

Impermeability to water and gasses is most common form of seed coat dormancy in the family Meliaceae. The nature of seed coat differs between legume species; in others the nuclear membrane appears to be the structure, which restricts gas exchange (Schopmayer, 1974). Impermeability is based on the physical and chemical properties of cells in various layers of the seed coat.

Simple and effective methods of propagation need to be developed for large scale dissemination. Seeds whose coats are impermeable to moisture and gasses must be pretreated to increase water imbibitions for germination success without injury to the embryo.

2.2.7.1. **Physical Methods (Scarification).**

Pretreatment to overcome physical seed coat dormancy involves softening, puncturing, wearing away or splitting the seed coat in order to render it permeable without damaging the embryo or the endosperm within. The number of seeds for germination in the nursery has increased as is better than indigenous method of pounding the seeds; KEFRI Kitui Regional Centre in conjunction with the researchers of the Japan government has designed a tool for cracking the hard fruits (Tegmen) of the *Melia volkensii* seed.

2.2.7.2. **Seed Pretreatments**.

Pretreatment trials that have been done on *M. volkensii* seeds are labour intensives. To get optimal germination, seeds have to be extracted from the drupe. After extraction the caruncle is removed and the seed coat is nicked or cut with a knife. If the seeds are just nicked and planted, 37% germination success has been reported but nicking the seeds then soaking in water for 12 hours and then slitting them just before sowing improved germination to 79 % (Muok *et al*, 2000). This shows that apart from seed coat dormancy the nucellus (thin nylon like membrane) has to be opened for germination to successfully occur.

Seeds resistant to germination respond well after being soaked in water for over 12 hours (Kemp, 1975c). It is recommended for some species after manual or mechanical scarification is done on them (Elamin, 1975), Chemicals need to be used for pre treatments to increase germination. Treatment using sulphuric acid, ethyl alcohol (Barton, 1974), xylene, acetone or chloroform (McKeever, 1937) has been recommended but the length of treatment must be carefully determined so as not to damage the embryo (Heit, 1976b). Use of hydrogen peroxide, gibberelic and citric acid is known to stimulate germination in dormant seeds (Ching and Parker, 1958; Hubbard, 1958, Frankland, 1961 and Cotrifo, 1962). However, treatment using gibberalic acid (GA3) has shown excessive elongation of the seedling, in some cases even preventing the seedling from supporting itself (Broschat & Donselman, 1987, 1988). Consequently it is not advisable to use GA3 presoak treatment despite any positive effects on germination.

The chemical most commonly used to break seed coat dormancy is sulphuric acid (H_2SO_4). Bonner et al. (1974) explains the use of H_2SO_4 acid in pretreatment of seeds. Materials and equipment include acid resistance containers (thick plastics preferred), wire containers and screens for handling, draining and washing the seeds. Toughness of the seed coat varies between lots and even between individual trees (Willan, 1985). A trial on seeds is required to get the optimum period of immersion in acid for each lot. The treatment period that yields a high percentage of swollen seeds (by water uptake) without visible injury is the right one (Bonner *et al.*, 1974).

Over soaking may pit the seed and even expose the endosperm. Insufficient soaking leaves the seed coat of most species gloss while coat of correctly treated seeds are dull,

but not deeply pitted (Bonner *et al*, 1974). Examples of tropical species which respond well are *Acacia albida*, 20 minutes; *A. Senegal* , 40 minutes (Laurie, 1974). In Sudan it was found that seeds of *Albizzia lebbek*, *Cassia fistula* and *Prosopis chilensis* could be stored successfully for a further 3 - 4 months after treatment with H_2SO_4 or water (Wunder, 1966). However, for *Melia volkensii* extracted seeds are very susceptible to fungal infections so scarification should wait until just before sowing (Kidundo, 1997).

2.3. Vegetative Propagation.

2.3.1. The Concept of Vegetative Propagation.

Vegetative propagation is where an exact copy of the genome of a mother plant is made and continued in new individuals (Jaenicke and Beniest, 2002). Plants unlike animals have meristematic, undifferentiated cells that can differentiate to the various organs necessary to form a whole new plant. A piece of plant shoot, root or leaf can grow to form a new plant that contains the exact genetic information of its own source plant. This method has been used for propagation of fruit tree species like oranges since biblical times. The most important vegetative propagation technique for tree species is use of cuttings, grafting, budding, layering and micro propagation.

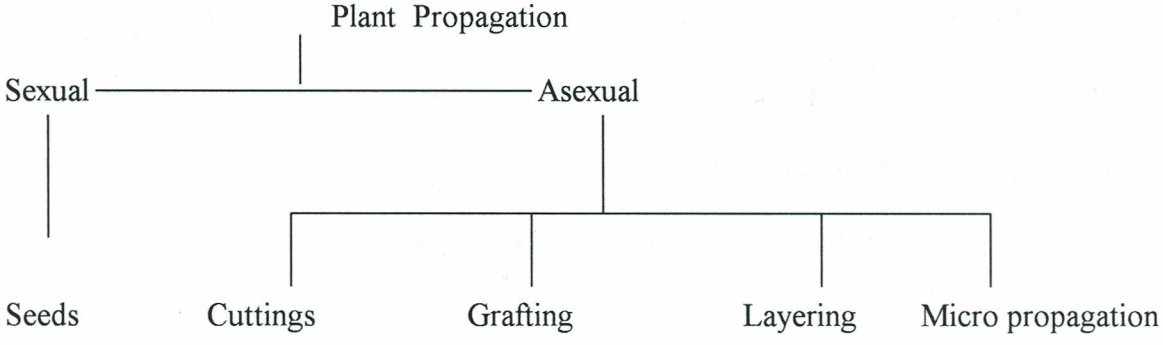


Figure 2.1 Types of vegetative propagation techniques

Cuttings are placed in a suitable rooting substrate and kept under high humidity until roots and shoots have formed. Grafting allows a combination of two or more desired characteristics into one plant. Layering is similar to cuttings but the propagules are only detached from the mother plant after the roots have formed (Palzer, 2002).

Micro propagation on the other hand is where plants are developed from a single cell which is grown in a septic culture media (Jaenicke and Beniest, 2002). It requires high investment and thus is used for high valued trees like Eucalyptus (Wakhusama and Kanyi, 2002) for commercial purposes. Palzer (2002) states that the main reason for using vegetative propagation could be (i) having seeds with problems of seed germination (ii) successful nursery technique for a given species not having been developed or (iii) trying to maintain the superior genotype of a mother tree, by combining desirable characteristics of two plants by grafting into a single plant or when production of a uniform plantation is desired.

2.3.2. **Cuttings**

Vegetative propagation of *Melia volkensii* could be an alternative propagation method since seed germination is low. Vegetative propagation technique using cuttings offers potential to grow more trees with desirable traits. The method is cheap, rapid and simple and does not require special technique as in grafting, budding and micro propagation (Palzer, 2002). Trees selected for cuttings should be superior in terms of height, diameter and straight bole (Kijkar, 1992).

Successful propagation by cuttings is influenced by rejuvenation of stock plants used, wood section, water selection and application of hormones and plant growth regulators (Jaenicke and Beniest, 2002). For purpose of propagation, biological age (age of tissue within a plant) is more important than chronological age. The more juvenile the tissue is from which cuttings are made, the greater the success in the propagator has in getting those cuttings to root (Hartmann *et al.*, 1990). The section of plant parts used for cuttings also affects the amount of success in rooting of cuttings. The base of the plant always tends to be juvenile than the actively growing parts of the plant. There is an increase in rooting from the apex moving down to the base of the stem parts (Sengbusch, 2003).

2.3.3. **Plant Hormones**.

Hormones, control development and plant growth because they affect the elongation, division and differentiation of cells. There are five major classes of plant hormones, one of which is auxin. Auxin is any chemical that promotes elongation, stimulation differentiation and branching (Palmer, 2000). Use of synthetic auxin on the base of cuttings tends to aid in stimulation of production of adventitious roots. Indole acetic acid (IAA), a type of auxin, can have this effect over only a certain concentration range. When the concentration is increased the auxin inhibits cell elongation (Palmer, 2002) hence there is need for a study to know the best concentration required in specific species. Auxins are often glycosylated or bound to proteins

Auxins are involved in the differentiation of vascular bundles; they control abscission and stimulate the opening of tree buds as well as rapid growth of young shoots among others (Sengbusch, 2003). There are a number of known synthetic auxins that are used

commercially in plant propagation, Indole Butyric acid (IBA), naphtyl acetic acid (NAA) and a well-known herbicide 2,4-D (Jaenicke and Beniest, 2002). Use of powder hormones is easier but they do not produce uniform rooting, as the hormones are insoluble in water. A more uniform method of application of auxin is to prepare a dilute solution of 20 -200 parts per million (ppm) depending on plant species (Ingram, 2004). Cuttings are then soaked for 24 hours. An alternative is a quick dip of the bases of the cuttings into a highly concentrated solution of auxin at 500 -10111 ppm for 3-5 seconds. The auxin solution should be localized to the bases of the cuttings (Palzer, 2002).

Effects of different concentrations of IBA on rooting have shown that cuttings treated with high IBA concentrations (100,150 and 200 ug IBA) were responsive ($p< 0.04$) in terms of number of roots per cuttings. Stem length on rooting showed approximately 82+/-, 4.9%; 78+/-, 5.4% and 58 +/-, 6.4% rooting success for 6, 4 and 2 cm cuttings stem length treatments. However effects of different node positions had no significant effect on final rooting percent (Mpeck *et al.*, 2003).

Shoots from seedlings of teak after auxin application in powder form showed better rooting ability than shoots from stumps. Increasing auxin concentration could increase rooting. Shoot tip cuttings gave longer root length than the second node cuttings (Kajornsrichon *et al.*, 2005). Once cuttings are severed from stock plant, the primary natural source of water uptake is eliminated. In ASALs, cuttings are placed in enclosures like the non-mist propagators where humidity is raised and temperatures are lowered to reduce evaporation and water loss. This simple technology is well adapted to rural areas of developing countries because it does not require a central water supply system or

electricity. The non-mist propagator is made from local materials and the technology could easily be transferred to rural farmers (Tchoundjeu, 1996).

None of the propagation methods will work if the right media is not used. The air content should be between 20–50 volume percent to promote root formation and growth. The percentage volume of air should not drop below 15 volumes percent (Gislerod, 1983). Most rooting medium contain a combination of sand, peat, sphagnum moss, and vermiculite (Hartman, 1975), however coconut husk on the other hand is recommended as it is fibrous and light weight, facilitating root development (Kijkar, 1991) and allows direct planting of cuttings into plastic bags, eliminating the need for transplanting cuttings into individual tubes (Kijkar, 1992).

The medium should be firm and dense to hold cuttings without movement during rooting and can hold moisture so that excessive watering is not needed. Sufficient aeration should be ensured; weeds and nematodes should be removed through sieving. The media should have adequate nutrients for plant growth (Richards *et al.*, 1964). Shading of cuttings is necessary to prevent leaf scorch and aids in the prevention of excess build up of carbohydrates, which actually hinder the development of rooting systems. Stanley and Toogood, (1981), recommend 20 % of shading.

After several 3-4 weeks callus should develop at the cut surface and following this new roots may appear. Shading should gradually be reduced to increase photosynthesis and watering should be reduced because the cuttings have functional roots to absorb water. When roots are 4-6 cm, the cuttings should be transplanted to individual tubes so as to

accommodate the delicate roots. Hardening off should resume so that the cuttings can be planted into fields (Palzer, 2002).

2.4. **Management of Seedlings in the Nursery.**

Seedling quality and grading is determined by the fitness of the seedling to survive when planted out in the field. The major attributes of seedling quality measured in the nursery include (i) The sturdiness quotient, that is, the ratio of height to the diameter of the root collar and (ii) The shoot to root length ratio. Survival studies, show that seedlings of between 17-30 cm stem height with sturdy stems and a well developed fibrous root system have a higher survival rate and make better initial growth than do either larger or smaller seedlings of this size (Scarbrough and Allen,1954; Wakely,1954; Carmen,1971; Williston,1974). Quality seedlings are necessary in areas with adverse environment such as dry, flooded, saline or nutrient deficient sites where only well developed plants have a good chance of survival. Poor quality seedlings are found to have a low chance of survival when planted out, which necessitates grading of poor quality seedlings from high quality seedlings.

Massive death of seedlings in a nursery may occur due to post emergence damping-off. Damping-off refers to sudden plant death in the seedling stage due to attack of fungi. It is most prevalent during the first few weeks after germination (Palzer, 2002). It occurs in most soils of tropical climate and in green houses (Pfelger and Gould, 1994). The two common types of diseases pre emergence and post emergence are characterized by infection and rotting seedlings especially stems close to ground level. Excessive watering of seedlings favours damping-off disease in the nursery.

There are three genera of fungus, *Rhizoctonia, Pythium* and *Phytophthora* which cause damping-off. *Rhizoctonia* root rot (*Rhizoctonia solani*) is the fungi found in hot temperatures. The fungi *Rhizoctonia* are found mostly in natural soils and can survive indefinitely. Plants attacked by these fungi have slightly sunken lesions on the stem or below the soil line. The fungi Pythium root rot *(Pythium spp.*) is found in cool, wet poorly drained soils caused by over watering. Seedlings attacked have their lower portions of the stem slimy and black. The fungi can survive for several years in soil and plant refuse. *Phytopthora* root rot (*Phytopthora spp*) fungi enters the root tips and cause a water soaked brown to black rot similar to *Pythium*. This fungus survives indefinitely in soil (Clothier, 2005). Most of these fungi also cause cuttings to rot (MOFGA, 2005).

The amount of damage the disease causes depends on type of fungus, soil moisture and temperatures. Control in watering is recommended as the disease is favoured by wet, humid, shaded environment (Palzer, 2002). Fungus kills young seedlings and germinating seeds thus accounting for severe crop losses in the nursery (Manning and Menzies, 1980). Older plants are seldom attacked as the development of secondary stem tissue forms a protective barrier and limits fungal penetration. However, portions of roots and stems still can be attacked, resulting in poor growth and reduced yields (Pfelger and Gould, 1994).

The most likely source of fungi is soil that is used to prepare the germination mix. However fungi can also originate from the irrigation water, compost, seed, dust, soil splash and some are able to cause infection from airborne spores (Palzer, 2002). Little

research has been done on this disease, but there is a high potential for this pathogen to cause economic losses. Disease severity is determined by the amount of pathogen in the soil, susceptibility of the crop, environmental factors especially soil moisture and temperature ((Pfelger and Gould, 1994).

2.4.1. **Symptoms of Damping-Off Disease**.

Post emergence damping-off common to *Melea volkensii* affects seedlings that have already emerged from the soil. They are attacked at or below the soil line. The infected stem portion becomes discolored and begins to shrink (Pfleger and Gould, 1994). Although the plant lives for a while, it is stunted and pale and will eventually die (Brown or white fungus grow on the surface on the potting media or on the seedlings themselves).

Pythium produces a white fast growing mycelium, which produces sporangia. The sporangia can germinate directly by producing hyphae with vesicles, which later produce zoospores. The zoospores form cysts and penetrate host tissues to initiate infection or produce a vesicle to continue the zoospores life cycle.

2.4.2. **Prevention of Damping-Off Disease.**

The following techniques are recommended to prevent damping-off (i) Using sterile and neutral pH potting soil, (ii) Sowing seeds thinly as crowded seedlings do not dry quickly after watering and this provides environment for fungus spores to germinate and (iii) Keeping potting media dry as this is less favorable to the growth of fungi (Palzer, 2002).

When watering is done late in the afternoon high air humidity and a wet soil surface might prevail through out the night and favor damping-off (Palzer, 2002). Seedlings known to be sensitive to damping-off need to be studied so as to know the best desirable conditions required for their growth to avoid high mortality of seedlings in the nursery. Control of damping-off in organic production systems is difficult, due to prohibition of synthetic fungicides. A successful biological control would be of considerable benefit for rural farmers in organic agricultural practice. Use of chemical fungicide could be implemented if the cultural method is not achieved. Also use of fungicide could be used although it is expensive and need to be used with care to prevent health problems to workers.

Wet soil allows swimming zoospores of fungi to move through soil and infect seedlings. Shallow planting at 8cm depth encourages maximum emergence and reduces disease in wet, early seeded fields. It is good to sterilize ones equipment while testing the best amount of water for growth of *Melia volkensii*. One of the most satisfactory and readily available sterilizing chemicals for nursery equipment is chlorine. The household bleach sodium hypochlorite (NaOCl) is also used at 10 % solution of the bleach concentration (Jaenicke, 1999).

CHAPTER THREE: RESEARCH METHODOLGY

3.1. **Study Area.**

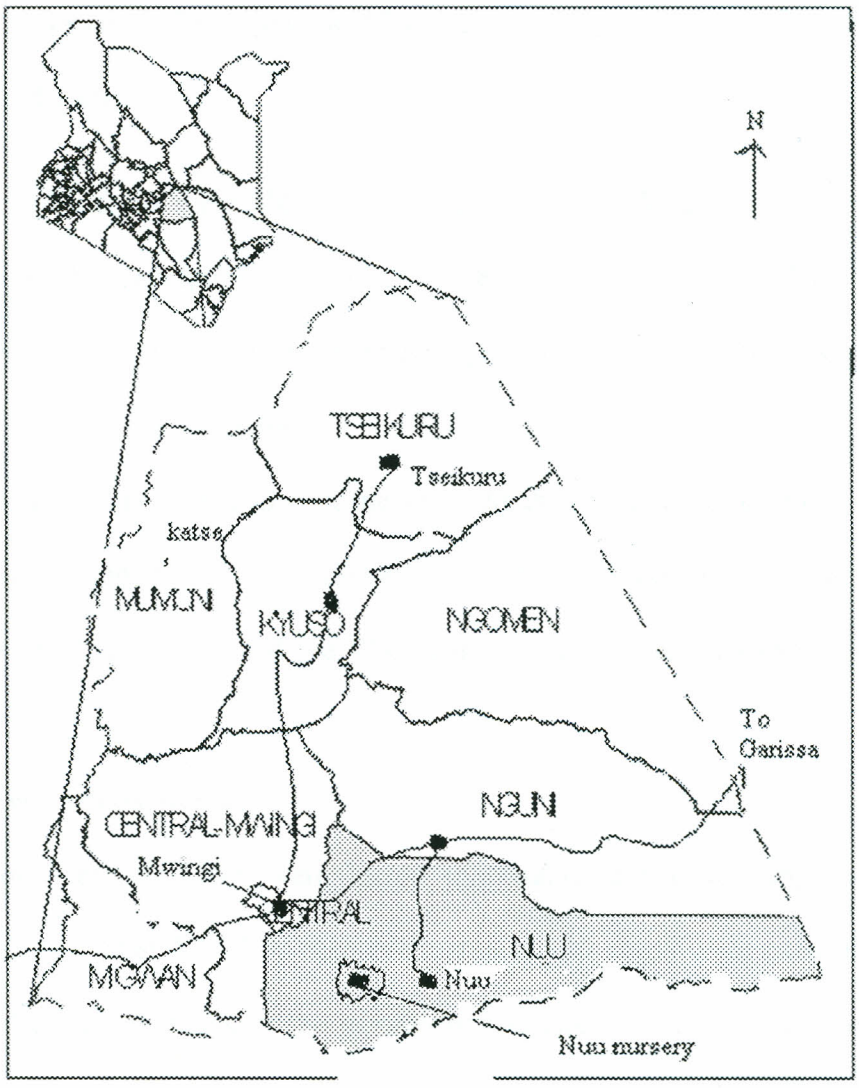
The research study reported in this thesis was carried out in Nuu division of Mwingi district (Figure 2). Mwingi district borders Kitui to the south, Machakos to the west, Mbeere and Tharaka Nithi to the north and Tana River district to the east. Nuu division lies between latitude 0°03′ and 0°12′South and longitudes 37°47′ and 38° 57′ East (Rural Planning Department, 2001). Temperatures range between 14 ° C and 34° C with a mean temperature of 24°C.

Nuu division is classified as semi arid with annual rainfall ranging between 500 – 700mm. It receives a bimodal pattern of rainfall with long rains occurring between March and May and short rains between October and December. The short rains are more reliable (Abeele *et al.*, 2005).

The study area is characterized by sandy, clay and shallow stony soils. The drainage is good as there was no water logging observed.

3.2. **Experimental Design**

The experiments were set in a randomized block design. Different treatments were put together to form blocks. The arrangement of the different treatments within a block was random. To avoid subconscious bias, randomization was done by means of tables of random numbers. Three experiments were carried out, (i) Seed germination; (ii) vegetative propagation and (iii) Seedling grading. Under seed germination seeds were extracted and pretreated in the nursery and under ambient conditions in the nursery.



Key:

Division boundaries

District Boundaries

Figure 3.1 Map of Kenya highlighting study site in Nuu division, Mwingi district.

3.2.1. **Experiment 1: Pretreatment Method.**

3.2.1.1 **Seed Extraction.**

Melia volkensii fruits were obtained from Kavisuni area, Kitui district. Stony endocarps are extracted by depulping fruits in a wooden pestle (Milimo and Hellum, 1989a, b). Seeds were extracted from the stony endocarps by using the KEFRI designed cracker and dried under shed for 2 -3 weeks.

Removing impurities such as debris, mechanically damaged, shriveled and immature seeds, cleaned seed samples. This cleaning method did not however distinguish damages that were invisible to the naked eye. The clean sample was weighed and recorded.

3.2.1.2. **Seed Pretreatment**

Seeds from different trees were mixed thoroughly and were subjected to different pretreatments (Table 3.1). For each pretreatment 120 seeds were used. Each treatment comprised of fifteen seeds in the laboratory and twenty-five seeds in the nursery. The volume of sulphuric acid (H_2SO_4) used to soak the seeds was twice that of seeds and the seeds were fully immersed into the acid for the required period of time, as recommended by Gordon and Rowe (1982).

Table 3.1 Different Pretreatment Subjected to *M. volkensii* Seeds.

Batch	Treatment method
I	Soaking seeds in water for 24 hrs.
II	Nicking then Soaking seeds in 10% H_2SO_4 acid for 30 minutes, washing with in running water for 10 minutes and then left to stand in water in 250ml beakers for 24 hrs.
III	Nicking then Soaking seeds in 10% H_2SO_4 acid for 10 minutes, washing with in running water for 10 minutes and then left to stand in water in 250ml beakers for 24 hrs.
IV	Nicking then Soaking seeds in 10% H_2SO_4 acid for 60 minutes, washing with in running water for 10 minutes and then left to stand in water in 250ml beakers for 24 hrs.
V	Soaking seeds in 10% H_2SO_4 acid for 30 minutes, washing with in running water for 10 minutes and then left to stand in water in 250ml beakers for 24 hrs.
VI	Soaking seeds in 10% H_2SO_4 acid for 10 minutes, washing with in running water for 10 minutes and then left to stand in water in 250ml beakers for 24 hrs.
VII	Soaking seeds in 10% H_2SO_4 acid for 60 minutes, washing with in running water for 10 minutes and then left to stand in water in 250ml beakers for 24 hrs.

Treatments were carried out at normal daily temperatures ranging between 18- 22 ° C according to Heit, (1976a). After soaking period was over, seeds were removed from the acid by carefully draining the acid then promptly and thoroughly washing in cold running water for 10 minutes so that all traces of acid were removed. Seeds were then left standing in 200ml of water for 24 hours. Seeds were germinated in both petri dishes and in prepared germination seedbeds in the nursery.

3.2.1.3 **Germination Testing**

a) **Laboratory Germination Capacity (LGC)**

The procedure followed was based on that of Turnbull (1975a). Pretreated seeds were divided into two lots. For example, treatment II, 120 seeds were soaked in 10 % sulphuric acid for 30 minutes and were then divided into two groups, of 45 seeds for laboratory experiment and 75 seeds for the nursery experiment. The 45 seeds were again divided into three lots, with for one replicate. The pretreatment were replicated thrice. Each pretreatment was put in a Petri dish, which had a filter paper inside. The size of the Petri dish was 15cm diameter and it accommodated 15 seeds only. Justice (1972) recommended spacing the seeds by 1.5 to 5 times the normal seed width or diameter between two seeds, in order to discourage the spread of fungus moulds.

One set of each pretreatment was arranged randomly to form a block. This was replicated two times, to form two other blocks. The three blocks of different pretreatments were sown in the laboratory. High humidity was maintained around the seed by covering the Petri dishes. Fungus growth was minimized by removal of decaying seeds; proper aeration and keeping the substrate wet enough to permit germination. Watering with

distilled water to avoid impurities into the Petri dish was done every time the filter paper was dry, excess watering was avoided to avoid fungus growth. Laboratory moisture, temperature, aeration and light were maintained at ambient conditions.

Germinated seeds were counted and recorded in the germination sheet form (Appendix 7.1). A seed was considered germinated when it reached a length of 2cm complete with seed coat enclosing the cotyledon. When seeds did not germinate for three weeks after onset germination counting stopped then a cut test was done on the remaining seeds. Germination was complete after 21 days.

b) **Germination Testing in the Nursery**

The method used followed one recommended for tropical pines in west Malaysia (Paul, 1972). The seed group of the pretreated seeds was used for nursery germination. The sample per pretreatment was 25 seeds, which was considered as one replicate. There were three replicates. Plastic germination seedbeds were filled with sand to a depth of 10 cm according to Justice (1972). The sand was sterilized by using benlate fungide, which kills fungi and other microorganisms. This was done just before sowing as the soil was of porous texture. This enabled adequate aeration for the seeds.

The pretreated *Melia volkensii* seeds were broadcast then covered with fine sand. The different pretreatments were arranged randomly within the germination seedbeds to form three blocks. The seeds were then lightly watered with a fine mist spray. The germination seedbeds were then covered with a plastic transparent sheet to maintain high humidity and temperatures according to Oomen and Koppe (1969).

A seed was considered germinated after the emergence and development of those essential structures (shoot and radical), which were indicative of the seeds capacity to produce a normal seedling under favorable conditions. Germinated seeds for each replicate were recorded in a germination test sheet (Appendix 7.1). Germinated seeds were removed as soon as they were recorded.

After 4 weeks, seeds that had not germinated underwent cut test to check on their viability. It involved direct eye inspection of seeds, which had been cut open with a scalpel. If the endosperm was of normal color with a well-developed embryo, the seed was considered viable and had a good chance of survival. Unviable seeds were those found to be milky, not firm, with moulds, decayed, shriveled, had a rancid smell or abortive embryo.

3.2.2. **Experiment 2: Vegetative Propagation**

The method used is well described by Ze'ev and Tchoundjeu (2002). Cuttings were obtained from selected trees in KEFRI Tiva plot in Kitui district during the dry season of September 2005. The trees were four years old. The branches obtained were from different sections of the stem; top, middle and bottom section (section nearest to the ground). The branches collected were those that were from straight stems.

Cuttings were cut in the evening at 4.30 p.m when the sun was not so intense so as to reduce water loss. Cutting of branches using a sharp secateur was ensured so as not to damage the bark. Each branch was then cut into 12 inch length pieces. The piece cuttings

were cut squarely at the base so that they were flat as slanted cuttings result into a one-sided root system (Wakhusama and Kanyi, 2002). Each piece of cutting had at least four buds. They were dipped into a bucket of water so as to ensure no water loss or air pockets in the cutting as they awaited packaging and transport.

Cuttings from each section were put in a labeled plastic bag and then transported in cool boxes to avoid desiccation. A block of ice was put at the bottom of the cool box to ensure low temperatures. However it was ensured that the cuttings did not to get direct contact with the ice block to prevent death of the cuttings. The cool box was then closed. The cuttings were then transported to Nuu Nursery in Mwingi District about 130 Km from the KEFRI plot. At the nursery, the cuttings were left standing overnight dipped in a bucket of water to avoid water loss. Very early the next day cuttings were treated and prepared for planting.

For each treatment five cuttings were used due to limited availability of materials. Rooting powder of different concentration was put in open dishes for easy application. The rooting powder used was 0.11% of indole butyric acid (IBA), 0.33% IBA, 0. 50% IBA and control with no treatment. Each basal of the cutting was placed in 0.5 – 1 cm. of the rooting powder, ensuring that the powder was well placed at the base of the cuttings.

Once all the cuttings had been dipped into the respective rooting powder (Table3.2), they were planted in a non-mist propagator. A non-mist propagator is a simple wooden frame of 1metre width and 3metre length enclosed by clear polythene sheeting. It is used as a green house in the dry area where there is no electricity. It helps to maintain moisture

within and thus reduce evaporation of water from the cuttings which had no roots and thus not able to absorb water from the soil.

In a non-mist propagator, a layer of sand substrate was filled at the bottom so as to lay a cushion for the coarse stones, which could other wise damage, the polythene sheet at the bottom. Small stones and gravel mixed with sand were then filled so as to act as a medium to maintain water. The fine sand was added as the rooting medium to a level height of 25cm from the bottom. Water was then added until the drainage layer (just below the rooting medium) was fully saturated. It was ensured that the rooting medium was moist but not water logged to prevent cuttings from rotting.

Table 3.2 Hormone Pretreatment to Cuttings of Different Sections of *M. volkensii* Stem in Vegetative Propagation Experiment.

Symbol	Treatment
BC	Bottom section, no treatment (control)
B1	Bottom section treated with 0.11 IBA
B3	Bottom section treated with 0.33 IBA
B5	Bottom section treated with 0.50 IBA
MC	Medium section, no treatment (control)
M1	Medium section treated with 0.11 IBA
M3	Medium section treated with 0.33 IBA
M5	Medium section treated with 0.50 IBA
TC	Top section, no treatment (control)

T1	Top section treated with 0.11 IBA
T3	Top section treated with 0.33 IBA
T5	Top section treated with 0.50 IBA

Cuttings were inserted into the rooting substrate to a depth of 2 – 3 cm, at an angle of 45 degrees and it was ensured they were firm so as to concentrate hormones at the bottom, and therefore hasten the initiation of roots. The exposed section had a minimum of two buds for leaf growth. Care was taken to ensure the cuttings were not planted upside down so as to ensure right movement of the hormone. The cuttings were then watered thoroughly to eliminate any air pockets and encourage close contact between cuttings and the mix.

To maintain uniform temperature for rooting success, the cuttings were again covered with a plastic sheet within the propagator, so as to maintain high humidity within the non-mist propagator. Initially watering was frequent because fresh cuttings relied on a moist, high humidity environment to avoid desiccation. Check ups of the water level and cleaning of the sheet of the non-mist poly propagator was done weekly in order to allow enough light. During hot weather, placing tree branches onto the plastic sheeting to prevent desiccation of cutting provided shading.

There were 12 different treatments, (B1- Bottom with 0.11% IBA, B3- Bottom with 0.33% IBA, B5- Bottom with 0.50% IBA, BC- Bottom control, M1- Medium with 0.11% IBA, M3- Medium with 0.33% IBA, M5- Medium with 0.50% IBA, MC- Medium

control, T1- Top with 0.11% IBA, T3- Top with 0.33% IBA, T5- Top with 0.50% IBA, TC- Top control) and each treatment was labeled, with treatment type, section of branch and date of setting. Each treatment was recorded in an Assessment Sheet (Appendix 7.5). This formed one block. The arrangement of the different treatment within the block was random (Appendix 7.3).

Periodic inspection of the cuttings for leaf growth and also carefully removing cuttings from the substrate revealed the extent of root development. Shading was reduced when the roots in the cuttings grew to one centimeter long. This was to allow photosynthesis. Watering was reduced from twice daily to once after the cuttings had functional roots and were able to absorb water from the soil mix.

3.2.3. **Experiment 3: Grading of Seedlings**

Four hundred pots were filled with substrate, a mixture of sand and nursery soil at a ratio of 1: 1. The soil was watered thoroughly using water mixed with benlate (fungicide) to ensure a substrate free of pathogens. Pricked out germinated seedlings from a non-mist propagator were then planted into the pots. The seedlings were then divided into four samples of 100 seedlings each. The height of each seedling in each sample was then recorded. This was classified as the first replicate.

The procedure was repeated twice so as to make three replicates. Each replicate was considered as a block. Treatments within a block were arranged randomly.

Different watering regime was applied in the morning to the young seedlings to allow drainage and evaporation of the excess water before the onset of evening. The water used was mixed with fungicide to ensure soil free of pathogens (Table 3.3).

Table 3.3: Watering Treatment Given to Seedlings of *M. volkensii* for Quality Grading of Seedlings.

Watering Treatment	Code
Watering 3 litres twice daily every day	Control
Watering 2.5 litres of water four times a week	1
Watering 5 litres of water four times in a week	2
Watering 10.0 litres of water four times in a week	3

Seedlings heights and root collar diameter for the four treatments were measured weekly for six weeks. Root length was measured after six weeks.

3.3 **Data Analysis**

Data analysis was done by use of Genstat (1995). Analysis was done between the treatments and also variation was checked between the blocks.

3.3.1. **Seed Pretreatment.**

3.3.1.1. ***Purity Tests and Seed Weight.***

The purity percentage of seeds was obtained by calculating

$$\text{Purity \%} = \frac{\text{Weight of pure seeds}}{\text{Weight of seeds and impurities}} \times 100$$

ISTA rules of (1996) prescribe that weighing be done in grams so as to calculate the percentage of its component parts to one decimal place. To estimate variation within the sample, smaller samples were used; eight replicates of 100 seeds as prescribed by ISTA were used from which the standard deviation (SD) and coefficient of variation (CV) were calculated as well as the mean. If C.V was less than 4, the mean was accepted.

The formula used to get the seed weight was

$$SD = \sqrt{n(\sum x^{2}) - (\sum x)\, 2/n(n-1)}$$

$$\text{Number of seeds per gram} = \frac{\text{weight of sample}}{\text{Number of seeds in sample}}$$

3.3.1.2. ***Germination Tests***

3.3.1.2.1 Germination Percentage

This is the number of germinated seeds for each pretreatment at the end of the experiment.

$$\text{Germination percent} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \times 100$$

3.3.1.2.2 Germination Energy and Energy Period

Energy period =number of days required to have daily germination of seeds being less than 25% of peak. Seward (1980) defined it as the percentage of germination when mean daily germination (cumulative germination) divided by time elapsed since sowing date reaches its peak.

$$\text{Germination energy} = \frac{\text{Seeds that germinate within energy period}}{} \times 100$$

Total number of seeds

3.3.1.2.3 Germination Value

According to Djavanshir and Pourbik (1976) this is the test of total germination at the end of the test period with an expression of germination or speed of germination.

GV= (∑ DGS/n) X GP/10

Where:

GV= Germination value

GP= Germination percent at the end of the test

DGS= Daily germination speed obtained by dividing the cumulative germination percent by the number of days after sowing

(∑ DGS= the totals obtained by adding every DGS figure obtained from the daily counts

N= Number of daily counts, starting from the date of first germination

3.3.1.3. ***Cut Test (seed viability).***

In cut tests the viability of seeds that had not germinated at the end of the germination period is verified

3.3.1.4. **Correlation between Laboratory and Nursery Results**

This was done to predict the nursery seed germination from the known laboratory results of *M. volkensii* seeds. The mean germination percentage (x) realized from the laboratory are the parameters used as independent variables, so as to predict the germination percentage in the nursery (y), these being the dependent variable.

The general linear regression formula used was

$y = a + b x$ ..... (Equation 1)

Where a = the intercept

b = the slope of the line produced

To obtain the slope

The formula used

$$b = \frac{(\sum xiyi - ((\sum xi)\ ((\sum yi)/n}{(\sum xi^2\ \sum xi2\ /n}$$

To obtain the intercept

$Y = a + bx$

$a = y - bx$

Regression coefficient R^2 = Treatment SS/ Total SS

The regression equation 1- R^2

Correlation between Laboratory and Nursery results = 100-(1- $R^{2)}$

3.3.2 **Vegetative Propagation**

Statistical analysis on vegetative propagation was done using Genstat to compare the growth of leaves, the length of roots and the rooting percentage between different treatments.

Observation was made for-

3.3.2.1.***Mean Number of Leaf Growth***- Three length classes were distinguished (i) Class a – Leaves whose length was 2cm or less, (ii) Class b – Leaves whose length was between 2cm and 6cm (iii) Class c – Leaves whose length was greater than 6cm.

3.3.2.2 ***Root Length***- the length in each cutting was taken and the mean obtained for each section.

3.3.2.3 ***Rooting Percentage*** – The percentage was taken to be the number of cuttings that had rooted after treatments in relation to the total number of cuttings of that treatment.

3.3.3. **Grading of Seedlings**

For grading of seedlings statistical data analysis was done by use of Genstat. Analysis for

3.3.3.1 ***Height*** – The seedling height was measured for all treatment

3.3.3.2 ***Root Collar Diameter***- was done between the different treatments and also between the blocks. Single parameters such as stem length, stem diameter and root length have a limited value in predicting seedling quality, and in turn the survival and growth of seedlings after field planting. Combining series of parameters into one value and then used as an index to measure seedling quality is considered a better value in measuring seedling quality.

3.3.3.3 ***The Sturdiness Quotient Index*** - Compares the ratio of seedling height against the root collar diameter. A value greater than six is considered not desirable. Seedling height was also compared against the root length for all the treatments.

3.3.3.4 ***The General Health of the Leaves***- the percentage of healthy green leaves was divided into three classes. Class 1, 30% of the leaves in each seedling was green. Class 2, 31-70 % of the leaves in each seedling was green while in class 3 over 70 % of leaves in each seedling were green.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Experiment 1: Pretreatment of *Melia volkensii* Seeds

4.1.1 Seed Extraction, Purity Percentage and Seed Weight of *Melia volkensii* Seeds

The number of seeds that were obtained after cracking nuts in Nuu nursery from different fruit sizes is presented in Table 4.1 below. The results show the purity of seeds was 77.36% while the inert matter (broken seeds and weeds) was 22.64%. Weighing of seeds in the sub samples showed the number of seeds in one kilogram was 4638 seeds.

Table 4.1 **Number of *Melia volkensii* Seeds Obtained After Cracking Nuts in Nuu Nursery from Different Nut Sizes.**

Nut Sizes	Types of Seeds					
	Good Seeds		Bad Seeds		Total No of seeds	
	No.	%	No.	%	No.	%
Large (>3.7cm Long)	267	79.5	69	20.5	336	100
Medium (3.1 – 3.7cm long)	94	75.8	30	24.2	124	100
Small (2.8 – 3.0cm long)	172	73.8	61	26.2	233	100

The results showed that big nuts, which had 4 to 5 seeds inside, had little damage done to them than in small nuts. The results concurred with those done in Tiva nursery where up to 80% reduction on seed damage was recorded when using the big nuts (Muok *et al*, 2000). This result of *M. volkensii* seeds is of low purity percent when compared with seed purity standards for grains. The rate of pure seeds should be over 90% (Brick, 1995). The results suggest that seed collection ought to be further improved on cleaning,

processing and storage of seeds. This calls for more cleaning of the seeds before selling. The use of sieves with different size perforators could be used to sift out small pieces of nuts and damaged seeds. Ordering using weight is easier than by the number of seeds required. Allowance of expected seeds reduction in germination tests and loses expected in the nursery and the field should also be factored in when ordering. Calculation of big nuts for species like *Melia volkensii* is simple as they can easily be counted. Palzer (2002) explains that smaller seeds on the other hand are hard to determine without experience. Rough estimates could be obtained from books (Von Carlowitz, 1986, Albrecht 1993 and Bien *et al.* 1996); however variations occur within figures of individual author.

During the cleaning process, fruits collected from the trees are depulped and soaked in water. Soaking in water allows the pulp to float to the surface and the hard nuts to sink to the bottom (Aldhous, 1972). With the current seeds, the separation of the hard nut and the pulpy material was not done well and hence more pulpy material was left with the hard nuts. The hard nuts are then dried before cracking. The seeds of *M. volkensii* are extracted from the hard nuts by using KEFRI nut cracking devise. This has improved the number and quality of sound seeds collected but the success of obtaining sound seeds depends on the individual doing the exercise (Personal observation). The amount of seeds extracted per day per person increased from 0.5Kg when using a hammer or knife to 5Kg when using the KEFRI devised machine (Most of the inert matter comprised of damaged seeds and pieces of the cracked nuts (Muok *et al*, 2000).

4.1.2 Germination Percentage of *Melia volkensii* Seeds

a) **Laboratory Results.**

Table 4.2 shows the germination percent obtained from seeds when nicked then soaked And those that were only soaked. Seeds that were nicked then soaked in 10% sulphuric

Table4.2. Germination Percentage of *M. volkensii* Seeds after Different Pretreatment in the Laboratory.

Time (minutes)	Treatment	Nick then soak (%)	Treatment	Soak (%)
10	III	53.33	VI	26.67
30	II	33.33	V	13.33
60	IV	11.11	VII	6.67
			I	11.11

Key: I- control, II- nick, soak in 10% sulphuric acid for 30 minutes, III-nick, soak in 10% sulphuric acid for 10 minutes, IV- Nick, soak in 10% sulphuric acid for 60 minutes, V- soak for 30 minutes in 10% sulphuric acid, VI- soak in 10% sulphuric acid for10 minutes and VII – soak in 10% sulphuric acid for 60 minutes

acid (H_2SO_4) for 10 minutes had the highest germination percentage of 53.33%, while those that were soaked in 10% H_2SO_4 for 60 minutes had the lowest germination rate of 6.67% at 5% significant level. Nicking then soaking seeds for thirty minutes and sixty minutes gave a germination percent of 33.33% and 11.11% respectively. Control treatment gave a germination percent of 11.11%. Soaking seeds in the acid for 10 and 30 minutes gave a germination percent of 26.67% and 13.33% The significant difference in germination percentage of *Melia volkensii* (mukau) seeds was observed in seeds that were nicked before soaking compared to the ones which were only soaked.

b) **Nursery Results**

The germination percentages of the nursery results are presented in Table 4.3. Nicking seed followed by soaking in 10% concentrated sulphuric acid for 10, 30 and 60 minutes gave an average germination percent of 52, 29.33 and 10.6 % respectively. Soaking seed for the same different period gave a germination percent of 26.67, 10.0 and 6.67 respectively. In control pretreatment where seeds were soaked only in water for 24 hours before sowing gave a germination percent of 9.33%.

Table4.3 Germination Percentage of *M. volkensii* Seeds After Different Pretreatment in the Nursery.

Time (minutes)	Treatment	Nick then soak (%)	Treatment	Soak (%)
10	**III**	52.00	**VI**	26.67
30	**II**	29.33	**V**	10.50
60	**IV**	10.60	**VII**	6.67
			I	9.33

Key: Key: I- control, II- nick, soak in 10% sulphuric acid for 30 minutes, III-nick, soak in 10% sulphuric acid for 10 minutes, IV- Nick, soak in 10% sulphuric acid for 60 minutes, V- soak for 30 minutes in 10% sulphuric acid, VI- soak in 10% sulphuric acid for10 minutes and VII – soak in 10% sulphuric acid for 60 minutes

Discussion

The results reveal that soaking seeds for different periods affect the germination percentage indicated by the different percentages obtained from the different treatments. The combination effect of nicking and soaking improved the germination percent of *M. volkensii* seeds as compared to soaking seeds only. This is observed when comparing the different treatments but soaked period is the same. The results concur with those done by

(Muok *et al.*, 2000) who found that nicking and soaking in water improved germination to 37%.

The long soaking in the acid in this experiment seems to inhibit germination of the seeds. The prolonged soaking of *M. volkensii* seeds in sulphuric acid may have killed some of the seeds. This is emphasized in the results of the same pretreatment but different soaking time. The pretreatment of 60 minute had the lowest germination percentage.

Improved germination in the laboratory could also be due to control conditions in the laboratory such as covering of the Petri dishes, while in the nursery, germination was done only in the non-mist propagator, hence reducing the germination per cent. The results concur with those of Muok *et al.*, (2000) who observed that, covering the germination boxes with a polythene sheet is necessary for germination to be successful. Covering maintains humidity and warmth in the germination boxes, which may be an important factor in germinating *Melia* seeds.

Bonner *et al.*, (1974) observed that low germination result in the nursery. It was found that laboratory results are not directly applicable in the field nursery, as the latter has limited control over the environmental conditions while in the laboratory it is conducted under near optimal conditions for germination. Some of the problems that affect germination in the nursery include insects, diseases and nematodes. Thus, each nursery manager ought to eliminate these nursery problems so as to convert the germination potential of seed lots as determined in laboratory germination capacity (LGC), to the actual field germination capacity (FGC)

4.1.3. **Germination Energy and Germination Period of *Melia volkensii* Seeds.**

The energy period of different pretreatment in the laboratory and in the nursery are presented in Table 4.4. Nicking seeds then soaking them in 10% sulphuric acid for thirty minutes (Pretreatment II), showed the longest period of seventeen days while control (Pretreatment I) and soaking seeds for 30 minutes in 10% sulphuric acid, (Pretreatment V) had the shortest period of thirteen days. The average energy period of the other pretreatments was fourteen days after sowing.

Soaking seeds for sixty minutes in 10% sulphuric acid had the lowest germination energy (vigor) of 6.67% while nicking and soaking seeds for ten minutes in the acid (treatment III) showed the highest vigor both in the laboratory and the nursery of 44.44% and 46.67 respectively. The germination energy in the laboratory for most treatments was higher than the nursery germination energy results as shown in Table 4.4. Treatment VI (Soaking seeds in 10% sulphuric acid for 10 minutes) had germination energy of 24.44 for the laboratory and 25.33% in the nursery.

Discussion

In the nursery the average energy period was fourteen days for treatment I, II and V (Table 4.4), which could be explained by the low temperatures experienced during the germination tests. Decreasing seed vigor is reflected in longer energy period (Brick, 1995) as reflected in the different pretreatments. The energy period of some species has been defined in advance. *Pinus aristata* Englelm has been found to be ten days (Kimondo, 2005). The results of this experiment concur with what Brick (1995) found

out in his study that germination of most species usually begins from four to seven days with peak period being between fourteen to seventeen days and is complete at twenty-eight days.

There was a significant difference in seed germination energy for the different seed pretreatment at 5% level of significance level. The germination energy in most pretreatment was similar to the germination percentage (Table 4.4). The experiment revealed that nicking improved germination energy. Allen (1958) noted that since the germination energy is an indicator to the vigor of the seeds in respect to the different pretreatments, the same vigor is likely to be reflected in the nursery and even in the field. Weak and delayed germination is often fatal (Aldhous, 1972). Slow germination results in less uniform seedbed density and seedling height, leading to a lot of seeds being culled during grading.

Table 4.4 Germination Energy and Energy Period of *M. volkensii* Seeds After Different Pretreatment in the Laboratory and in the Nursery.

Pretreatment	Energy period (Days)		Germination Energy(Percent)		Germination percent	
	Laboratory	Nursery	Laboratory	Nursery	Laboratory	Nursery
I	13	14	11.11	9.33	11.11	9.33
II	17	14	33.33	26.67	33.33	29.33
III	14	15	44.44	46.67	53.33	52.00
IV	14	15	11.11	10.67	11.11	10.60
V	13	14	13.33	9.75	13.33	10.50
VI	14	16	24.44	25.33	26.67	26.67
VII	16	16	6.67	6.67	6.67	6.67

Key: I- control, II- nick, soak in 10% sulphuric acid for 30 minutes, III-nick, soak in 10% sulphuric acid for 10 minutes, IV- Nick, soak in 10% sulphuric acid for 60 minutes, V- soak for 30 minutes in 10% sulphuric acid, VI- soak in 10% sulphuric acid for10 minutes and VII – soak in 10% sulphuric acid for 60 minutes

4.1.4 **Germination Value of *Melia volkensii* Seeds.**

The results of germination values are shown in Table 4.5 for laboratory and nursery treatments. Treatment III (nicking followed by soaking in 10% sulphuric acid for 10 minutes) showed the highest germination value of 210.85 and 187.13 in the laboratory and the nursery respectively. Treatment VII (soaking seeds in 10 % sulphuric acid for 60 minutes) had the lowest germination value of 0.43 and 0.21 for laboratory and nursery respectively.

Nicking seeds improved the germination value significantly. This can be observed by comparing the values of the nicked seeds for all the pretreatment to those of the seeds that are not nicked. Experiment II, III and IV shows a germination value of 70.79, 210.85 and 7.12 respectively as compared to those that were not nicked in experiment V, VI and VII. They had a germination value of 13.11, 41.04 and 0.43 respectively with the same soaking period. This trend was observed both in the laboratory and in the nursery results. Treatment VI (Nicking seeds then soaking in 10% sulphuric acid for 60 minutes) in the laboratory had 41.04 germination values while the nursery was 40.89.

Discussion

The analysis of variance of the germination value revealed that there was a significant difference between the treatments and also between the laboratory and nursery germination at 5% significant level. This agrees with Palzer (2002) who explains that Laboratory Germination Capacity (LGC) is conducted under optimal condition for germination, while field germination capacity is interrupted by weather conditions, soil conditions, insects, pathogens and even the planting technique used in sowing the seeds.

Another problem could be pre emergence damping-off disease depending on watering or temperatures in the respective nursery where the experiment is done. Soaking seeds for long period (Treatment IV and VII) also reduced the germination values both in the laboratory and the nursery. This could be attributed to the long period the seeds were soaked in the sulphuric acid thus depressing the seed germination process (Willan, 1985).

Table 4.5. Germination Values of *Melia volkensii* Seeds After Different Seed Pretreatments in the Laboratory and Nursery.

Seed Pretreatment	Germination Value		
	Laboratory	Nursery	SED
I	7.97	5.26	1.36
II	70.79	54.68	8.06
III	210.85	187.13	11.86
IV	7.12	6.32	0.40
V	13.11	7.06	3.03
VI	41.04	40.89	0.07
VII	0.43	0.21	0.11
SED	51.79	44.47	

Key: I- control, II- nick, soak in 10% sulphuric acid for 30 minutes, III-nick, soak in 10% sulphuric acid for 10 minutes, IV- Nick, soak in 10% sulphuric acid for 60 minutes, V- soak for 30 minutes in 10% sulphuric acid, VI- soak in 10% sulphuric acid for10 minutes and VII – soak in 10% sulphuric acid for 60 minutes, SED- standard error deviation

The results from the pretreatment shows that nicking followed by soaking for 10 minutes in 10% sulphuric acid gave the best pretreatment. Germination value *per se* is meaningless, but when two pretreatment tests are compared on the same lot, the more

active or vigorous lots can be identified by the higher value (Okoro, 1976). Costales and Veracion (1978) found it a good measure of seed quality for *Terminalia ivorensis* and for *Pinus kesiya.* Djavanshir and Pourbeik (1976) found germination values were closely related to the survival of plants in the field and the nurseries.

4.1.5 **Homogeneity of Germination Results of *Melia volkensii* Seeds.**

Correlation of the laboratory results to nursery was found to be 99.85%. The best germination in the test gave 53.33%, of which 24% was weak and dying seeds (0.533 X 0.46) giving the potential of the lot as (53-24), 29 per cent. To plant 200 trees 450 seeds are required.

Table 4.6 Germination Percentage of the Nursery Results (Y) and Predicted Germination Percentage of the Nursery ($\hat{Y}$) of *Melia volkensii* Seeds When Using Laboratory Results.

Seed Pretreatment.	Pretreatments							
	I	II	III	IV	V	VI	VII	SED
Realized (Y)	9.33	29.33	52.0	10.6	10.5	26.67	6.67	13.09
Predicted ($\hat{Y}$)	12.38	34.16	53.76	11.8	12.38	27.64	8.04	13.41
Laboratory (X)	11.1	33.3	53.3	11.1	13.3	26.6	6.6	
SED	1.53	2.42	0.88	0.60	0.94	0.48	0.69	

Key I- control, II- nick, soak in 10% sulphuric acid for 30 minutes, III-nick, soak in 10% sulphuric acid for 10 minutes, IV- Nick, soak in 10% sulphuric acid for 60 minutes, V- soak for 30 minutes in 10% sulphuric acid, VI- soak in 10% sulphuric acid for10 minutes and VII – soak in 10% sulphuric acid for 60 minutes, SED- standard error deviation

Discussion

The relationship between the laboratory results and the nursery results of seed germination of *M. volkensii* seeds is used to predict the nursery seed germination from the known laboratory results of *M. volkensii*. Table 4.6 shows the predicted nursery results from the germination results obtained in the laboratory.

The deviation of predicted nursery results ($\hat{\mathbf{Y}}$) from the laboratory results of germinated seeds measures the failures of the results obtained from laboratory germination percent to predict the germination percent of nursery results. A nursery manager can predict the amount of seeds required for germination in the nursery after doing germination tests of a few seeds in the laboratory. By embracing the concept that seeds die progressively and not all at once, the germination result also reveals the measure of the living and the dead seeds. This can be used to calculate the weak and dying seeds from the living portion as explained by Belcher (1978). The calculation helps the nursery manager to make the correct order of seeds.

4.1.6 **Viability of *Melia volkensii* Seeds Using Cut Test**.

Soaking the seeds in water for 24 hours showed the highest viability of 71.11%. Nicking followed by soaking seeds in 10 % sulphuric acid for 60 minutes gave the lowest viability of 57.78%. The range of seed viability between the highest and the lowest was 13.33% (Table 4.7). Morandini (1962) and Willan (1985) explain that the greatest risks to seed viability depend on the aeration and temperatures of where the seeds are stored. The results indicate a low viability trend. According to Muok *et al*, 2000, *Melia volkensii*

seeds can be stored at 11-15% moisture content for some time and still have a viability of over 80.

The seed that were used for the experiment were collected from private farms and the way the farmers stored their seeds is not clear. This could explain the lower seed viability in the study. Most private farmers store their seeds in granaries or even in their kitchens where aeration is limited due to high temperatures from their cooking stoves. This tends to reduce the viability of the seeds. Viability studies of tropical species are inadequate in comparison with both the severity of the problem and the large number of species of potential value for plantations. Preserving viability of recalcitrant seeds has been suggested (Kings and Roberts, 1974) but little progress has been done. To maintain viability, mature and properly dried seeds can be stored in airtight containers at room temperature (Salim *et al.*, 1998).

Table 4.7 Viability of *Melia volkensii* Seeds After Combining Germinated Seeds With Un-germinated Seeds Which Were Done Cut Test Experiment Both in the Laboratory and in The Nursery

Treatment	GSL	CTL	TOT L	GSN	CTN	TOT N	V LAB	VNUR
I	5	27	32	7	44	51	71.11	68.00
II	15	16	31	22	28	50	68.87	66.68
III	24	6	30	39	9	48	66.67	64.00
IV	5	21	26	8	32	40	57.78	53.33
V	6	26	32	14	37	51	71.11	68.00
VI	12	19	31	20	30	50	66.88	66.68
VII	3	26	29	5	40	45	64.44	60.00

Key: GSL – germinated seeds in the laboratory, CTL –Cut test seeds in the laboratory, TOT L-.Total viable seeds in the laboratory, VLAB Viable % seeds in the laboratory, GSN – germinated seeds in the Nursery, CTN –Cut test seeds in the Nursery, TOT N-.Total viable seeds in the nursery, VNUR Viable % seeds in the nursery. I- control, II-nick, soak in 10% sulphuric acid for 10minutes, III- nick, soak in 10% sulphuric acid for 30 minutes, IV- Nick, soak in 10% sulphuric acid for 60 minutes, V- soak for 10 minutes in 10% sulphuric acid, VI- soak in 10% sulphuric acid for 30 minutes and VII – soak in 10% sulphuric acid for 60 minutes

4.2. **Experiment 2: Vegetative Propagation of *Melia volkensii* Cuttings**

4.2.1. **Leaf Growth of *M. volkensii* Cuttings**.

4.2.1.1. ***Leaf growth length of 2cm or less (Class A)***

Generally, there was a steady decrease in number of leaf growth from week 9 to week 15 in class A. Cuttings of the top section treated with 0.50% IBA (T5) had a mean number of leaf loss of 9 leaves to 3 while cuttings of the medium section with no hormone treatment (MC) had a mean number of leaf loss of 4 leaves to 1. B3 had a mean number of leaf loss of 9 to 2 in the same period.

After week 15, the top section treated with 0.5% IBA (T5) and untreated (TC) showed increase in number of leaf growth from a mean number 3 and 1 to a mean number of 19 and 3 in week 27 respectively. The leaves of cuttings in the top section treated with 0.3% IBA and 0.1% IBA dried in week 21.

All cuttings from the medium section irrespective of the treatment did not show any increase in mean number of leaf growth and by week 21 all the leaves had dried up. All cuttings obtained from the bottom sections showed growth of leaves at week 27. Cuttings of the bottom section treated with 0.33% IBA (B3) had an increase in number of leaf growth in week 27 (15) while cutting treated with 0.11% IBA (B1) had the least number of leaves (8 leaves). The mean number of leaves in class (a) for cuttings treated with 0.5% (B5) and untreated (BC) increased to 9 and 11 respectively by week 27.

Table 4.8 Number of Leaves That Grew to Length of 2cm or less (class A) After Hormone (IBA) Pretreatment on Cuttings of *Melia volkensii* Obtained From Different Sections of the Stem

Treatment	Wk3	Wk6	Wk9	Wk12	Wk15	Wk18	Wk21	Wk24	Wk27	SED
B1	3.67	5.07	6.47	3.13	1.00	4.47	5.33	6.20	7.33	0.38
B3	5.40	6.87	9.00	5.20	2.33	5.93	8.53	11.40	14.53	0.68
B5	3.60	5.27	7.20	3.93	1.27	4.93	6.07	7.93	9.00	0.46
BC	3.00	4.40	6.20	2.87	0.67	4.00	6.13	8.53	10.53	0.39
M1	3.27	4.33	6.13	5.13	2.07	0.53	0.40	0.00	0.00	0.31
M3	2.27	3.40	4.53	3.73	1.20	0.33	0.00	0.00	0.00	0.32
M5	2.87	4.07	5.27	4.33	1.33	0.20	0.00	0.00	0.00	0.31
MC	1.47	2.67	3.60	2.80	0.47	0.07	0.00	0.00	0.00	0.22
T1	1.60	2.87	3.93	3.27	0.93	0.33	0.00	0.00	0.00	0.25
T3	2.53	3.93	5.20	4.07	1.20	0.20	0.00	0.00	0.00	0.38
T5	6.00	7.40	9.33	6.00	3.33	7.33	11.07	14.67	18.67	0.65
TC	3.40	5.80	7.33	4.20	1.20	4.80	3.33	2.67	2.67	0.53
SED	0.44	0.49	0.56	0.51	0.43	0.40	0.40	0.45	0.44	

Key: B1- Bottom, with 0.11%IBA, B3- Bottom with 0.33%IBA, B5- Bottom with 0.50%IBA, BC- Bottom control, M1- Medium with 0.11%IBA, M3- Medium with 0.33%IBA, M5- Medium with 0.50%IBA, MC- Medium control, T1- Top with 0.11%IBA, T3- Top with 0.33%IBA, T5- Top with 0.50%IBA, TC- Top control, SED- standard error deviation

4.2.1.2. *Leaf Growth Length Greater Than 2cm up to 6cm (Class B)*

All cuttings of leaves in class B showed the same trend as in class A. Leaves grew to week 9 followed by leaf loss up to week 15. After week 15, some cuttings had leaf growth and others had dried up. Table 4.9 shows all cuttings from the bottom section had a steady increase in leaf growth up to week 9. However, leaf loss was observed from week 9 to week 15. In B1, B3, B5 and BC, the mean number of leaf loss was 4 to 1, 5 to 1, 5 to 1 and 6 to 1 respectively. After week 15, there was an increase in leaf growth with cuttings treated with 0.3% IBA (B3), untreated (BC), 0.5% IBA (B5) and 0.1% IBA (B1) having a mean number of leaves of 12, 10, 9 and 5 respectively at week 27.

Table 4.9 Number of Leaves That Grew to Length of between 2cm and 6cm (class B) After Hormone (IBA) Pretreatment on Cuttings of *Melia volkensii* Obtained From Different Section of the Stem.

Treatment	Wk3	Wk6	Wk9	Wk12	Wk15	Wk18	Wk21	Wk24	Wk27	SED
B1	2.00	3.40	4.40	2.33	0.73	2.93	4.27	3.87	5.07	0.42
B3	2.60	3.73	5.13	2.27	0.67	3.53	5.47	8.20	11.87	0.54
B5	2.07	3.53	4.73	2.53	0.93	3.53	5.47	7.27	8.67	0.54
BC	2.27	3.67	5.73	2.73	0.93	3.33	4.93	7.47	9.53	0.46
M1	1.47	2.73	4.13	3.40	1.20	0.53	0.27	0.00	0.00	0.38
M3	0.73	2.20	2.93	2.47	0.60	0.13	0.00	0.00	0.00	0.24
M5	1.13	2.60	3.93	2.67	1.07	0.27	0.00	0.00	0.00	0.32
MC	0.33	1.40	2.27	1.40	0.47	0.07	0.00	0.00	0.00	0.19
T1	0.40	1.87	2.53	1.80	0.93	0.33	0.00	0.00	0.00	0.27
T3	0.87	2.07	3.40	2.93	1.00	0.47	0.00	0.00	0.00	0.32
T5	2.87	4.27	6.00	3.27	1.53	5.60	7.27	10.67	14.80	0.60
TC	2.20	3.80	4.93	3.00	1.07	3.93	1.47	1.00	1.67	0.43
SED	0.32	0.43	0.51	0.44	0.35	0.40	0.39	0.44	0.48	

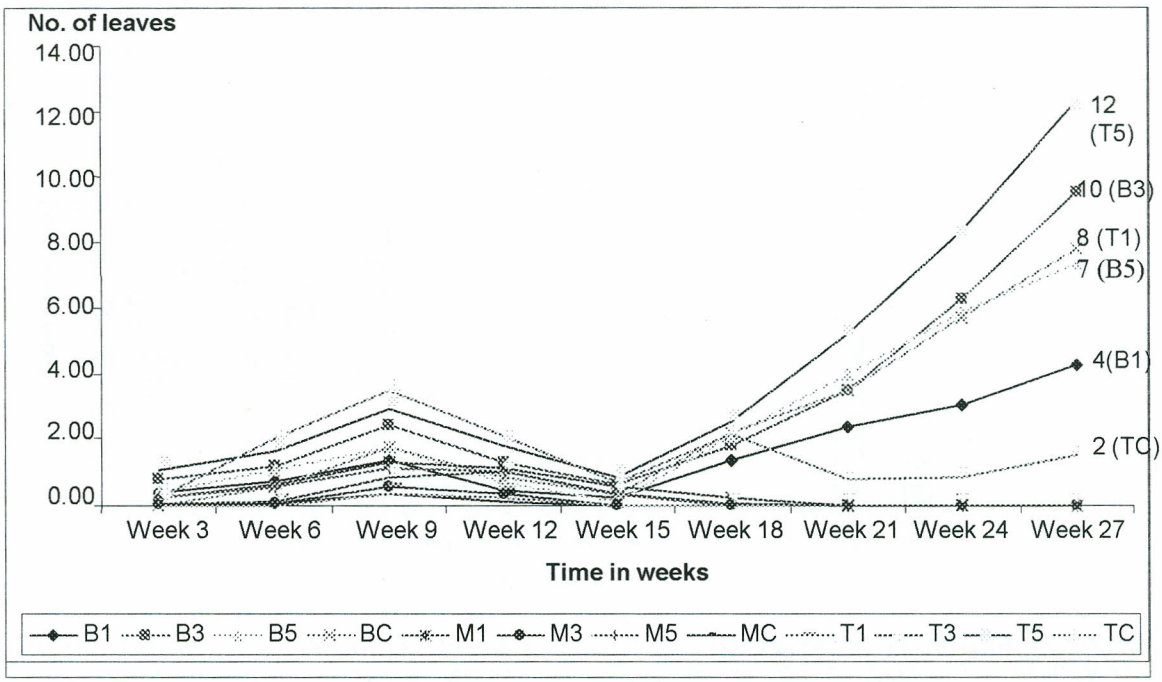
Key: B1- Bottom, with 0.11%IBA, B3- Bottom with 0.33%IBA, B5- Bottom with 0.50%IBA, BC- Bottom control, M1- Medium with 0.11%IBA, M3- Medium with 0.33%IBA, M5- Medium with 0.50%IBA, MC- Medium control, T1- Top with 0.11%IBA, T3- Top with 0.33%IBA, T5- Top with 0.50%IBA, TC- Top control, SED- standard error deviation

All leaves in class B cuttings from the medium section and from top section treated with 0.1 IBA (T1) and 0.3 IBA (T3) had dried up by week 21 weeks. However the number of leaves of cuttings treated with 0.5 IBA (T5) and untreated (TC) had increased to 15 and 2 respectively by week 27.

4.2.1.2. ***Length of Leaf Growth Greater Than 6cm (Class C)***

Cuttings from the top section treated with 0.5% IBA showed the highest number of leaf growth throughout the experiment in class C. There was a high significant difference in mean number of leaf growth at 5% between cuttings from the top section treated with 0.5% IBA (T5) and other treatments (figure 4.1). The mean number of leaves in the top section treated with 0.5% IBA (T5) section of class (c) after 27th week was 12. Untreated cuttings from the top section (TC) showed the least increase in mean number of leaf growth of class C category of 2. All cuttings obtained from the bottom section showed

increase in mean number of leaf growth of different numbers in all the treatments B3, BC, B5 and B1 with each having 10, 8, 7 and 4 respectively.



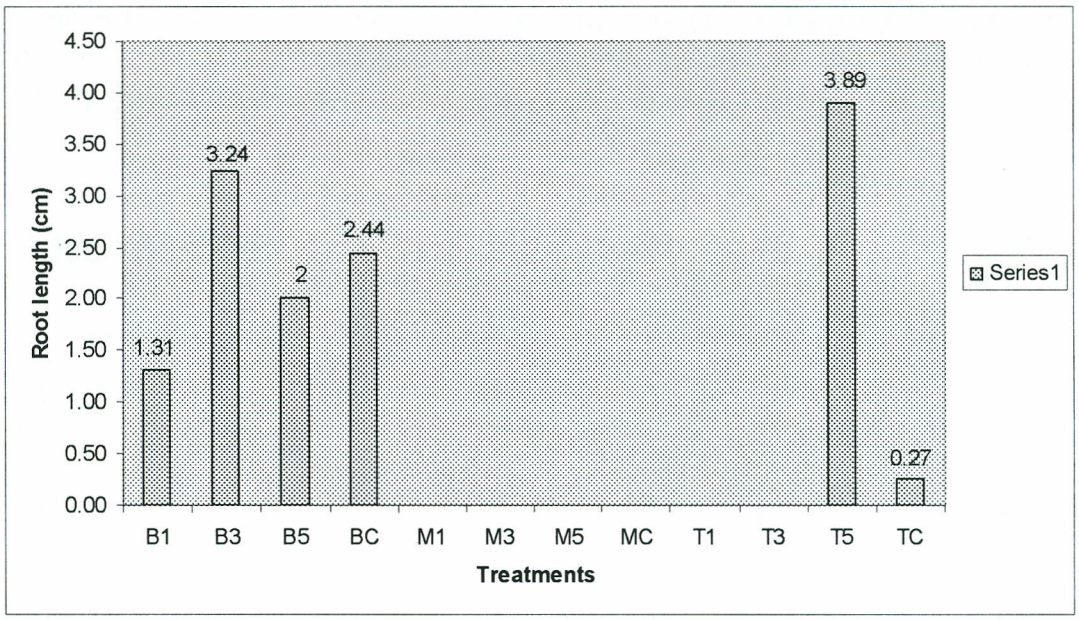
Key: B1- Bottom, with 0.11%IBA, B3- Bottom with 0.33%IBA, B5- Bottom with 0.50%IBA, BC- Bottom control, M1- Medium with 0.11%IBA, M3- Medium with 0.33%IBA, M5- Medium with 0.50%IBA, MC- Medium control, T1- Top with 0.11%IBA, T3- Top with 0.33%IBA, T5- Top with 0.50%IBA, TC- Top control

Figure 4.1 Number of Leaves That Grew to Length of More Than 6cm (Class C) After Hormone (IBA) Pretreatment on Cuttings of *Melia volkensii* Obtained From Different Sections of the Stem

4.2.2. Rooting of *Melia volkensii* Cuttings

Rooting was observed from week 18 to 27. The roots that had grown were measured and the average mean length in week 27 is shown in (Figure 4.2). There was a significant difference at the cuttings of the bottom section, with the ones treated with 0.33% IBA (B3) showing the longest mean root length in this section (3.24cm) and also the highest rooting percentage of 73% (Table 4.11). Cutting of the bottom section treated with 0.5%IBA (B5) showed a decrease in rooting length (2.00cm) and even in rooting success

(45%) against the bottom section untreated (BC) which had a mean root length of 2.44cm and a 53% rooting.



Key: B1- Bottom, with 0.11%IBA, B3- Bottom with 0.33%IBA, B5- Bottom with 0.50%IBA, BC- Bottom control, M1- Medium with 0.11%IBA, M3- Medium with 0.33%IBA, M5- Medium with 0.50%IBA, MC- Medium control, T1- Top with 0.11%IBA, T3- Top with 0.33%IBA, T5- Top with 0.50%IBA, TC- Top control

Figure 4.2 Average Root Length (cm) Measured from Cuttings of *Melia volkensii* Obtained from Different Sections of the Stem and Treated with Different Hormone Concentrations in Week 27.

Cuttings of the bottom section treated with 0.11% IBA (B1) had the least success in rooting with only 37% rooting success (Table 4.10) and 1.31cm mean root length (Figure 4.2). The cuttings collected from the medium section did not grow any roots as they had already dried up by week 21.

Rooting occurred successfully in cuttings from top section and treated with 0.5% IBA (T5) and untreated (TC). There was a significant difference between T5 and TC in week 27, showing a 93 % and 32% rooting success in the cuttings respectively (Table 4.10). The mean root length for cuttings from the top section treated with 0.5% IBA (T5) and

untreated top section (TC) were 3.89cm and 0.27cm (Figure 4.2) respectively suggesting a big influence by the rooting hormone on this section of the cutting.

Table 4.10 Effect of Hormone (IBA) Application on Rooting Percentage of *M. volkensii* Cuttings Obtained From Different Section of the Stem in Vegetative Propagation Experiment.

Cutting treatment	Duration in Weeks				
	18	21	24	27	SED
	Rooting (%)	Rooting (%)	Rooting (%)	Rooting (%)	
TC	24	27	30	32	2.75
T5	37	55	73	93	18.50
B1	22	27	31	37	4.75
B3	30	43	57	73	14.25
BC	20	32	43	53	11.00
B5	25	30	40	45	7.50
SED	4.8	8.9	12.9	18.3	

P< 0.05. Key: TC-Top section control, T5- Top section with 0.5% IBA, B1- Bottom section with 0.11IBA, B3- Bottom section with 0.33IBA, B5- Bottom section with 0.50IBA, BC- Bottom control, SED- standard error deviation

Rooting started earlier in the eighteenth week with the Top section treated with 0.5% IBA (T5) and the Bottom section treated with 0.33% IBA (B3) having the rooting success of 37% and 30% respectively compared to the controls which had 24% and 20% for Top section untreated (TC) and Bottom section untreated (BC) respectively.

Analysis of variance revealed that treatment subjected to the cuttings from the different stem sections affected the number of leaf growth at 0.05% level of significance ($P< 0.001$). Table 4.8 and 4.9 and Figure 4.1; show the mean number of leaf growth of the three classes on *Melia volkensii* cuttings in all the treatments during the 27 weeks of the experiment.

Presence of leaves on a cutting helps to promote rooting. Leaves produce sugars to provide energy for physiological processes that go on within the plant. Energy is necessary for root formation. It takes a lot of energy for the plant to produce new roots. Growth of leaves shows the ability of the cutting to transpire without the cutting drying. Sugars and carbohydrates in the phloem of woody plants are also used to drive the process of rooting. Carbohydrates are utilized as the energy source necessary for rooting especially in harder to root species (Haissig, 1986).

Wound root develop only after the cutting has been removed from stock plant and are a natural response to the healing process that occur at the base of the cutting. Cuttings usually produce suberin. This is a cork like material produced by cuttings as a first response to wounding. Its function is to prevent the wound from easy access of pathogens into the plant and prevent the wound from drying. The availability of water explains the continuous growth of leaves in all the cuttings in the first 9 weeks.

After suberization, cells behind the suberin layer start to divide in formation of wound periderm (differentiation). This one is related to the ability of each cutting. The loss of leaves between week 9 and week 15 (Figure 4.1) is the response of the cuttings ability to

survive without roots. Root formation at this stage is determined by the wound response where normal cells divide though they were not destined to become roots. The different hormone concentration applied to each cutting assisted in growth of new leaves in the bottom and top section.

Cells generally located near the vascular cambium divide and differentiate into root initials. The different ability and response of cuttings sections together with aid of the different rooting hormone concentration on the cuttings for cells to develop into other type of organs like root initials is reflected through the survival of the cutting through growth of the different number of leaves that grew in each cutting between week 15 and week 27. This concurs with what Kijkar (1992) explains that the part of the donor tree where the cuttings are collected determine the rate of rooting. Location of plant parts that are used as cuttings is related to biological and not chronological age. Cuttings derived from the bottom section that is, up to one meter above the ground show greater rooting success because of the build up and storage of carbohydrate at this region (Wongmanee *et al.*, 1989).

In *Melia volkensii*, roots do not form immediately cuttings are taken but there is growth of callus first. Callus is formed at the base of cuttings and is basically a loose layer of cells where the roots form. Callus is produced at the site of wounding when a cutting is placed in rooting media. It often takes on the appearance of fluffy, white blobs of cells at the base of cuttings and resemble tumor like growth. This was observed between week 12 and 18. Roots originate from the callus itself. As explained by Souza and Nascimento,

(1984) this tends to be a characteristic found in difficult to root species of plants such as woody plants like *Melia volkensii* and the rose flower.

Plate 1: *M. volkensii* Rooted Cutting With Grown shoots ready to be harvested for Rooting

There was a slight significant difference in the root length on week 27 between the cuttings of the bottom section B1, B5 and BC irrespective of the hormone concentration (Table 4.11). The use of 0.5% IBA hormone in the top section (T5) showed a high significant difference at 5% significance level ($p<0.001$) against the control. The rooting success of the two was 93% and 32% respectively. The results concur with those of Kajonsrichon *et al.*, (1995) who found that increasing auxin concentration leads to increase in the number of roots. They also found out that shoot tips gave longer root length.

This research study has shown that vegetative propagation of *Melia volkensii* is possible. Cuttings should be obtained from the bottom section of the trees and 0.3% IBA rooting hormone should be used. Cuttings cannot be obtained directly by felling the plus trees. A few trees with good qualities like straight boles, high seed production and are resistant to pests and diseases, can be selected and used to make a multiplication area, which is sometimes referred to as "hedge orchards" or "scion orchards". A scion or hedge orchard could be set up for establishment of an industrial scale plantation (Plate 1). This consists of rooted cuttings of coppicing shoots from selected plus trees out planted in rows. The trees can be clearly identified and the shoots harvested monthly. Shoots collected at least 1 meter above the ground level show a high rooting rate and could be used for rooting exercise. This will create a better breeding program. Shoots collected higher than the 1meter do not root well, even if a root hormone is applied (Wongmanee *et al.*, 1989, Kijkar, 1992). This agrees with the results observed in all the cuttings in the medium section, which did not root irrespective of the different hormone concentration applied to them. Pong-anant (1989) and Wongmanee *et al.* (1989) suggest that though some clones are high performing, their cutting may root poorly. Such clones should be removed from the multiplication area and only those that have at least 70% rooting rate should be kept.

Rooting hormone is beneficial in propagation of *Melia volkensii* through stem cuttings. It is important to note that even without using hormones, some rooting still took place. Since most farmers are not able to afford the rooting hormone, they can make scion orchards of some few trees and cut the trees leaving stumps of 20-30 cm heights, which they can use to get their cuttings. This will be a better alternative to farmers who have been planting root suckers which sprout after injuries made to mother trees (Teel, 1984).

4.3. Experiment 3: Seedling Quality and Grading of *Melia volkensii.*

4.3.1. Seedling Height (cm) of *Melia volkensii*

Height of *M. volkensii* seedlings taken over six-week duration in Nuu division, Mwingi district are presented in Table 4.11. The seedling height for the first three weeks of the experiment in all the treatments was almost the same. Watering with 2.5 litres, showed a significant difference in week 3 against the other treatments with a mean height of 7.1 cm and the others had a mean heights of 8.4cm, 8.0cm and 8.9cm for 5litres, 10 litres and control respectively.

In week 4, there was no significant difference between the normal watering (control) and treatment with 10 litres of water four times in a week, (alternating). The mean height of seedlings was 11.6cm and 11.3 respectively. However in the fifth week, seedlings watered with 10 litres grew faster to a height of 15.1cm against the control (13.6cm). The same trend continued to week 6 where the mean height was 19.3cm and 15.6cm respectively.

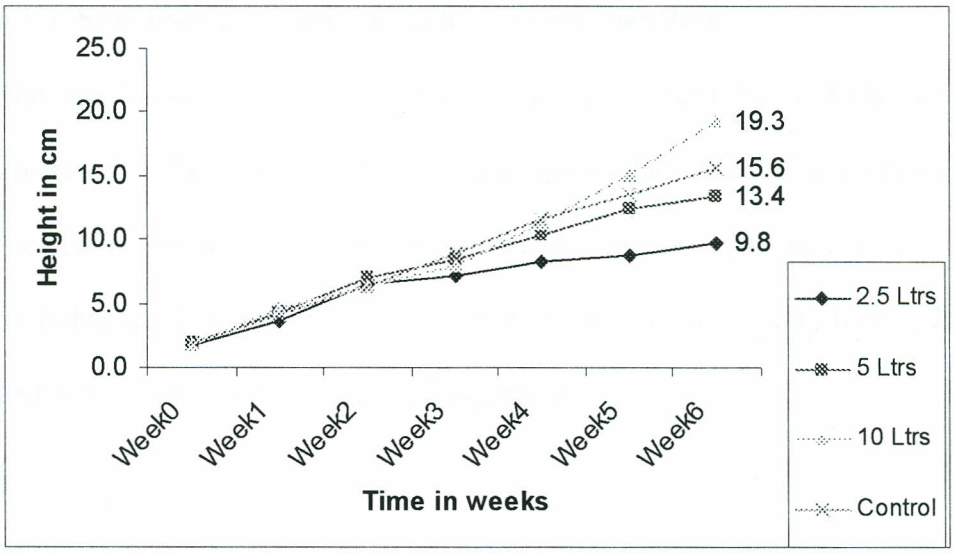


Figure4.3 Average Height of *M. volkensii* Seedlings Measured after Being Treated With Different Watering Regimes for Six Weeks in Nuu Nursery, Mwingi District

4.3.2. **Root Collar Diameter of *Melia volkensii* Seedlings.**

Table 4.11 shows that, in week one there was no significant difference in growth of the root collar, however in the second week there was a significance difference between 2.5 litres watering regime and 5.0 litres, 10 litres and control. In week six, using 10 litres had the highest root collar diameter (3.34 cm) while 2.5 litres treatment had the lowest root collar diameter of 1.38cm. There was a significant difference in treatments with control having a root collar diameter of 2.44cm while watering with 10 litres had 3.34cm root collar diameter.

Table 4.11 Average Root Collar Diameter (cm) of *M volkensii* Seedlings Measured After Being Treated With Different Watering Regimes for Six Weeks in Nuu nursery, Mwingi District.

Treatment	Week0	Week1	Week2	Week3	Week4	Week5	Week6	SED
2.5 litres	0.19	0.42	0.78	0.82	1.04	1.18	1.38	0.019
5 litres	0.21	0.51	0.83	1.05	1.33	1.65	1.86	0.017
10 litres	0.19	0.54	0.78	1.11	1.83	2.69	3.34	0.018
Control	0.21	0.49	0.77	1.00	1.66	2.07	2.44	0.017
SED	0.01	0.02	0.02	0.02	0.02	0.02	0.02	

SED- standard error deviation

4.3.3. **Sturdiness Quotient of *Melia volkensii* Seedlings**.

The sturdiness quotient (the ratio of height of seedling to root collar diameter) is presented in Table 4.12. In the first four weeks there was no significant difference in the root collar diameter in all the treatments. At week 6 watering with 10 litres produced a desirable sturdiness quotient of 5.7. The sturdiness quotient of control, 2.5litres watering and 5.0 litres had 6.3, 7.1 and 7.2 respectively

Table 4.12 Ratio of the Average Seedling Height Against the Average Root Collar Diameter (Sturdiness Quotient) of *M. volkensii* Seedling Measured in Nuu Nursery, Mwingi district

Treatment	Week0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	SED
2.5 litres	8.9	8.6	8.3	8.6	8.0	7.5	7.1	0.002
5 litres	9.0	8.6	8.4	8.0	7.7	7.6	7.2	0.003
10 litres	9.5	8.5	8.2	7.2	6.2	5.6	5.7	0.001
Control	9.5	8.6	8.3	8.9	7.0	6.6	6.3	0.004
SED	0.002	0.001	0.001	0.003	0.001	0.001	0.006	

SED- standard error deviation

4.3.4. **Shoot: Root Ratio of *Melia volkensii* Seedlings.**

Figure 4.4 shows the root length under various water treatments in week six. Highest root length of (20.6cm) was recorded in seedlings that received 10 litres of water on alternate days. Application of 2.5 litres of water recorded the least (6.3cm) root length though this was still significant.

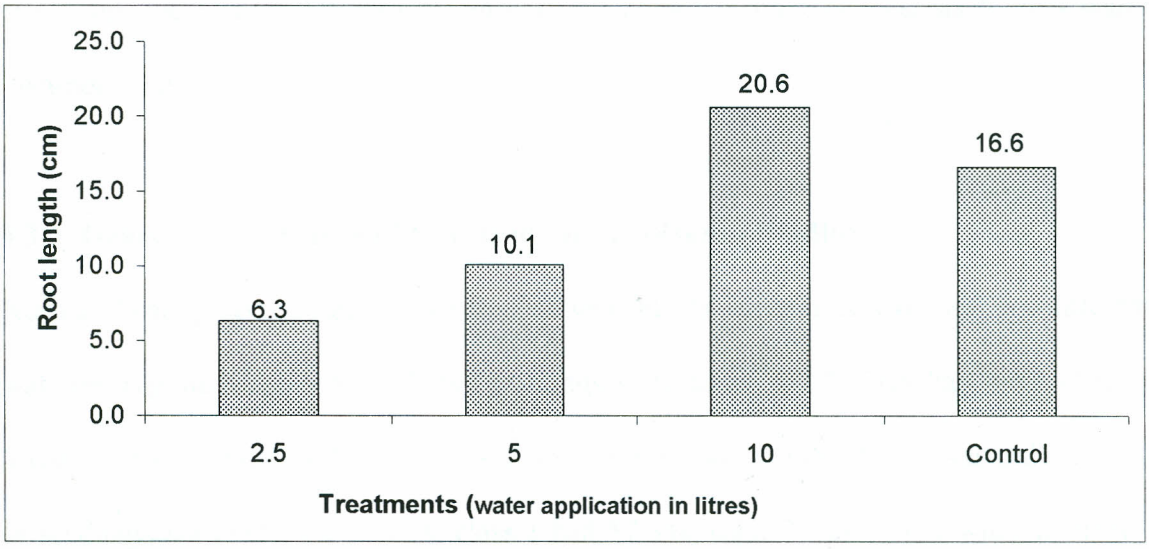


Figure 4.4 Average Root Length (cm) of *M. volkensii* Seedlings at the End of the Sixth Week under the Different Treatments in Nuu Nursery, Mwingi District.

There was a highly significant difference between the treatments (Figure 4.4). Root length in 10 litres of water was 20.6 cm, which was significantly different from the

control, 2.5, and 5 litres, which had root length of 6.3cm, 10.1cm and 16.6cm respectively

Table 4.13 Shoot: Root Length Ratio of *M volkensii* Seedlings Subjected to Different Watering Regimes in Nuu Nursery, Mwingi District.

Treatment	Shoot: Root ratio
2.5 litres	1: 1.9
5.0 litres	1: 1.3
10 litres	1: 0.9
Control	1: 0.9
SED	0.2

SED- standard error deviation

Analysis of variance revealed that different treatments subjected to seedling affected the root to shoot ratio. Table 4.13 shows 2.5 litres water treatment gave a significant difference in the shoot: root ratio compared to others. The highest ratio was 1.9 (2.5 litres) and the lowest 0.9 obtained in both 10 litres and control whereas 5 litres water treatment had 1.3 ratios.

4.3.5. **General Appearance of Leaves in *Melia volkensii* Seedlings**

Normal healthy green leaves were observed in the seedlings exposed to different watering regimes. Table 4.14 shows seedlings watered with 2.5 litres had most of their leaves in class 1 with 66.8%, in class 2 only 19.6%, while in class 3 it was only 13.7%. In seedlings watered with 5 litres, class 1 had 57.3%; class 2 had 37.4% while in class 3 it was only 5.3%. Seedlings watered with 10 litres had most of their leaves in class 3 with an average percent of 79.7%; very few seedlings were in class 2 and class 3 with each class having a percentage of 13.4 and 6.9. Normal watering (control) had most of their

leaves in class 2 with 64.6% where as leaves in class 1 and class 2 had 13.2% and 2.2% respectively.

Table4.14 General Appearance (Yellowing) of Leaves of *M.volkensii* Seedlings for the Different Watering Regime in the Sixth Week Just Before Planting Out

Treatment	Mode	Class	Frequency	%	Cumulative %
2.5 litres	1	1	181	66.8	66.8
	1	2	53	19.6	86.3
	1	3	37	13.7	100
5 litres	1	1	161	57.3	57.3
	1	2	105	37.4	94.7
	1	3	15	5.3	100
10 litres	3	1	20	6.9	6.9
	3	2	39	13.4	20.3
	3	3	231	79.7	100
Control	2	1	38	13.2	13.2
	2	2	186	64.6	77.8
	2	3	64	2.2	100

Discussion

The most desirable qualities in assessing seedlings are not easily accessible e.g. the rooting system in assessing seedlings quality, thus height, root collar diameter, root length and the general appearance of leaves are used. The seedling height is one parameter used to determine quality of seedlings. Palzer (2002) explains that the best seedling height to be used for transplant is 15 to 40 cm. The results show that watering with 10 litres four times in a week on alternative days is the best. However, seedlings obtained from watering with 2.5 litres and 5 litres could also be used but should be planted in more favorable sites or where watering is possible (Figure 4.4).

Palzer (2002) suggest that for better survival of seedlings in the harsh environment, the root collar diameter should be at least 2cm. The seedling should have sturdy stems and a

well-developed fibrous root system. This will help make a better initial growth than small seedlings (Gilmore, 1976, Blair and Cech, 1974). The nursery stock size classes of Ontario Ministry of Natural Resources (2001) recommend that the root collar diameter for hardwood species in small, medium and large classes to be 1.3cm, 2.0cm and 2.8cm respectively. In this research experiment, watering with 10 litres gave a root collar diameter of 3.36cm that was quite desirable. Dey and Parker (1997) explain that the root collar diameter provides an integrated measure of the growth potential of planting stock because of its strong relationship with shoot and root characteristics associated with field performance. Ease of measurement and significant, positive correlation of stem diameter with root system size also make root collar diameter an operationally attractive morphological feature for use as a nursery-grading criterion.

The desirable sturdiness quotient obtained after watering with 10 litres of water is attributed to the better growth after alternate watering rather than in the continuous daily watering in the control. Continuous watering did not give the seedlings enough time to take up the water from the soil hence slow growth. It could easily lead to the post emergence damping-off disease at the root collar. In 2.5 and 5.0litre watering regimes, they did not give a desirable sturdiness quotient because the water was inadequate for the seedlings. In both the treatments the sturdiness quotient was more than 6, hence undesirable. Measurement of sturdiness quotient is less rigorous but is non destructive and can therefore be monitored through out the growth of the seedling in the nursery. The ratio is used to measure the seedling quality (Dickson *et al.*, 1960).

The shoot: root ratio is an important measure for seedling survival. It relates the transpiring area (shoot) to the water absorbing area (roots). According to (Jaenicke, 1999, Palzer, 2002) a healthy plant is one with 1:1 or 1: 2 shoot: root ratio. The results indicate that all seedlings are healthy for planting with the least watered (2.5 litres) showing the best ratio. These could be incorrect in that it potrays that it is the most desirable plant while the expected should be the 10 litres water treatment which did not have a high shoot to root ratio. The results can be explained by the fact that watering seedlings with 2.5 litres of water was inadequate and thus roots grew longer in such for water, this was also observed in the seedlings watered with 5 litres. The results concur with May (1938) who observed that the best quality stock is that which has a relatively small shoot and large root system. Lack of growth in the root system with seedlings watered with 10 litres and the control is due to the availability of water on the upper part of the seedling. The balance between shoot and root is of importance to survival of seedling because an elongated seedling has a transpiring surface out of proportion to the absorbing capacity of the roots. Seedlings with short roots could be used in areas where moisture contents is high like near the rivers while those with long root length could be used in drier areas.

The results revealed that seedlings with healthy green leaves were in 10 litres watering regime with a frequency of 79.9% in class 3 category that is over 70 % of leaves in each seedling were green while those of 2.5 litres had most of the unhealthy leaves with 66.8% in class 1 category that is only 30% of the leaves in a seedling were green.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 **Conclusions**

The results of this research study showed seed purity percent of 77.36%. This was low as compared to the international standard. Pure seeds are those with a purity percent of 90 percent and over. The seeds from big nuts were also not easily damaged during the extraction when using the device from KEFRI.

The results of germination tests like germination percentage, germination energy, energy period and germination value subjected to seeds of *Melia volkensii* for the different pretreatments both in the laboratory and the nursery revealed that nicking followed by soaking in 10% sulphuric acid for 10 minutes gave the best germination results (treatment III) of 53.33%. Using combined techniques of nicking and soaking, improved germination by two times as compared to seeds soaked in 10% sulphuric acid for 10 minutes which gave a germination percent of 26.67%.

The average viability of seeds in all the pretreatments was 66.69% in the laboratory and 63.81% in the nursery. The nursery results could be predicted from the laboratory results because the correlation between the two sets of results was found to be 99.85%. The results are useful in that germination tests will be done to few seeds and the results will form the basis of the quality of seeds required in the nursery.

In vegetative propagation experiment of *M. volkensii* cuttings from the bottom section treated with 0.33%IBA had a rooting percentage of 73. It also revealed cuttings from the

top section treated with 0.5IBA had a rooting percentage of 93. In conclusion use of vegetative propagation technique is the best from this research study

Watering using 10 litres of water four times a week gave the best quality of seedlings. Watering on alternate days is the best as continuous watering makes seedlings susceptible to damping-off.

5.2 **Recommendations on Enhancing Propagation of *Melia volkensii***

The following recommendations can be made based on this research study:

1. The seed collecting organization (KEFRI) ought to further improve the processing of the seeds. Proper training on the use of the cracking device should be expanded to the staffs of the Forest department. In order to avoid a lot of impurities in the seed lots, use of sieves with different size perforators could be used to sift out impurities such as small pieces of nuts and damaged seeds.
2. Big seeds with four or more seeds inside should be used rather than small seeds that easily get damaged during extraction.
3. It is also recommended that during pretreatment seeds should be nicked then soaked in 10 percent sulphuric acid for 10 minutes, the seeds should then be washed thoroughly in running water for ten minutes then soaked for 24 hours before sowing.
4. To maintain viability it is recommended that during seed collection farmers should deliver the seeds as early as possible to the nursery stores. This will ensure viability of the seeds is maintained as the stores have better aeration and

temperatures are controlled. Farmers can also be trained on how best to store seeds in their homes before delivering them to the nursery.

5. When rooting cuttings it is recommended to obtain cuttings from the bottom section and treat them with 0.3IBA. Cuttings from the bottom section are the best as they have shown ability to root even without the use of the rooting hormone. Individual farmers can set up "scion orchads" easily for mass production of cuttings. Farmers can also be trained in application of rooting hormone
6. From the study, it is recommended to use 10 litres of water for watering seedlings on alternate days. Frequency of watering should be dictated by the local weather conditions. For example, on a rainy day no watering is needed. Alternate watering leads to better growth than daily watering for these species of ASALS.
7. To allow rapid growth of fibrous roots, a nylon sheet should be laid down on the nursery bed before placing the pots so that the roots can grow on the nylon sheet. This will help avoid root pruning and ensure roots are present during planting. Availability of mass root when planting out contributes to the survival of the seedlings in the field where more roots allow more water absorption.
8. In any nursery, there are always poor quality seedlings and would have a low chance of survival if planted out. The separation of these seedlings from high quality seedling is referred to as culling or grading. It is thus recommended, best quality seedling to be planted on most difficult sites. Grading should be based on shoot characteristics (seedlings height, RCD and general appearance of leaves) that can rapidly be assessed by even relatively untrained labor

5.3 **Recommendation for Further Research on *Melia volkensii* Propagation.**

1. Trials could be done on soaking seeds for shorter period or use of acid of less concentration could be applied.
2. Mechanical scarification by use of rotating drums can be tried in order to assist in opening up of the hard nut without causing damage to the embryos so as to save time.
3. Seed quality currently being used is from people's farms. Grafting trials from known plus trees should be tried so as to get seeds of known quality within a shorter period.
4. "Scion orchards" could be set up and act as a demonstration plots for farmers in Nuu division, Mwingi district. Use of different rooting hormone concentration on the cutting from the bottom section could also be tried in order to achieve over 90 percent rooting. Farmers could also consult in case of problems. The shoots from these cuttings could be used in establishing plantations in the Government gazetted hills of Nuu division. This will also help to achieve the overall national objective of increasing tree cover, soil rejuvenation and soil stabilization.
5. Cuttings should be obtained from these "Scion orchards" and trials made on different rooting hormone concentration. Grafting trials should also be tried from plus trees so as to get seed orchards of known mother origin.
6. Use of these cuttings by farmers will lead to promotion of farm forestry. Economic benefits from planting of *Melia* include availability of fuel wood, for the overgrowing population. The tree is fast growing with a rotation of 8-10 years. The valuable timber when available will lead to other development.

M. volkensii is an agroforestry tree species in that it can be intercropped with agricultural crops. Trial plots of different spacing should be tried to check which spacing is best for best growth of trees and crops.

7. Seedling growth depends on the soil properties and compositions. More trials should be done, with different types of potting substrates or different type of potting materials so as to see their effect on growth of their seedlings.

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APPENDICES

APPENDIX 7.1 Germination test sheet

Germination Test Sheet (extracted from Paul 1972

es	M volkensii								
	Nick, soak for	30 min	in 10%	H2SO4					
ot No.	298-016/05	Place	Lab						
	29-Mar-06	Ger %	53.33						
leted	18-Apr-06								
after sowing	Sub	Samples	(3 X 15 seeds)	DT	CT	CT %	MDG %	DGS	no.of counts
	1	2	3						
	0	0	0	0	0	0.00	0.00	0.00	
	0	0	0	0	0	0.00	0.00	0.00	
	2	2	2	6	6	13.33	1.67	1.67	1
	1	2	2	5	11	24.44	2.72	4.38	2
	0	1	1	2	13	28.89	2.89	7.27	3
	1	0	1	2	15	33.33	3.03	10.30	4
	1	0	0	1	16	35.56	2.96	13.26	5
	1	1	0	2	18	40.00	3.08	16.34	6
	1	1	0	2	20	44.44	3.17	19.52	7
	0	0	1	1	21	46.67	3.11	22.63	8
	1	0	0	1	22	48.89	3.06	25.68	9
	0	0	0	0	22	48.89	2.88	28.56	10
	1	0	1	2	24	53.33	2.96	31.52	11
	0	0	0	0	24	53.33	2.81	34.33	12
	0	0	0	0	24	53.33	2.67	37.00	13
	0	0	0	0	24	53.33	2.54	39.54	14
	9	7	8	24					
st	2	3	1	6	30				
viability						66.67			
/alue		210.9							

APPENDIX 7.2 Variation (Analysis of variance) of germination of *M volkensii* seeds obtained from the Laboratory results to predict Nursery results.

Source of variation	d f	S S	M S	F
Block	2	2.14	1.07	32
Treatment	6	113.66	18.94	
Error	12	7.2	0.6	
Total	20	123	5.85	

$P<0.01$

$1- R^2 = 1- (0.924)^2$

$=1-0.853$

$=100-.15$

$=99.85$

APPENDIX 7.3 Lay out of the Treatments for Cuttings in Vegetative Propagation Experiment

Replicate 1	Replicate 2	Replicate 3
Bottom control (BC)	Top with 3% NAA(T3)	Middle with 1%NAA (M1)
Middle with 1%NAA (M1)	Middle with 1%NAA (M1)	Middle with 5%NAA (M1)
Bottom with 1% NAA(B1)	Top with 1% NAA(T1)	Top with 3% NAA(T3)
Top control (TC)	Bottom with 5% NAA(B5)	Bottom with 3% NAA(B3)
Middle control (MC)	Bottom with 1% NAA(B1)	Top with 1% NAA(T1)
Bottom with 1% NAA(B1)	Bottom with 3% NAA(B3)	Bottom with 5% NAA(B5)
Middle with 5%NAA (M5)	Top control (TC)	Top control (TC)
Middle with 3 %NAA(M3)	Middle with 3%NAA (M3)	Bottom with 1% NAA(B1)
Top with 5% NAA(T5)	Bottom control (BC)	Middle with 3%NAA (M3)
Top with 1% NAA(T1)	Middle control (MC)	Top with 5% NAA(T5)
Top with 3% NAA(T3)	Top with 5% NAA(T5)	Bottom control (BC)
Bottom with 5% NAA(B5)	Middle with 5%NAA (M5)	Middle control (MC)

APPENDIX 7.4. Germination Test Sheet (Extracted from Paul 1972)

Germination table of Different pretreatments on *M volkensii* seeds in the laboratory

Pretreatment	Replicate1	Replicate 2	Replicate 3	totals	Mean percentage	SED
I	13.33	13.33	6.67	33.33	11.11	
II	40	26.67	33.33	100	33.33	
III	60	46.67	53.33	160	53.33	
IV	6.67	13.33	13.33	33.33	11.11	
V	13.33	13.33	13.33	39.99	13.33	
VI	33.33	26.67	20	80	26.67	
VII	6.67	13.33	0	20	6.67	
	173.33	153.33	139.99	466.65	155.55	2.79
SED					4.37	

ANOVA Table

S of var	**df**	**S S**	**M S**	**F**
Blocks	2	81	40.5	30
Treatments	6	5037.99	839.67	
Error	12	333.52	27.79	
Totals	20	5452.51		

APPENDIX 7.5. Vegetative Propagation Result Sheet

Sample No.	Treatment	Week	Replicate	Length of leaves a	b	c	Root length cm
1	T5	27	1	19	17	16	4.1
2	T5	27	1	17	15	14	3.7
3	T5	27	1	21	19	16	4.4
4	T5	27	1	19	16	13	3.9
5	T5	27	1	24	19	14	4.7
1	T5	27	2	17	15	14	3.8
2	T5	27	2	21	14	11	4.3
3	T5	27	2	20	14	12	4
4	T5	27	2	18	12	10	3.7
5	T5	27	2	22	16	12	4.2
1	T5	27	3	16	15	12	3.5
2	T5	27	3	16	14	10	3.4
3	T5	27	3	15	12	11	3.2
4	T5	27	3	17	14	11	3.7
5	T5	27	3	18	10	9	3.8

APPENDIX 7.6. Map of Kenya Highlighting Mwingi District.