Perception, Management and Usage of *Melia volkensii* by Farmers. A Case Study from the Kibwezi District, Kenya

by

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CONTENTS

ABBREVIATIONS

ACTS	- African Centre for Technology Studies
ACIAR	- Australian Centre of Agricultural Research
AFRENA	- Agroforestry Research Network for Africa
AMREF	- African Medical & Research Foundation
CARE	- Co-operative American Relief Everywhere
CGIAR	- Consultative Group on International Research
CIKARD	- Centre for Indigenous Knowledge for Agriculture & Rural Development
GTZ	- Deutsche Gesellschaft für Technische Zusammenarbeit
ICRAF	- International Centre for Research in Agroforestry
IIED	- International Institute for Environmental Development
IIRI	Institute of Rural Reconstruction
IITA	- International Institute for Tropical Agriculture
IITE	- International Institute for Training and Education
JICA	- Japanese International Co-operation Agency
KARI	- Kenya Agriculture Research Institute
KEFRI	- Kenya Forestry Research Institute
KENGO	- Kenya Energy Non Governmental Organisation
NMK	- National Museum of Kenya
ODI	- Overseas Development Institute
OFI	- Oxford Forestry Institute
OUP	- Oxford University Press
PANESA	- Pasture Network for Eastern & Southern Africa
SIDA	- Swedish International Development Authority

Abstract

Although the efficient propagation of *M. volkensii* from seed and cuttings is the scientific dilemma, this study found that the farmers in Kibwezi and other areas continue to successfully grow and manage the tree to meet their needs. The management of *M. volkensii* which had developed around Kibwezi was basic and could be improved upon to develop a means of integrating the tree more successfully into an agroforestry system.

This study showed that irrespective of farmers' knowledge, the management of *M. volkensii* was determined by the changing needs of the farmer. The fact that the tree was retained in the shamba was not due to any perceived benefit to the soil stability, soil fertility or the stability of crop yields. The main advantage of the tree being in the shamba was having the tree itself, because it is valuable species. Within the shamba the tree could be protected from goats, although it was most frequently fenced. Farmers believe that the tree grew 'better' when it was managed in the shamba and so continued to maintain the tree amongst the crops despite the 'shading' effect *M. volkensii* has on adjacent crops.

At the end of the dry season, during September/ October, many of the trees were severely lopped for fodder. It is possible that the trees' drought resistance and the infrequency of the defoliation was the reason that the trees survived such drastic treatment while under 'environmental stress'. Where fodder was not such a crucial requirement the trees were pruned later and the canopy was thinned for the subsequent annual crops.

From this study it was not possible to discern a difference in the growth rates of *M. volkensii* under different management regimes, when grown on different soils or in different climatic conditions. It can not however be concluded that these variables have no effect on tree growth, it is just that the complex relationships obscure any trends in this data set. The research trials showed that the tree has wide variability of growth rates under the same management and conditions. The farmers perceived the growth rates of *M. volkensii* on stony volcanic soils to be 'somehow slower' than that of trees on sandy clay soils.

This study also showed that the farmers had no perceptions or knowledge of how their management system could affect the trees overall productivity or rotation period. The farmers' knowledge of the trees management only appeared to be passed on within the family or to close neighbours. The uses of *M. volkensii* products were found to be various, and characteristic of a subsistence system where nothing goes to waste.

CHAPTER 1: INTRODUCTION

1.1 Kenya

The Kenyan development strategy emphasises the need to address the problems of the country's extensive semi-arid regions (Mohammed, Scott & Steeghs, 1985). As the population has increased, the land pressure in areas of high potential production has resulted in migration to the drier regions. Kenya's most deprived populations live in semi-arid areas. In these regions about 80 % of the population are involved in subsistence agriculture and pastoralism. It is within these agricultural systems that livestock production assumes great importance, not just as a protein source and a means of stable income, but also as a means of draught power and transport (Buck, 1980).

1.2 Forestry

The importance of trees in farming systems is of high priority within Kenya. The Kenya Forestry Master Plan (1994) emphasised that fast tree growth in areas of high or medium potential production made tree growing a feasible use of agricultural land. Tree planting is problematic, however, in arid or semi-arid areas where ecological constraints are paramount, and livestock fodder is mainly provided by the natural vegetation. Trees can best be incorporated into farming systems where little or no competition occurs with the agricultural crops, or where the competition is compensated for by soil improvements and protection (Kenya Forestry Master Plan, 1994).

Kenya is not short of research and community extension regarding the use of trees in both reafforestation and agroforestry. KEFRI (Kenya Forestry Research Institute) has an extensive training, seed collection and extension programme. KENGO (Kenya Energy Non Governmental Organisation) is the leading non-governmental organisation (NGO) with regards to tree planting, and is the umbrella group for 140 NGOs and community groups involved with agroforestry and fuel wood activities (Kenya Forestry Master Plan, 1994).

The responsibility for tree planting within Kenya primarily lies with governmental bodies, such as the Ministry of the Environment and Natural Resources, the Ministry of Agriculture and the Ministry of Energy and Regional Development. This is supported by the President's Commission on Soil, the Environmental Secretariat and the Ministry of Culture and Social Service. Finally the responsibility for tree planting is addressed by the research institutes (ICRAF), the NGOs and the community groups they are working with (Mohammed et al., 1985).

1.3 Agroforestry

The concept of agroforestry as a productive system and as a scientific discipline emerged at the beginning of the 1980s. Agroforestry is the integrated use of woody perennials in agricultural systems. Trees are planted and managed to stabilise cropping systems and to provide services or products without undue competition with annual crops. In rural areas trees are planted on grass bunds (ridges) at the edge of terraces, on the boundaries between farms, between different crops and within the actual cropping area (ICRAF, 1993).

Many of the techniques, such as alley cropping, fodder banks and boundary planting, were initially developed in western Africa. The marginal lands and semi-arid areas lacked the same attention and research, however agroforestry extension in Kenya has resulted in the mass awareness of the importance of integrated landuse. The process of extension has integrated indigenous and derived knowledge within communities and has provided a system whereby research can be disseminated to the small scale farmers in rural areas. Local co-operation fosters the attitudes and skills required to determine the needs of the community and possible modes of action to provide for those needs (Kaudia, 1990).

ICRAF is just one of the institutes involved with the research and extension of agroforestry techniques within Kenya. With its headquarters in Nairobi, ICRAF is involved with widespread research and 'on farm' work within Kenya. The use of economically important indigenous dryland species, such as *Melia volkensii*, in the application of agroforestry is limited by several factors. The two main problems have been the lack of technical information and the limited collaboration between individual governmental departments and other organisations and institutes (Kaudia, 1990). The dissemination of information from the research bodies to the farmers is improving as extension becomes more widespread but there is still a need for a better understanding of the farmers knowledge, management and perceptions of the indigenous species.

CHAPTER 2: *MELIA VOLKENSII*

2.1 Distribution

M. volkensii is indigenous to semi-arid East Africa and occurs across Ethiopia, Somalia, Tanzania and Kenya. In Kenya, it is found in the Northern Frontier Province, the Masai district, and the Machakos district (Flora of Tropical East Africa, 1990). The Machakos district has recently been divided and the subdivisions include the Kitui and Kibwezi districts. Within the tribal 'Kikamba' region *M. volkensii* is known as 'mukau'. Although *M. volkensii* is generally a low altitude species it has been found growing at 1350 m (4,429 feet) in the Samburu district, and it has been successfully planted at 1660 m (5,446 feet) on the ICRAF Field Station at Machakos.

2.2 Environment

M. volkensii is very drought resistant. It generally thrives on well drained soils from sandy loams to sandy clays, but is intolerant of heavy clays (Stewart & Blomley, 1994) and black cotton soils (pers. comm. Milimo). It is naturally found along water courses and in Acacia - Commiphora woodland.

2.3 Ecology

As a valuable dryland, dry season fodder tree, *M. volkensii* is conspicuously green in dry regions (ICRAF, 1992). The tree grows to around 20 m in height, and the crown often has a browse line produced by giraffe (Flora of Tropical

East Africa, 1990). The bark is pale grey and fairly smooth (ICRAF, 1992) although pronounced vertical fissures develop with age (Flora of Tropical East Africa, 1990). The leaves are bright green and compound. The leaflets are lance-shaped, tapering towards the apex and up to 4 cm long, with a slightly serrated margin. All young shoots are densely hairy (Noad & Birnie, 1989).

The flowers are small, white, fragrant and in loose sprays which are up to 12 cm long (Noad et al, 1989). They occur on auxiliary and older branchlets. The drupe is green, oval and 3 - 4 cm long (ICRAF, 1992), turning yellowish green when ripe (Milimo, 1986). The fruit clusters are conspicuous on bare branches and are eaten by wild animals and goats (Noad et al, 1989); there are also used to fatten cattle with no ill effect (Mwangi & Rembold, 1986). The endocarp is very thick and bony with a star-like 5-lobed apical depression and rose-like 5-lobed basal depression. The drupes tend to have only two fertile locules (Flora of Tropical East Africa, 1990).

2.4 Propagation

The germination of the seeds is problematic as there are several stages of dormancy (Milimo, 1989). Root suckers and wild seedlings (wildings) are the simplest and most effective methods of propagation (ICRAF, 1992).

2.5 Products and Uses

The fruits and leaves of *M. volkensii*, as already mentioned, are used as dry season fodder for cattle and goats. Traditional hollow log bee hives are made from the wood and the bees use the tree's flowers as forage. The leaves can act as a mulch and the tree can also be used for soil reclamation and to control soil erosion (ICRAF, 1992). The mature timber is pale reddish brown and resembles mahogany. It is a valuable hard timber and construction wood. As it is strong, durable and resistant to termite (white ant) attack, the mature wood is valued locally for a variety of uses (Noad et al, 1989). Medicinal uses have been reported. A small amount of the liquid from the boiled bark is said to cure aches and pains. Such medicine can be poisonous in overdose (Kokwaro, 1993).

CHAPTER 3: AIMS

There is very little literature regarding *M. volkensii* and the vast majority of it pertains to the chemical composition of the foliage or the problems of germination and propagation.

The purpose of the study was to gather indigenous information regarding *M. volkensii*. It was also important to gain an understanding of the farmers' use and management of *M. volkensii* and their perceptions of its effect within the cropping system.

It is hoped that the results of the study will be a start in filling a gap in the literature and be of use to those working with small-scale farmers, and to farmers themselves, in the rural areas of semi-arid Kenya.

CHAPTER 4: STUDY LOCATION

4.1 Machakos District

The Machakos district has a bimodal climate which ranges from the drier sub-humid to the semi-arid zone. The rainfall is highly unpredictable and varies between years. Most of the agricultural land is between 1200 - 1300 m with two growing seasons, each greater than 90 days. The natural vegetation is Acacia - Combretum woodlands. The soils are predominantly alfisols. Gully erosion of the mid-slopes is a severe problem and sheet erosion is widespread. The farming is mixed pastoralism and subsistence cropping. There are no major cash crops grown in the area and family incomes are based on the sale of produce or livestock and off-farm earnings (Warner, 1993).

The Machakos district is one of East Africa's exceptions in that it is a highly populated region yet fails to receive 750 mm rainfall in four of every five years (Morgan, 1972). Machakos district has a potential productivity which is much greater than is presently realised. The problem for the farmer is the conflict between growing crops with low reliable yields or with high yields but an uncertain harvest. This has led to the planting of low yielding, drought resistant crops in the areas affected by persistent famine (Morgan, 1972).

The Katumani Dryland Agroforestry Research Station, Machakos is at an altitude of 1660 m, 1° 33' S latitude and 37° 14' E longitude. The station is situated seven miles south of Machakos town at Katumani (Rao, 1990). The mean annual rainfall is 760 mm bimodally, of which 300 - 350 mm occurs each season. The precipitation recorded for 1963 of 1370 mm and 1987 of 370 mm highlight the high variability of yearly rainfall. Two crops of short duration are possible each year as the evaporative demand tends to be around 1800 mm.

4.2 Kibwezi

Kibwezi is a small township, with a population of less than 1,000, situated north of the Nairobi - Mombasa road. In the last few years the area was made into a separate administration district, in that a section of the southern part of the Machakos district became the Kibwezi district. The Kibwezi meteorological station is located at an altitude of 915 m and has recorded a long term mean annual temperature of 24 ° (degrees centigrade). The evaporative demand recorded was 2094 mm, with a bimodal precipitation of 641 mm annually. This is indicative of the region's mean annual rainfall of between 600 and 700 mm (Tiffin, Mortimore & Gichuki, 1994). The probability of getting less than 2/3 of the evaporative demand in a growing season is 77 % in the long rains (March/ May) and 60 % in the short rains (November/ January) (Toubler, 1983).

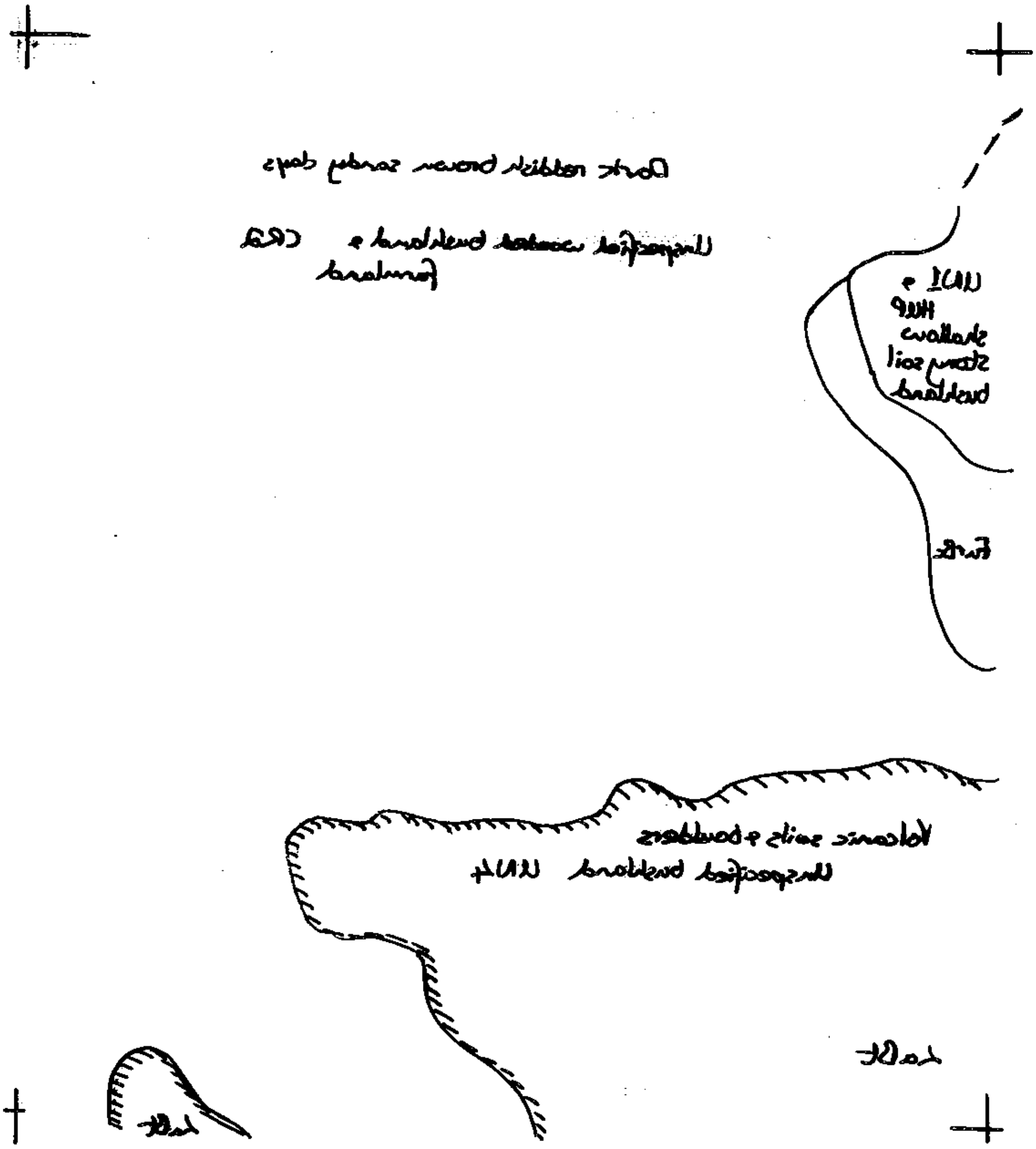
The southern Machakos district (Salama, through Kibwezi, to Mitio Andei) is estimated to have an average of 13 sheep and 45 goats per household, and cropping systems consist of maize and pigeon pea, beans, cow pea or green gram. Small farms are considered to be 0 - 9.9 ha, medium farms from 10 - 19.9 hectares, while large farms are greater than 20 hectares. The constraints on agricultural production are drought, capital, livestock disease, plant pests and disease, the poor infrastructure and a lack of extension work (Mukhebi & Gitunu, 1988).

The soils of the study area are divide into three distinct types. 1) The majority of the area is on well drained Ferral-chromic luvisols, which consist of moderately deep dark red to dark-reddish brown friable to firm sandy clays or clays. 2) The area generally south and west of the town has been affected by volcanic lava and is excessively drained, exceedingly stony to bouldery rock land with infills of humic soil material (Fig Ia, LaBt). 3) To the west the area is bordered by the Mbui Nzau hills where the soils of the lower mid-slopes are Acri-rhodic ferralsols. These soils are also well drained, very deep dark reddish-brown friable sandy clays to clays (Fig Ia, FurBc). The whole area has a moderate to high risk of erosion (Toubler, 1983).

The vegetation of the area is generally unspecified bush land and farmland (Fig Ia, CR2). The area is bordered by unspecified wooded bushland thicket and dense wooded bushland to the south and west of Kibwezi town (Fig Ia, UN4). The vegetation of the upper slopes of the Mbui Nzau hills to the west of the area is unspecified bushland and wooded bushland of *Themeda triandra, Digitaria* *macroblephora* (10 - 40 %) and grasses with Combretum species, *Ginidia latifolia*, *Acacia senegal* and other trees and shrub (Toubler, 1983).

4.3 Kitui

Kitui town is the principal town of the Kitui district which is situated east of the Machakos district. There is a KEFRI training centre in the town, and a nursery at Tiva from which re-afforestation and community projects are based and *M. volkensii* is propagated. At the Tiva nursery the annual precipitation fluctuates between 500 and 900 mm (bimodally) and evapotranspiration tends to greatly exceed 2000 mm yr^{-1} (Mulatya & Takahashi, 1992). The surrounding area perpetually struggles under droughted conditions and crops such as sorghum are reported to fail every third or fourth season.


Dark reddish brown sandy clays
Unspecified wooded bushland & CR2 farmland
UN1 & HUP shallow stony soil bushland
Volcanic soils & boulders
Unspecified bushland UN4
Rock
Rock

KIBWEZI

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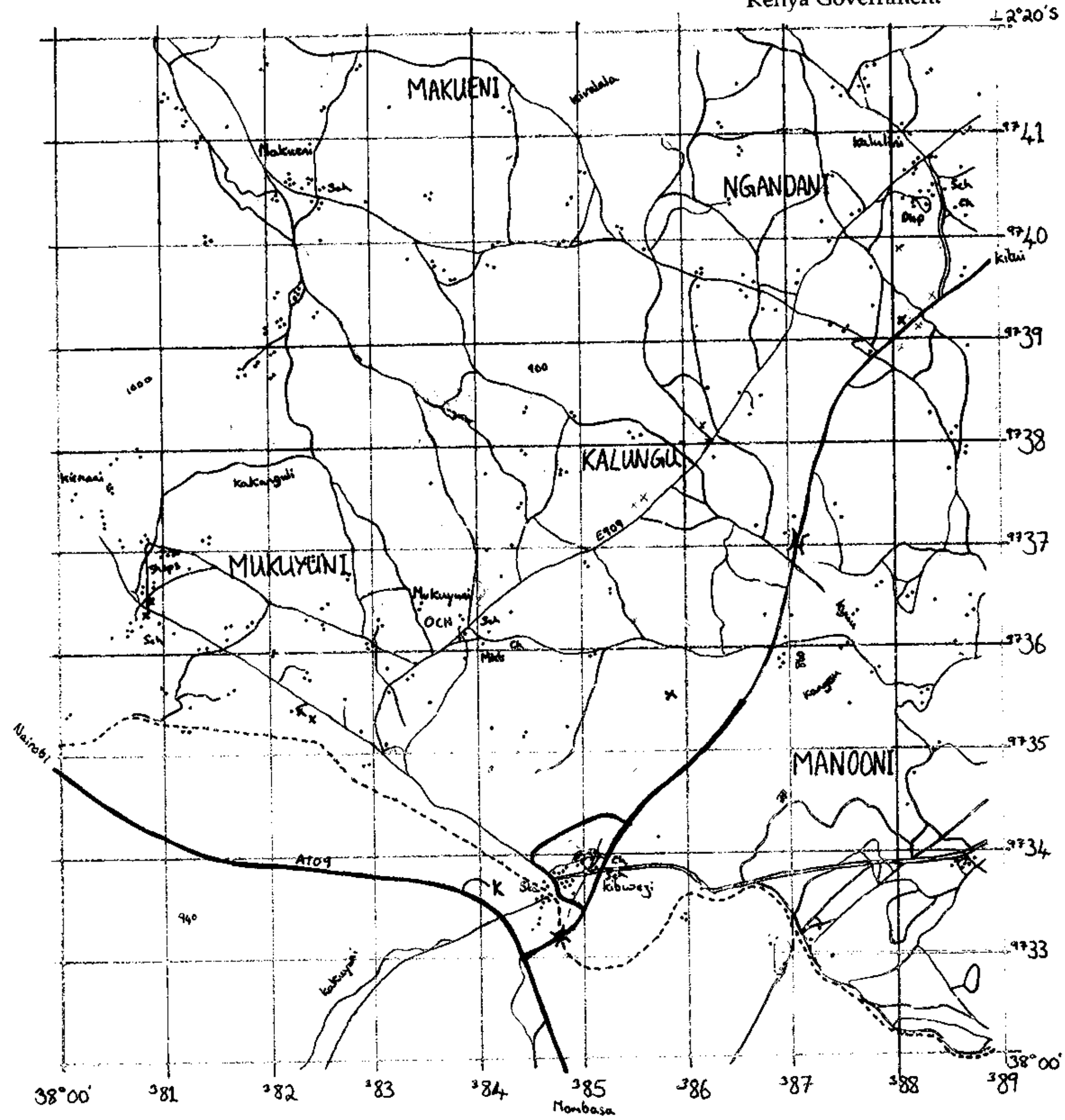


All weather road tarmac
unsurfaced
Dry weather road
Footpaths
Railway
River
Contours (hundreds)
(twenties)

MKT market
Disp dispensary
OCH old court house
K KEFRI
Ch church
Sch school
Sta station

Farmers; Mukau planted
Mukau retained
Non-grower
Farmers group

CHAPTER 5: METHODOLOGY

5.1 Approach

5.1.1 Rapid Rural appraisal

Over the last few decades the realisation of the importance of farmers in the process of scientific research and the development of innovations has led to an increase in field work and the evolution of many different and interrelated techniques, each with their own benefits and problems. For the purpose of this study, a 'bottom up' survey with high levels of farmer participation was preferred. Some aspects of the exhaustive Farmer Systems Research (FSR) seemed ideal although the use of a multidisciplinary team was not an option (McCracken, Petty & Conway, 1988).

Rapid Rural Appraisal (RRA) was developed after FSR to provide a quicker and more accurate analysis of farming systems and avoids the use of formal interviews to obtain data from farmers and key informants by using semi-structured interviews. Rapid Rural Appraisal is frequently used in agroforestry research and emphasises the relevance, accuracy and timeliness above the quantity of information collected (Scoones & Thompson, 1994) . This approach involves the use of a wide range of techniques such as seasonal calendars, group discussions, transect walks and farmer generated flow diagrams and systems charts.

With limited time available for field work, it was decided to conduct this survey based on Rapid Rural Appraisal (RRA) techniques in order to obtain an overview of the area and the agricultural system and relevant issues. The final techniques used in the field were not as varied as originally planned. The hybrid of methods used here works for an initial survey and the topics covered were determined by the farmers perception of relevant issues.

Initially a few weeks were spent in Machakos, as *M. volkensii* had recently been introduced in 'on farm' trials, and at Kitui in order to observe some of the propagation techniques and KEFRI's comprehensive extension scheme. The main study time was spent in the Kibwezi area, however.

The key area of Kibwezi was carefully sampled although as with RRA the 'statistical' requirements were not often adhered to; the triangulation of data was used instead. Triangulation is the verification of data collected through observations, secondary data and the farmer interviews. Unlike FSR, RRA considers the use of qualitative descriptions and diagrams to be of importance. The underlying philosophy is to achieve 'optimal ignorance' by investigating key processes and properties relevant to the objectives while ignoring irrelevant aspects and unnecessary detail (McCracken et al, 1988).

Topical RRAs are undertaken to answer specific questions (McCracken et al, 1988). In this study, the objective was to consider the effect of farmer perceptions on the management of *Melia volkensii* within their cropping systems. As farming systems are complex and dynamic, due to the interaction of ecological and socio-economic processes (McCracken et al, 1988 & Stewart et al, 1994) this study of *M. volkensii* with regards to the farming system touched on a wide range of issues.

5.1.2 Qualitative Research

Qualitative data are often disregarded by scientists due to problems such as the lack of control over interviewer bias, compared with the rigid control provided by the inflexible structure of quantitative formal interviews. However, the strengths of the more flexible approach could be argued to outweigh, if not negate, the problems. Qualitative data collection enables the study of the specific attitudes, beliefs and perceptions of small groups or individuals, the aim being to acquire in-depth interviews and observations of a cross-section of the population of interest in the (limited) available time (Casley & Kumar, 1988).

5.2 Field Work

In order to work in the field and collaborate with the various institutes and community groups who had previously any work with *M. volkensii*, it was necessary to obtain permission and assistance from a wide range of people.

Having obtained permission to contact the field staff of several of these institutes, it was obligatory to obtain permission to work with farmers from local officials and village elders.

5.2.1 Interviews

It had been hoped to conduct initial group interviews as a means of introducing myself and sharing my reasons for wishing to interview farmers. An overall view of the local agricultural community and their farming systems needed to be obtained as the context in which *M. volkensii* is grown and managed. Introductory group interviews did not happen due to difficulties of organisation in the field. Two group interviews were undertaken, one was a group of farmers who had set up their own commercial tree nursery, and the other was a local co-operative of carvers. Both meetings were set up arranged by the KEFRI extension worker.

Once it had been decided to interview around 40 individual farmers, due to the time limitation of the field work, they were selected with some degree of randomisation! The randomisation involved whether the farmers were in and willing to spend some time talking about *M. volkensii* when their shamba (for the purposes of this study 'cultivated land') was visited. Some effort was made to ensure the age range, educational range and wealth brackets of farmers in the area were represented, although obtaining this type of data was problematic and to some degree relied on the observations of individual household situations.

At least five non-growers (non-adopters) of *M. volkensii* were included in the survey in order to ascertain some of the reasons for not retaining (adopting) or planting the tree and to add to the overview of the farming system obtained from growers.

A formal interview was produced to ensure that the questions were relevant to the information required to meet the project aims (Appendix I). The questions were carefully checked with the field assistant to ensure that the meaning was clear and that the questions did not lead to specific 'expected' answers.

Having studied several questionnaires and surveys used by ICRAF and having tested the interview in Kitui, it was decided, because of the time constraints, to use the interview as the basis for semi-structured individual interviews. Semi-structured interviews allowed new lines of enquiry to arise naturally from the farmers perspective (Martin, 1995) and incorporated new questions inspired by previous interviews in the community. The decision was reinforced, while undertaking the trial interviews in Kitui, by the fact that farmers were much more forthcoming with information during informal conversations in their fields than when the questionnaire was formally adhered to. The visits to the "on farm" trials in Machakos and the farmers in Kitui acted as a dry run for working with the field assistant/ interpreter and ensured familiarity with the interview questions, technique and the field situation.

The confidentiality of the interview setting was an important consideration in obtaining the confidence of the respondent. Some respondents seemed unsure or uncomfortable and had difficulty articulating their opinions and perceptions to the interviewer, and in these cases recording body language proved useful. In two cases where the women farmers had friends present during the semi-structured interview all appearances to help the 'mzungu' were made but payment was expected for any information. This only happened in these isolated cases and was put down to peer pressure.

The possibility of whether the respondent's knowledge was firsthand, and whether they were in a position to give accurate information had to be considered. The credibility of field answers was assessed with hindsight, by looking at the entire interview and the knowledge displayed and for secondary corroboration, in order to ascertain whether the answers were considered, perceptive, boastful or excessively authoritative (Casley et al, 1988).

There is an argument for assuming that farmer estimates of produce, or dates of planting and of ages are fairly accurate (Poate, 1988). It would be difficult to accept that a subsistence farmer would be unaware of the harvest output of crops which was key to his survival. This method depends on a consistent unit of harvest output, which is problematic when useable products such as fodder or firewood are consumed within the household. A standard sack of charcoal or maize would be 90 kg, which is not so problematic.

With regards to planting dates and tree ages a couple of farmers could not admit that they were not sure of their trees age, in an attempt to be helpful they stated several dates and ages. This problem was infrequent and contrasted with farmers who had recorded the day a tree was planted or calculated the date in relation some family event. With no means of verifying this data it had to be assumed that the farmers were correct, and every effort was made to ensure inflated or conveniently rounded figures or dates were acknowledged and if possible clarified.

By keeping a log of interviews, body language and my personal impressions, attitudes, frustrations, insights and the problem of biases could be frequently reviewed. By updating the record daily, the direction of the next set of interviews could be rectified to prevent problems or omissions continuing once they had been recognised.

Ideally the field assistant should have been involved and proved in previous survey situations (Casley & Lury, 1981). Due to unforeseen circumstances this was not possible. The interpreter and field assistant used had however previously worked for ICRAF, and being from the southern Machakos area was familiar with the customary language and respect due to the elders amongst the Kamba in Kibwezi. My field assistant was personable, diligent and quickly gained the trust of both young and more senior farmers alike, which was vital for the purpose of the study.

5.2.2 Field walks

Direct observation enabled a visual corroboration of data obtained in the semi-structured interviews. In theory this should be used as a second opportunity to discuss issues with the farmer, and clear up any queries resulting from an initial assessment of the interview. However, in most cases the farmers wished to go round the shamba directly after the interview. Walking in the farmer's field enabled an overview of the area and the cropping system to be obtained.

5.2.3 Tree Measurements

The *M. volkensii* on each shamba was recorded by way of various measurements. Height was defined as the vertical distance to the highest growing point of the tree (Stewart & Salazor, 1992). A clinometer was used to measure the angle between the base and the top of each tree, at least 20 m from the base of the tree.

The slope of the ground had to be taken into account to minimise the errors. The height of each tree was then obtained using trigonometric calculations.

The diameter at breast height (dbh) is a standard measurement which is taken at a vertical height of 130 cm as an indication of productivity. For bushy multi-stemmed or multi-purpose trees the basal diameter at 10 cm is more useful. The Oxford Forestry Institute (OFI) recommend the measurement of all stems at 30 cm, for multi-stemmed trees, to give a very accurate measure of biomass accumulation (Stewart et al, 1992). As *M. volkensii* has a very regular bole, unlike *Acacia bussei* (Stewart et al, 1992), the crown diameter was not necessary as an indicator of biomass. As the branches of *M. volkensii* are often lopped for fodder and firewood, the crown diameter would have been a problematic and an inaccurate measurement. The crown diameter of unpruned trees was of interest, however, when considering the area of shade that affected the neighbouring crops.

The tree measurements of specimens at the various research sites were taken, as the age and management processes had been documented and it was hoped the contrast of productivity with trees grown on farmers shambas in Kibwezi would be valuable.

5.2.4 Calendars

Calendars and schematic diagrams can be useful in that they visually represent some of the important issues of the cropping system (McCracken et al, 1988). The production of cropping and labour calendars for the agricultural systems in Kibwezi was undertaken in order to provide a clear representation of the system as a whole. This background was essential for the understanding of how *M. volkensii* and its management fits into the farmer's timing and work load.

5.2.5 Mapping

The location of each farmers shamba was mapped to provide an idea of altitude, and position with relation to the other farmers interviewed within the area. Careful mapping enabled the use of secondary data such as soil maps and vegetational maps when analysing the data for possible trends. The resulting map was based on the Kibwezi 1: 50,000 map (Fig I & Ia).

5.2.6 Secondary data.

The use of secondary sources was important in corroborating data obtained in the field, although a consideration of the credibility of secondary sources was also necessary (Casley et al, 1981). Over the last decade there have been several studies regarding the propagation of *M. volkensii*. There is also some work that has been done on the different provenances (germplasm from different localities) and on woodlots at different altitudes, which unfortunately has never been published. There has also been little published on farmer knowledge and management. Contacting extension workers involved with past studies produced some valuable insights and information. Such independent additional information could then be used to check possible survey bias and to refine survey estimates (Casley et al, 1981).

5.3 Analysis

Had the formal survey been adhered to, the results could have been statistically analysed using the computer SPSS package. Very few of the farmers answered the same set of questions due to the nature of semi-structured interviews, due to their limited available time, and other factors. As a result statistical analysis has not been undertaken here due to the amount of 'missing' data. The use of percentages has been employed to indicate the number of farmers of the relevant subset who clarified or specified a given point.

The longhand analysis of the survey data is presented in the following chapters but can not be claimed to be complete as undoubtedly more data would generate new insights (Ely, 1991) into the farmers management and perceptions of *M. volkensii*. The analysis is a comparison of farmer perceptions grouped around management aims and practices. Initially it was hoped that differing management practices would be reflected in the productivity and knowledge of the tree. As no clear trend emerged, no further attempt was made to define different models.

5.4 Limitations

During the course of this study every effort was made to check and recheck the validity of the information being assimilated.

Some problems were encountered during the field work which could have been overcome or avoided with a greater availability of time. Working in the field was only possible with the support and co-operation of field workers from various organisations. The fact that I had to prioritise my time could not be expected to influence their schedules. Although offers were made to organise group meetings with contact farmers and women's groups these did not materialise in the time available.

The benefit of semi-structured interviews is that they can be more flexible to the farmers time limitations. As September is a busy month when land preparation and construction projects are undertaken several farmers could not spare us much time and so interviews had to be brief. To this end the 'structure' of the interviews had to be prioritised. Although all farmers were asked about the management and use of products from the tree a decreasing proportion covered the remaining topics.

In general the structure of the discussions was reasons for adopting *M. volkensii* followed by management practices, timing and the related underlying reasons. The tree/ crop interaction and the trees effect on the environment was often followed by the mention of minority products. Most discussions with farmers started with some inquiries about their family and shamba and ended with the farmers perception of problems on the shamba and possible solutions and the differences in their management of the shamba compared with their parents.

The openness of the farmer, the time they were willing to spend with us and their confidence to direct the conversation to topics that they perceived as relevant all reduced the limitations of the chosen approach of this study. As the 'progressive' and 'open' farmers were not necessarily contacted at the beginning of the study further time in the field would have enabled some of the areas they highlighted to be followed up with other farmers.

The limitation of the field measurements is that they only provide an indication of what was found in the field. It is not possible to assume that the accumulative effect of the variable processes such as management, rainfall, evaporative demand and pests has been similar on any given group of *M. volkensii*. It can be said that all these factors are partly responsible for the noise in the tree data collected (Appendix II). Finally, the wide variation seen in the measurements of the 'ten year old' trees affects any average trend lines plotted and has been assumed to be the result of farmers using the figure 'ten' as a nice round number.

CHAPTER 6: RESULTS AND DISCUSSION

Unless otherwise stated the following findings are the result of the semi-structured farmer interviews and field measurements of this study. Percentages have been attached to data to demonstrate the relative importance of the findings, and relates to the farmers with *M. volkensii*. Any relevant discussion is then referenced to the current literature.

6.1 Farmers

6.1.1 Interviews

Forty six farmers were interviewed in total, and for the purposes of this study 'farmers' were adults working on the land. Forty of the farmers were adopters of *M. volkensii*, by either planting or retaining the species. Twenty one of the farmers were men and 25 were women. Table 1 shows the split between the genders as well as those who were household heads (HH). All the people interviewed were immediate relatives of the HH, with the exception of a farm manager of a commercial holding. Only three of the women were household heads in their own right, two were widows and the third had a husband who was perpetually drunk. In several cases the women were 'acting household heads' as their husbands or eldest sons had jobs away from the farm. The four of the six daughter-in-laws knew the uses and benefits of *M. volkensii*, but knew nothing regarding its management or effect on the crops.

Table 1: Farmer Status, Gender and 'Age'

Age	HH (male)	Man	HH (female)	Woman	Daughter-in-law
Old	7	-	2	9	-
Unknown	2	3	1	5	-
Young	4	6	-	-	6
				TOTAL	46

The gender split of farmers interviewed was relevant to both the management and the perceptions of *M. volkensii*. The timing of planting and harvesting *M. volkensii* was the responsibility of the HH, with pollarding and pruning assigned to the more agile sons or grandsons. This study found that in general the women were responsible for the annual crops and livestock, as shown in Lewinger Moock & Rhoades (1992). This apparently meant that their actions whether tree seedlings were retained or removed. Where the men folk did not work on the shamba their perceptions of the trees effect on the crop was vague or inconsistent with the field observations.

Some difficulties were encountered when trying to obtain information about the household. The older generation of Kambas do not count girls as part of the family, as they will leave when they marry. Apparently it is considered to be bad luck to tell strangers how many sons your wife, or wives, have blessed you with and a few were loath to exchange names with us.

Education was another conversational pitfall. Grandmothers were fond of relating the academic merits of their many grandchildren, although this often remained uncorroborated. Few of the older generation had attended school past 'primary' according to local teachers and extension workers. The study then found that education did not always equate to a greater knowledge and understanding of the farming system. This was highlighted by one lady who had attended a college in Nairobi and recently married into the area, but was asking for suggestions and explanations as to how to manage the *M. volkensii* in her shamba.

6.1.2 Land and Tree Tenure

In theory, land in the Kibwezi area is individually owned. As yet, some of the farms had not been surveyed and not everyone had a title deed (pers. comm. Robert Kisyala). A couple of the men wished to show their title deeds but on the whole this issue was avoided. In two separate cases a handful of farmers were planting *M. volkensii* (amongst other trees) despite contention over the ownership of the land they were cultivating. The extreme was the 'Kithito cha Kivuthini' group where the commercial sisal plantation were claiming the farmers land. Despite that, and contrary to expectation, the farmers were planting half hectare woodlots on each of 19 shambas.

Table 2: Farmers and Shamba size

	Adopters		
Shamba size (ha)	Planter (15)	Retainer (25)	Non-Adopter (6)
0 - 2.9	-	5 (1)	5 (4)
3 - 9.9	5 (5)	>2 (8)	-. (1)
10 - 19.9	1 (2)	-	1 (1)
> 20	1 (2)	2 (2)	-
Did not know	-. (6)	-. (14)	-

N.B The numbers in brackets relate to the area of land owned, while the other numbers pertain to the area of land cultivated (shamba).

It was found that the difference between owned and cultivated hectarage was the result of a variety of 'on farm' constraints, such as labour, time and seed.

With the limited sample size it was not possible to state categorically that shamba size had any relation as to whether farmers adopted *M. volkensii* in the Kibwezi area, although this was inferred. From Table 2 it can be seen this survey found farmers who planted *M. volkensii* tended to own and cultivate more than 3 hectares. At the other end of the spectrum the semi-structured interviews also found that 'non-adopting' farmers listed limited shamba size as a reason for not planting or retaining timber trees (Chapter 8.3). Action Aid classify the 'very poor' as those who cultivate less than 1.5 ha. This observation could appear to be skewed as the majority of 'non-adopters' interviewed cultivated and owned less than 3 hectares, however the average farm size in the Kibwezi area was 2.8 ha in the mid-1980's (Muhammed et al, 1985) which suggests this finding is fairly representative of the rural community. When the cultivated area was less than 2 hectares no trees of any species were found to be adopted within the shamba.

If the land belonged to the second wife then the household head had to persuade the wife of the value of letting him retain or plant trees. This was the only example of a woman being the decision maker regarding the planting of *M. volkensii*.

M. volkensii has been private property by tradition, due to the value of its timber (Brokensha et al, 1988). In Kibwezi the tree remained the property of the person who had planted it in all cases. Where the tree had been retained it was deemed the property of the household head. In one case (2.5 %) the sale of the timber not for the benefit of the owner but was providing the grandmother's pension. *M. volkensii* growing outside cultivated land remains under the jurisdiction of the forestry department. So *M. volkensii* within the forest bounds can not be felled without written permission from KEFRI. In order to assist forest regeneration written permission is required to graze cattle in the forest while goats are prohibited as they are much less fussy and eat any seedlings around (pers. comm. Mr Kungu).

6.1.3 Agricultural System

In semi-arid areas the agricultural systems used by farmers are very diverse in order to minimise the risk of crop failure (Rowland, 1993). From the RRA and interviews used in this survey the agricultural system of the Kibwezi district was found to be in a dynamic phase. It is only in the last thirty years that education has been widely available to the rural population. As education has become more widespread there has been a variable uptake of 'new' agricultural techniques. In the last ten years, organisations such as CARE, Action Aid and AMREF have been amongst those whose input has added to the work done by various Kenyan authorities around Kibwezi. Additionally, knowledge is continually brought from other areas as women marry into local families and as new families buy land in the area, making the reason for the huge variation within the agricultural system obvious.

The Kambas of the area were not farmers traditionally but pastoralists travelling up to 30 km for grazing and were not as reliant on the land as the present generation. The current generation of Kambas generally have fewer livestock and are subsistence farmers. The older generation, or grandparents, practised shifting cultivation as there was more land available. They generally still used hoes to cultivate the land and planted several types of seeds in the same hole using a digging stick. Those of the younger generations hired tractors in order to plough, if they were of sufficient financial standing. The younger generation also planted crops in single lines, except for on the stony volcanic soils. Various degrees of rotation were employed by younger farmers, although this was dependant on the size of the shamba and their perceptions each crops effect on subsequent yields. Terracing was relatively new in the area and still relatively limited, though most people were aware that soil erosion was a huge problem in the area even if they had not perceived it as a problem on their shamba.

Another recent development was that farmers who had livestock applied manure to the maize, and in a few cases to all crops when there was sufficient manure available. This study that the number of farmers using manure was low and four (10 %) farmers did not see manure as a benefit but a problem as they had perceived an increase in pest problems on their manured maize. McCrown, Keating, Probert and Jones (1992) indicate that the Kambas lack of awareness of the need to preserve soil fertility in the shamba threatens the sustainability of their food production.

An overall agricultural calendar was obtained from in-depth interviews with a two of small farmers and one large-scale farmer (Fig. II). From the semi-structured interviews most farmers intercropped maize with pigeon pea, either as alternate rows or up to three rows of maize to one of pigeon pea. Beans were generally grown as a single crop (or 'sole cropped') as they do not do well if disturbed after flowering. In two cases, the bean sole crop was planted with scattered maize plants. This ensured that the soil was not left unprotected once the beans had been harvested in January and June (Fig. II).

Fig. III Tree Calendar *Melia volkensii*

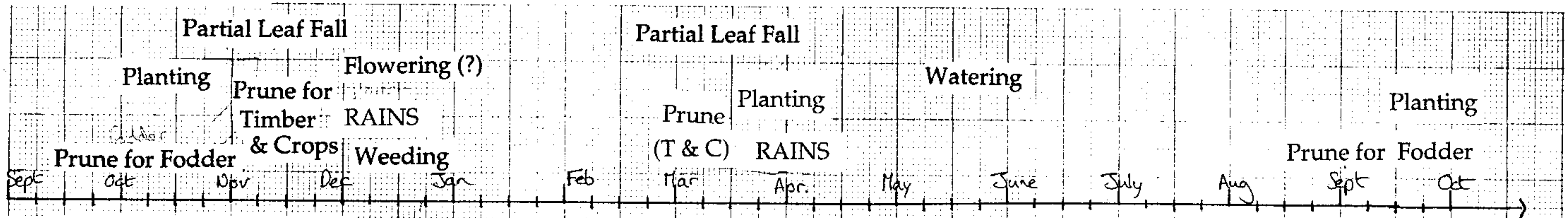
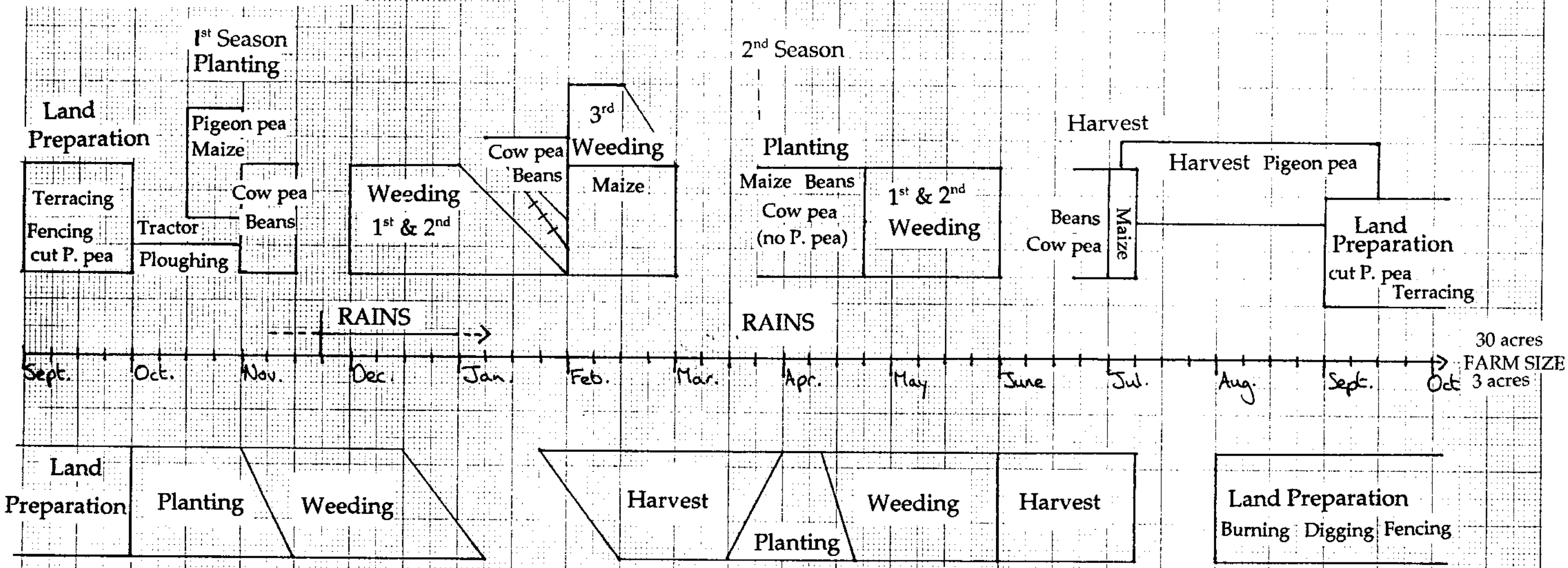


Fig. II Agricultural Calendar



Semi-rotations occur where farmers had insufficient land to ensure that each subsequent crop was different. Maize/ pigeon pea intercrops were followed by maize/ cowpea, or the beans were rotated within a shamba of maize/ cowpea intercrop. While working around Kibwezi it was interesting to note the prevalence of the maize/ pigeon pea intercrop across the area as this agroforestry system allows seasonal crops the benefits of a modified micro-climate (Monteith, Ong & Corlett, 1991).

One farmer planted a maize and bean intercrop on land that had first been ploughed using oxen. Apparently the increased infiltration of precipitation enabled the beans to succeed in the intercrop. In several cases farmers no longer planted millet, despite it having done well on the local soils, because when the children were at school there was nobody to scare the birds away.

6.1.4 Agricultural Constraints

The main agricultural problems in the area were firstly the lack of rains and their infrequency, secondly the soil erosion and the resulting poor fertility, and thirdly the termites. This survey found that farmers frequently placed their agricultural constraints in this order. This could be linked to the fact that some of the farmers felt that the termite problem could be minimised with hard work. Terracing and the application of manure was more difficult to manage for farmers with limited labour and livestock. The biggest problem was that there was nothing that could be done if the rains are insufficient or discontinuous. The only things farmers could do is to ensure that they have planted the crops before the start of the rains, although this is risky.

At the other end of the spectrum, a few farmers on flat areas of sandy soil felt that there were no constraints on their farm. Generally speaking, they had access to nearby water and they could not see the sheet erosion. As they had not farmed the soil for more than fifteen years they were still getting some 'decent' yields. When pressed, one farmer admitted that the rains could be seen as a problem even though there was nothing he could do about them. Apparently, amongst some of the farmers the perception of problems was related to the ability of an individual to overcome that problem.

One of the very poor farmers saw 'time' as the biggest constraint. Due to the time spent searching for food for the family she had no time to prepare the land for the next planting. In this case money was required to buy the seed, which would be difficult as the last ~~goats~~ three goats had already been sold, very probably to cover the school fees for her three boys. Very few of the very poor farmer were willing to discuss farming and the constraints they face as the last two or three seasons have been very harsh. Some of the bigger farmers said that they had managed to harvest 'average' yields, but conditions were so dire in

September 1996 that food handouts were being distributed, especially to the small farmers with larger families around Kibwezi.

Farming on the rocky volcanic soils required planting with a stick and hand weeding. This limited the area cultivated, but yields tended to be good as the soil was comparatively rich. One lady farming on a sizeable 8 acres of volcanic land would be unable to buy a few acres of land of the sandy loam. She perceived her constraint to be the time it took to cultivate the soil. Ultimately finance was the main household constraint as it had prevented them from moving, but once again as she was unable to alter that she felt it did not count.

A couple of larger farmers with over seven acres perceived their biggest constraint to be a lack of finance, with which to employ extra labour and buy tools.

Fig. IV Management for Timber; *Melia volkensii* & hen coop

Fig. V 'Big Shade'; 9 year old tree with a canopy radius of 8 m

6.2 Farmer management of *Melia volkensii*

In general, "farmers around here don't plant ('Mukau'), and are now beginning to realise they have a problem as there are too few mukau and they are sparsely scattered due to the rate of felling for timber over the last few years. The problem is (that mukau) is hard to propagate and the farmers haven't overcome that." KEFRI Extension Worker, Kibwezi.

6.2.1 Propagation

The main problem with *M. volkensii* has always been the propagation process (Milimo, 1986). Action Aid and KEFRI concur that seed collection was not an issue as the tree produces seeds prolifically. The *M. volkensii* seed has a three stage dormancy which can be broken under laboratory conditions with germination rates of around 80 % (Milimo & Hellum, 1989). The problem for farmers remains how to achieve germination, or a means by which to multiply the tree effectively and with some degree of efficiently. Although the tree was perceived to be 'bad' because of the germination problem, that had not prevented some farmers in Kibwezi from trying to solve the problem themselves.

Ten farmers (25 %) were found to have planted *M. volkensii* seed. Five of the forty farmers who had retained or grown *M. volkensii* (12.5 %) had planted many untreated seeds with limited success. Several seeds were planted in one hole, allowing for the "survival of the fittest". One farmer selectively planted the seeds that had cracked naturally, as he felt this increased their chance of germination. Natural cracking of the seed apparently takes two seasons (a year). In the first season the fleshy drupe dries up leaving the hard seed coat which cracks in the second season, due to the dry heat of the environment.

Three farmers (7.5 %) roasted or burnt the seeds in order to speed up the germination process by then removing the seed coat manually. Once the seed coat was removed, germination of the seed took three weeks once planted in a 'nursery'. Two farmers (5 %) carefully removed the seed coat using a panga. No farmers were found split the radicle end of the seed, a method which is successfully employed (ICRAF/ GTZ, 1991) and spread by KEFRI extension workers around Kitui. This would have indicated that contact with extension workers had resulted in an increase or change in the planting of *M. volkensii* around Kibwezi.

One farmer then soaked the black seeds for 'a while' before planting them in a nursery; after three months any that were going to germinate would have done so. The other farmer removed the black seeds and discarded any that had black mould or were chipped, thus selecting the seeds he felt had a good chance of germinating. Four black coated seeds were then planted in each hole, covered, and the straw and weeds on the shamba burnt, prior to crop planting. It was felt this improved the germination rate. Two other farmers (5 %) had noticed that burning weeds on their shamba resulted in the sprouting of *M. volkensii* seedlings, and a passer-by suggested that burning beneath mature trees would initiate the germination of the seeds.

Seven of the farmers (17.5 %) had transplanted seedlings. Three had transplanted seedlings from around *M. volkensii* in the forest, and the rest had been taken from neighbouring shambas. All but one of the seven farmers had also successfully planted seeds. Smaller seedlings transplanted just before the November rains survived better than older seedlings, as confirmed by one farmer who had transplanted seedlings over a foot tall, which became "rather sick" despite careful watering. This could well have been due to root damage. Another farmer had planted thirty or forty seedlings along a raised terrace, and although they had all lost their few leaves in the dry season he was hopeful, due to previous experience, that the seedlings planted before the April rains would revive once the November rains started.

Only two of the fifteen farmers were found to have planted either seeds or seedlings at the time of the April rains. All the other farmers felt that any species of tree seedling should be planted before the November rains when the rains tend to be of a shorter duration, but more substantial.

One farmer, who had retained *M. volkensii,* felt that cut branches could be planted as a means of propagation. As this was not corroborated in the literature and one farmer in Kitui specifically contradicted this by saying "*M. volkensii* fence posts did not sprout like *Commiphora africana*" indicating that this should be regarded with caution.

One farmer (2.5 %) had strenuously weeded *M. volkensii* seedlings out of her shamba. Despite this, several three foot tall seedlings were discovered one year when the pigeon pea stalks were being removed, and so the trees were retained. Another farmer had *M. volkensii* in the shamba where the seeds had fallen and grown. If these farmers knew how to plant *M. volkensii* seeds the majority of them would prefer to plant this timber tree outside the cropping areas.

At present the prolific production of root suckers from plough damaged roots was the most reliable and efficient means farmers had of cloning or propagating *M. volkensii*. Eight farmers (20 %) had root suckers which they were managing, three had unsuccessfully tried to transplant them. Such a low technological practice are important as it increases the opportunities available to farmers who wish to utilise valued indigenous forest species (Leakey in Werner & Müller, 1990). From this study it could be said that it is the local recognition of the value of *M. volkensii* and its ability to fulfil farmers needs that has retained the farmers interest in the propagation of the species (Unruh, 1994) despite the problems this entails.

6.2.2 Watering;

Five (12.5 %) of the farmers who planted seed did so just before the November rains, so there was no need to water them. Of the three farmers (7.5 %) who had transplanted seedlings, one watered them "for a long time", one watered with "one small jerry can a day for five months", while the third farmer's seedlings died "within three days of being watered, so why waste precious water on them?". Watering regimes varied greatly, and comments ranged from 'a little, in the dry season initially', to 'twice a day for the first two months' or 'for three months', to 'three years' and 'for a long time'. Although water was more plentiful than in neighbouring Mbui Nzau, it was reasonable to presume that a farmer's willingness to water tree seedlings would depend on their evaluation of the required products, the availability of both water and time in such a harsh semi-arid environment.

Planting in October meant this drought resistant species had almost ten months before it would undergo severe drought stress without any watering at all. Several of the farmers who had not planted *M. volkensii* stated that only seeds or seedlings that had been planted require watering. This was their way of showing that retaining seedlings or trees, such a *M. volkensii*, made more sense than planting as the tree would require less work.

6.2.3 Weeding

When *M. volkensii* seedlings were retained in the shamba they were weeded with the crops, which was generally twice a season. If the rains were 'good' crops needed to be weeded three times to ensure a decent harvest. Where labour was employed on a larger farm, the lady farmer had sufficient time to weed round tree seedlings more frequently until they were two years old. Thirteen farmers (32.5 %) felt that weeding was important. It would seem that weeded *M. volkensii* grows without <u>any</u> problems. One farmer emphasised this in that a young *M. volkensii* left on his shamba died within the two years after he was evicted, this he attributed to weed competition.

Five female farmers (12.5 %) complained that weeding unwanted seedlings out from around *M. volkensii* trees in the shamba was an ongoing job. Weeding is considered to be a 'woman's job' so it could be argued that the women were instrumental in whether tree seedlings were retained within the shamba. Two farmers stated that they could not distinguish between *M. volkensii* seedlings and another tree species when the seedlings sprout in the goat boma. In both cases the women would have retained *M. volkensii*, but rather than have other trees grow they clean weeded the whole area.

It was also thought that *M. volkensii* seedlings growing outside a cultivated area need to be 'spot weeded' when small, as they were not as competitive as adjacent grasses.

6.2.4 Fencing

Fencing was irrelevant in three cases (7.5 %) where the children were not in school on smallest farms, or someone was employed to herd the livestock on the richer farms, as this prevented goats from browsing on the shamba. On 30 % of the farms young *M. volkensii* seedlings were fenced with thorn branches to prevent goats "disturbing" them. The tree could not "grow so rapidly" and tended to be multi-stemmed if the goats removed the bark and young branches. It was observed that goat-damaged trees with no subsequent management had upwards of 8 thin stems.

Once the trees were older the fencing could be removed. Occasionally during the dry season goats stripped the bark from older *M. volkensii* which recovered once the rains arrive, unless they have been ringed. One farmer smeared cow dung on the damaged areas and surrounding trunk in order to discourage the goats.

One farmer showed the deep scars where goats had removed the tree bark and explained that the "goats mouths (were) somehow poisonous". It would be more likely that the bark was removed from the young tree when it was under severe drought stress, and that the occlusion or closing of the scar would be prolonged. The healing of pruning or browsing damage would be affected by the health of the tree, the size of the wound and the season (Evans, 1992), the longer the wound is open the greater the probability of the tree being affected by disease or insect pests.

On nearly all shambas around Kibwezi thorn branches are used to fence the boundaries. This practice was costly in time and resources being susceptible to fire when the weeds were burnt and has to be repaired or reinforced at least once a year. With this in mind it was understandable that where goats were not grazing loose within the shamba individual trees tended to be left unfenced. In a couple of these cases the goats were tethered until the children returned from school to herd them. One lady stood in the shade with her back against the *M. volkensii* when her goats browsed in the shamba and this way she prevented them damaging her timber tree.

6.2.5 Pruning

Twenty seven farmers (67.5 %) talked about pruning which was the single most important management practice for both retainers and planters. It became apparent that there are two very different types of pruning. Half of those farmers started pruning the young trees once they had reached 1 m, or from

Fig. VI Severe Defoliation for Fodder; firewood drying on the terrace bunds

Fig. VII Root Suckers

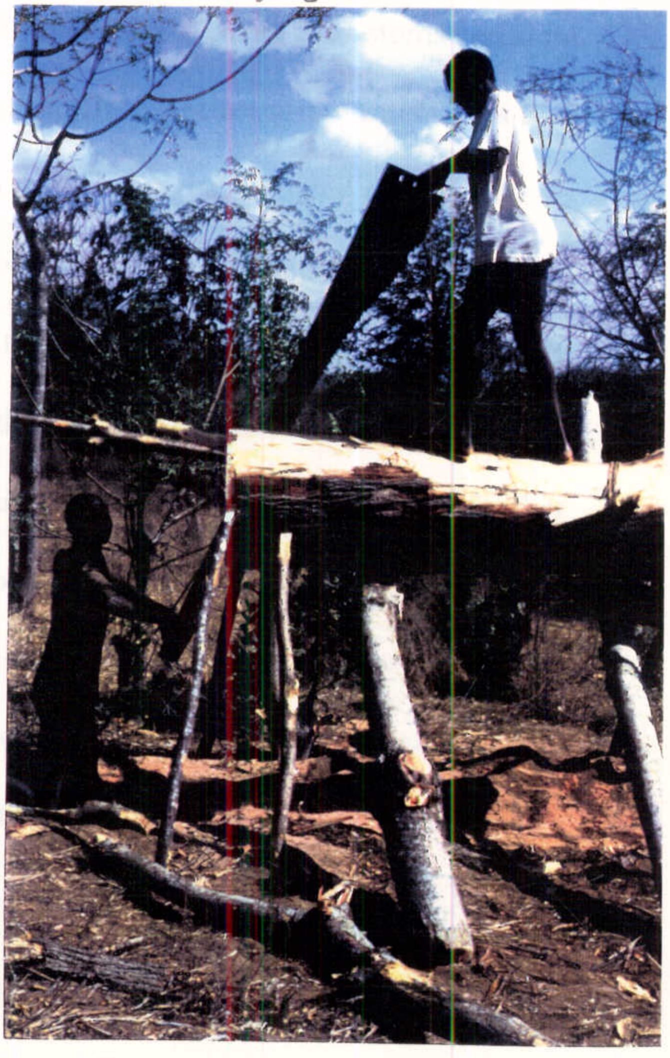


Fig. VIII Harvesting for Timber

around 4 - 6 months. This initial pruning involved nipping the sides shoots from the main stem to ensure a straight stemmed tree. The aim was to obtain a young tree with a maximum of two straight stems, eventually to a height of 5 metres.

Once the tree had been pruned for the first 3 - 5 years the stem would grow straight, the timber would be free of knots and pruning was no longer necessary. Any further pruning was to prevent branches spreading and to control the amount of shade that affected the crops. The second type of pruning was done in April and November at the beginning of the rains.

According to one farmer interviewed "one stem would have 'sufficient nutrients' to grow very tall, but two stems was the best option". Up to four stems could be left if a large amount of short timber was required. From a few interviews and field observations it would seem that 'most experienced farmers' maintained 4 - 8 straight top branches for extra timber production in their attempt to grow the perfect timber tree (Fig. IX). Although the ideotypic *M. volkensii* should have possessed a straight bole to 5 meters, this would make thinning the canopy problematic. In order to make ascending into the canopy easier for further pruning the odd branch stump was left to assist the farmer in his climb (Fig. IV).

In most cases these prunings were an important source of goat fodder and so the pruning occurred throughout September and October when goat browse was

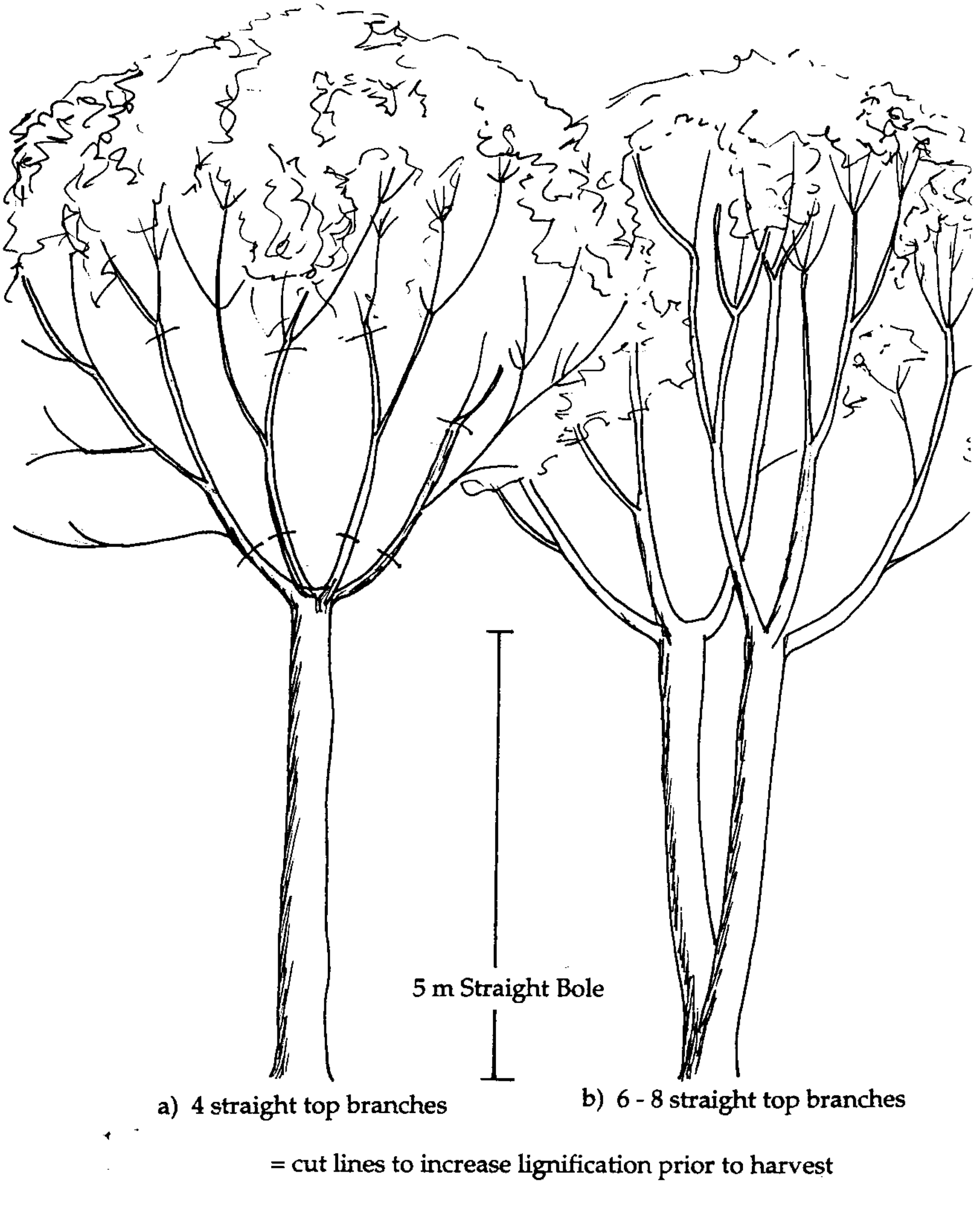


Fig. IX Ideotypic *M. volkensii* Managed for Timber limited. In several cases this pruning was observed to result in severe defoliation (Fig. VI) to meet the demand for fodder. It was claimed that "mukau *(M. volkensii)* (was) not affected by pruning like other trees". This could certainly considered to be true in some part in that these trees have routinely survived such management. If there was no requirement for livestock fodder then the pruning was left until the end of October, just before the main rains.

Pruning would affect the crops as the tree water requirement would be reduced (Ong & Huxley, 1996), altering the balance in favour of the crops. The ability of the tree to recover from severe defoliation would depend on the stem and roots reserves. If the result of pruning was a turnover of root matter then the adjacent crops would benefit from the increased mineralisation of nutrients in the soils. the time and degree of pruning are also relevant.

As an indication that a change in farm management can affect the management of the tree, one farmer was pruning the basal branches of his trees higher in order to get the tractor nearer to the trunk when ploughing. While on three of the larger farms prolific root suckers were the result of tractor plough damage to the roots of *M. volkensii* and farmers were beginning to manage them, by pruning (Fig. VII). Another farmer uprooted any weak or damaged young trees which had led to the production of stronger root suckers. In one case the farmer was planning to prune the root suckers and use them as a fodder bank.

As with any rule there were exceptions, despite pruning being given to be the most, and in some cases the only, necessary management practice four farmers (10 %) had not pruned the *M. volkensii* at all. One of them did not have goats, two did not know that the foliage could be used as fodder and in the final case the household head had forbidden the cutting of the tree, though his wife and son did not know why.

6.2.6 Coppicing

Coppicing, which is commonly used in fodder production, was not a management practice generally used by farmers who grow *M. volkensii*, as their main aim was to obtain a few stems of timber girth. Only two farmers (5 %) used coppicing to produce short rotation small diameter poles. This wood, as with pruned branches, was used for fence poles, making chairs, general construction purposes, for ugali spoons and other utensils that can be carved from the immature wood. The items carved from a three year old tree would bring in 344/= (Kenyan Shillings) (about £4) when sold at the local market. With over fifty trees in a woodlot on such a short rotation, one farmer was certain of the value of his *M. volkensii*.

When larger trees were cut, the stump often resprouted and the many stems produced were strong and could be coppiced for fodder. Three farmers who had retained *M. volkensii* had not fenced the young trees. The result of goat damage was multi-stemmed trees which were too misshapen to produce good timber, but poles were produced and harvested when required. These few, trees and one farmer's line of pollarded *M. volkensii*, were pruned for dry season fodder as the foliage is easily accessible when only three to four metres from the ground. Coppicing of root suckers might lead to the management of fodder banks on farms where tractors have been used (Fig. VII) without affecting the adjacent crops as drastically as farmers perceive timber trees do.

Lopping and coppicing are common practices within agroforestry systems. If *M. volkensii* were not so drought resistant it would be unlikely to tolerate this management system as trees that are subjected to pruning during periods of undue environmental stress tend to exhibit sub-optimal survival and vigour of the remaining stumps (Huxley, 1987).

6.2.7 Harvesting

The reddish mature heart wood was required for timber. The maturation of *M. volkensii* involves the gradual lignification of the white wood into usable red wood timber over a period of up to fifteen years. The heart wood is strong but light, termite resistant and durable. Few farmers harvested the *M. volkensii* at a set age, those who did said it was best to wait until the tree was 10 - 15 years old.

Many farmers preferred to cut the tree when it had reached the required diameter. To ascertain this timing farmers checked the heartwood was the right colour by making two bisecting slices a couple of inches into the main stem. If the tree was ready to be harvested the segment removed should have no more than an inch depth (2.5 cm) of white wood in it, as the amount of immature wood decreases with increased tree age. The white wood was stripped from the felled tree before the timber could be sold. One farmer, whose father was a carpenter and whose family had managed *M. volkensii* for several generations, explained that the rate of lignification of the heart wood could be increased by cutting the top branches to about 2' (60 cm), 6 - 12 months before harvesting the tree. According to two farmers, if the timber was required sooner than that, then the bottom of the trunk could be burnt.

As *M. volkensii* was grown primarily as a timber tree, this study found that there was very little variation in the local thinking regarding the correct harvesting time. It was often stated that a tree of basal diameter of 2 - 3' (over 60 cm) was mature and ready to be cut. If this was the case several farmer's need for timber resulted in harvesting well before that, as six very respectable trees of just over 40 cm basal diameters were 'ready to be felled' on four different shambas. The reverse was also true, on two farms where the current need was not for timber or cash, the *M. volkensii* was being kept for shade, and as insurance against some future need. One of those farmers was away and his mother was unable to cut the tree until he decided it was 'mature' and could be sold for timber, or used to help build a new house.

6.3 Tree / Crop Interaction

The lack of current literature implied that farmers were unaware of any negative effect that the tree had on the crop. Eight farmers (20 %) that the tree had no effect on the surrounding crops. Two of the farms were on volcanic soils and the crops were planted more than four metres away. Two of the farmers were men who admitted that they did not know if the tree affected crops as they "(didn't) have anything to do with the crops" as other people tended their shamba. The remaining four farmers (10 %) had two trees, out of twelve, that were more than six years old. It is possible that the effect of young trees with a much lighter canopy was not obvious to the farmers who were not expecting to see any effect as they all believed that careful pruning would prevent shading.

6.3.1 Perceived Effects

The majority of the farmers (80 %), however, were convinced that the tree had a negative effect on the crops. One farmer (2.5 %), who only managed his tree for timber, stated that it would be impossible to use *M. volkensii* for agroforestry because of the way it shaded the crops. This was contradicted by the actions of two farmers (5 %) discussed later in this section.

It can be seen that the crops near *M. volkensii* are weak and thin, and farmers perceive this to be the result of shading, and the fact that "crops have to look to find the sunlight". Maize was thought to be worst affected by its proximity to *M. volkensii*, followed by pigeon pea. Two farmers (5 %) never plant beans near the tree while other farmers perceived beans to be less affected by the tree than other crops. Not surprisingly, the farmers perceived that there was no effect when the bean crop was young. One farmer felt that cow peas were least affected by *M. volkensii*, but did not know why, and no other farmer mentioned any effect on that crop.

Several of the farmers were aware of the tree affecting all surrounding crops. It would seem probable that the farmers perception is biased towards the visible stunting of the two tall crops, maize and pigeon pea. The effect on the productivity of the crops is unlikely to have been as clear cut as observations of plant stunting might suggest as dry conditions favour greater seed production in pigeon pea (Gibbon & Pain, 1985). As *M. volkensii* accentuates the water limitation of the semi-arid cropping system there might well be a subsequent increase in the pigeon pea production adjacent to the tree.

Only two (5 %) of the farmers in this study, both of whom had planted *M. volkensii*, had experimented with growing different crops in the shade. They had found that shade tolerant 'horticultural' crops such as pepper do well. This might also be because these crops are normally watered, unlike the arable crops. Pepper (*Capsicum annumum*) is no better adapted to lowland tropical conditions than tomato. In order to survive under tropical solar radiation and produce a crop it should be grown in partial shade of 50 - 60 % (Messiaen, 1992) which *M. volkensii* can provide.

Forage grasses and legumes are amongst the crops that suffered least from the competitive effect of shading as the yield is from the vegetative parts (Huxley, 1987). Growing grasses around a timber tree could have a significant effect on the annual stem increment and subsequently on the time to harvest, the effect would be greatest when the tree is younger and less competitive. Many farmers might not wish to pay the price this would involve. The growing of legumes under the tree would require careful consideration. As cow pea is one of the most drought tolerant legumes (Gibbon et al, 1985) it might be possible for this to be successfully grown adjacent to *M. volkensii*.

Where farmers were pruning the tree for timber or fodder, it could be suggested that cassava and sweet potato are planted in the shade. According to the literature there is little yield penalty when the shade is less than 50 % and when there is limited nitrogen and cooler temperatures during storage root initiation (Huxley, 1987). Another way of reducing the risk of crop loss would be to plant low yielding hardy crops such as sorghum and millet instead of maize (Huxley, 1987). In practice this might not be favoured by the farmers as unlike maize, sorghum and millet tend to be affected by birds when in the field and the harvesting time of sorghum is more crucial which does not allow farmers to be flexible in the timing and management of sorghum compared to maize. One problem would be that both sorghum and millet are intolerant of shade (Blomely, 1994).

6.3.2 No Perceived Effect

There is "no (perceived) effect on the crops" when the tree was "pruned properly", so that the canopy was not too dense or spreading, or when the trees were less than 5 years old. The frame of reference was the shade produced by unpruned *M. volkensii* (Fig. V) and other trees. For example, one farmer said that compared with the evergreen, dense and spreading canopy of Mango or *Croton megalocarpus* the sparse canopy of *M. volkensii* did not affect the crops.

In two cases the farmers claimed that maize was not affected by the tree, though observations noted maize less than 1 m tall within 2 m of the tree! Amazingly some of these plants had managed to produce small cobs, which may explain why the farmers felt there was "no effect". In all these cases the frame of reference which the farmer was using resulted in the perception that the crops were unaffected by the tree. In just two cases the farmers seemed to have little knowledge of the tree and might have had so little interest that they had not observed the stunted crops which surrounded the tree.

It was not unexpected that the farmers were apparently unaware of the effect of *M. volkensii* on its micro-climate, other than that of shade.

6.4 Tree / Micro-environment Interactions

6.4.1 Soil

Ten farmers (25 %) made some comment on the effect of *M. volkensii* on the soil. Four of those felt that there was no notable effect, as the soil under the shade of the tree was "not much different" to the soil on the rest of the shamba. They said "once the tree (was) cut the crops do well, as the shade has been removed".

A further three farmers noticed that the soil under the tree was harder than the surrounding soil. Two farmers attributed this to the fact that the tractor could not plough near the tree because of the lowest branches. Hand hoeing was hard work, however, making cultivation near the tree seem relatively more difficult than on the rest of the shamba.

Only two (5 %) of the farmers with *M. volkensii* felt that the leaf fall resulted in soil enrichment, as decomposing leaves enhanced the nutrient status of the surrounding soil. Neither of these farmers allowed goats to browse in their shambas. The fact that goats eat *M. volkensii* leaves whether they fall or are pruned could explain why many farmers have no perception of the tree effecting the soil fertility by way of a leaf mulch.

6.4.2 Water

One farmer (2.5 %) observed that when the tree shed its leaves in April, the young pigeon pea near the line of trees died. The farmer felt that the leaf fall was "burning" the pigeon pea. As *M. volkensii* is deciduous and loses it leaves when subjected to extreme water stress this observation confirmed that there is competition for water between the tree and the adjacent crops which caused the death of young pigeon pea and doubtless affected the yields of other crops. This has been supported by trials at Machakos (ICRAF) which have shown *M. volkensii* to have a very high water uptake when compared with other agroforestry trees and subsequently that the neighbouring crops suffer severe water stress (pers. comm. Chin Ong). The fact that farmers perceived the problem of the agroforestry system to be shade when the evidence proves that the competition for water is the real problem is not unique to *M. volkensii* or Kibwezi (Ong, Corlett, Singh & Black, 1991).

Apart from the effect *M. volkensii* has on the soil, a tree obtains moisture, nutrients and mechanical support from the earth (Evans, 1992). During this study not one single farmer perceived water competition to be a possible effect of the trees proximity to the crops. It is likely that this below ground interaction is in fact more significant to crop yields than shading is (Ong et al, 1996). One farmer (2.5 %) placed a leaf mulch around any tree seedlings he planted (including *M. volkensii*) in order that the seedlings could benefit from relatively more soil moisture, due to reduced surface evaporation. Just one farmer suggested that the tree might need lots of manure, and that lack of it could have been why the adjacent crops were weak. Two farmers (5 %) felt that, though *M. volkensii* "didn't mind" the stones, the trees growth rate was somehow slower on the volcanic soils, compared with the sandy clays where there would be greater rootability.

While *M. volkensii* is perceived to be a fast growing, drought resistant tree ideally suited to areas such as Kibwezi, it would be hard to accept that management to conserve the soil moisture and nutrient status would not improve the trees growth rate. This presumes that the growth rates obtained 'on farm' were under sub-optimal conditions for *M. volkensii*. Where seedlings had been watered and had some fertiliser applied over the first twelve months on a single farm in Machakos fantastic growth rates had been obtained. This unsupported observation suggests that improved management could be rewarded with an increase in the trees productivity.

6.5 Pest and diseases

Despite their local popularity, it was widely recognised that goats are the main pest of *M. volkensii*. This has been a major reason why some farmers tolerate the tree within the cultivated area (or shamba), where it is protected from both goat damage and passers-by. When the tree is small, goats "cut" the seedlings down by grazing them off inches above the ground. If subsequently protected, the tree will develop as a coppice. Young trees that have had bark removed will recover in the rains, providing the tree had not been ringed. All the farmers who had planted *M. volkensii* fenced the seedlings for this reason (Chapter 6.2.4).

Termites were a problem in the area, and three farmers observed that the *M. volkensii* seedlings were subject to termite attack when they are small. It would seem that if the seedling was weeded, then the absence of dead grasses near the stem prevented termite attention. This fact could increase the survival rate of seedlings in field trials. One farmer stated that "until the seedling has its own root system it is affected by rots and pests".

Many of the older trees, both on experimental plots and 34 % of those on the farmer's fields, showed superficial termite damage. Only the white outer wood is affected by termites; the red heart wood of a mature tree is termite resistant. One farmer mentioned that he painted the lower section of posts with engine oil to prevent termites attacking the white wood of the pole and then ascending to destroy the thatch.

As *M. volkensii* contains an antifeedant (Mwangi et al, 1986) it was not expected to find the tree subject to even this superficial insect pest problem. Two of the farmers in this study echoed this by stating that "*(M. volkensii)* is not affected by swarms of caterpillars like other trees".

One farmer who transplanted seedling noted that "a disease affected it when it was small, causing the leaves to go yellow and die". If the reported amount of water used was accurate, then it could be concluded that the seedlings 'drowned' in the daily dose of 18 litres of water, as *M. volkensii* is intolerant of waterlogged soils (pers. comm. Patrick Milimo).

It was observed that some trees had a white fungal growth in the apex of the flush of new leaves. This fungal problem was not noted to have resulted in secondary tissue damage but was similar to the fungus on the apex of some of seedlings planted at ICRAFs trials. One theory offered was that the seedlings had been over watered. If this was the same fungal problem as in the farmers field its presence must be attributed elsewhere.

Another field observation from this study around Kibwezi was that most trees in the KEFRI Provenance trial and 10 % of the local farmers' *M. volkensii* exhibited symptoms of a disease or insect problem. The symptoms were oval patches of raised 'flaky' bark which were 'hinged' on one long edge. The patch was always lengthways along the stem and up to 3 cm in length. Neither farmers or scientists could venture any reason for this.

6.6 Tree Physiology

From this study it would appear that farmers had little knowledge of the physiological stages of *M. volkensii* growth.

6.6.1 Leaf fall

Partial leaf fall was known to occur just before the onset of the rains. At the end of each October this leaf fall was more complete than after the shorter dry season in March. Some farmers (7.5 %) perceived that M. *volkensii* never lost its leaves, as the tree retained some green leaves until the rains started when grown on cultivated land. The fact that wild *M. volkensii* were observed to have lost all their leaves by mid September had not been noted by the farmers. One new woman settler had noted that in Kibwezi the canopy of *M. volkensii* was not as thick in the dry season as it was in her parents home village in a less arid area of central Machakos.

6.6.2 Flowering

Only 10 % of the farmers felt they knew anything about flowering. One farmer pointed out that only one tree had not started to produce a new flush of leaves in late September and explained this tree was about to flower. Apparently flowering does not follow any pattern. Any tree will not flower more than once a year, this will not be around a given date but when the tree has had sufficient rain. As farmers manage the tree for vegetative products the reproductive processes have no real significance to the farmers.

6.6.3 Fruit Production

One farmer felt that this happened just before leaf fall as that was when you could observe the trees many fruit. When the trees fruit are only used as goat fodder it is not surprising that the farmers have no knowledge of *M. volkensii*'s reproductive cycle which produces fruit in 12 - 13 months (Milimo & Hellum, 1989)

6.7 Summary

- Men and women have different roles in the planting and managing of the tree.
- The problems of propagation have not prevented 25 % of the adopters planting seed, and half of those trying seed treatments.
- Planting of seeds or seedlings generally coincided with the November rains to reduce the need for watering.

- Trees were maintained in the shamba primarily to prevent goat damage, and one third of adopters fenced the young trees.

- Weeding is a woman's job, trees were weeded with the crops and this was considered to be second in importance to pruning.

- Pruning is the most important practice in the management of *M. volkensii*.

- Coppicing is not common in this area, but would seem to be more valuable.

- The valuable heartwood timber is generally harvested before it reaches 15 yrs.

- Most farmers (80 %) perceived the tree/ crop interaction due to the shade.

- Two farmers are trying to improve the system with crops that succeed in the 'shade' of *M. volkensii*.

- One quarter of the adopters had diverse perceptions of the trees effect on the soil, which reflects the differing methods of shamba management.

- No farmer perceived any competition for water between the tree and the crops.

- Farmers see goats as the main pest of the tree, but had also observed termites and rots effecting the seedlings and superficially on older trees.

- Farmers exhibited no knowledge of the trees growth outside their management.

CHAPTER 7: PRODUCTS AND USES

When asked to list the main products or uses for *M. volkensii*, there were no differences observed between the farmers who had planted and those who had retained *M. volkensii*.

7.1 Timber

Of the 15 (37.5 %) farmers who talked about timber qualities, 14 (42.5 % of adopters) said that the main use was for construction timber as the wood is strong with a good reddish colour, termite resistant, hard wearing and weather resistant and it "lasts long, unlike other wood". The wood is good for planing and for "making straight edges". The carvers group ranked the timber as being of limited 'hardness' and as one of the lighter woods they used for carving. This contrasted with the farmer group who felt the timber was of intermediate 'hardness' as they had differing uses for the timber (Appendix III).

According to one farmer/ carpenter, the quality of *M. volkensii* is better than camphor wood *(Ocotea usambarensis)* as it "accepts nails without splitting". Brief conversations with carpenters in Kibwezi town confirmed Blomely's statement (1984) that *M. volkensii* heartwood is comparable with camphor. In Kibwezi the balance is tipped by the transport costs necessary to obtain camphor.

The wood is not resistant to water and so sunken sections of posts rot, with a diameter of 30 cm (12") a pole would last ten years. Because of the termite resistant quality of the timber it is used for the corner posts of traditional huts even if there are insufficient poles for the wattle and daub walls.

7.2 Fodder

The main use for the prunings was fodder (57.5 % of adopters). In one case the tree had been retained through three generations as an important source of dry season fodder for the family's goats. Although most farmers use some foliage, seven farmers used the leaves and fruit as an invaluable dry season fodder. "In the dry season very little competes with the goats love of mukau *(M. volkensii)*, even its dry leaves" (Fig. VI).

Farmer were unable to estimate the amounts of fodder they harvest. One 64 year old tree was reported to produce sufficient fodder for ten goats, while two six to ten year old trees produced more than enough fodder for eight goats under a less severe pruning regime.

7.3 Firewood

Three farmers (7.5 %) perceived firewood as the second most important product from the tree. Most farmers pruned *M. volkensii* to some degree, and 30 % of the farmers stated that the second most important use for the prunings was for firewood. Once the goats had removed the foliage, straight branches were removed while the 'useless' branches were left to dry in order to be used as firewood. Four farmers (10 %) mentioned that branches were left on the terrace bunds, in 'trash lines', until they had dried sufficiently (Fig. VI). It was not possible to corroborate the statement that *M. volkensii* is used for charcoal (Weiss, 1987) though under conditions of financial need this might be the case.

7.4 Medicine

In this survey the most commonly reported medicinal usage of *M. volkensii* was as a 'cure' for malaria. The consensus of opinion was that a small number of leaves are taken and boiled, the resulting 'tisane' is then poured off and a small amount drunk. The prescribed dosage ranged from half a cup three times a day to a glass once a day "until the body stops aching". "Only a little can be taken" as the liquid is bitter.

Measles and chicken pox are treated by boiling the leaves up and using the liquid to bathe the afflicted child. In one case the sap was also used in the liquid. Again the frequency of treatment varied from three times to just once a day, but it was widely agreed that after three days the symptoms started to disappear. Chicken pox spots were cured after a week to ten days, and the measles rash within a week. Only in one case was it suggested that the child should also drink a small amount of the liquid before being scrubbed down. The washing may have an antiseptic and soothing affect, but the normal course of a measles rash is for six to fourteen days without treatment. Chicken pox spots heal in about one week unless they have become infected (Barr and Matthews, 1991).

In only one case a farmer explained that great care should be taken of children's eyes when they have measles. He went on to say that his mother had splashed the *M. volkensii* infusion in the child's eyes during bathing in order to "give relief". Apparently this treatment should be accompanied by using egg white on the eyes "to somehow oil them". This was uncorroborated by the farmers interviewed.

Medical science recognises that severe conjunctivitis is a common complication of measles in rural areas in the tropics, and is usually obvious two days before the measles rash is evident (Barr et al, 1991). As this is occasionally accompanied by corneal ulceration and loss of vision, it is intriguing to find *M. volkensii* also used as a curative eye wash for conjunctivitis. Measles is a viral infection that affects the mucus membranes (Barr et al, 1991). The only benefit of the eye wash is likely to be one of soothing, though it could be speculated that the *M. volkensii* infusion also acts as an antibacterial prophylactic.

In more than six interviews and conversations older women recommended bathing or 'body scrubbing' with the *M. volkensii* lotion for the relief of pain when patients are suffering from a "swollen body" or muscular pain. Once again it was thought to be an effective "cure".

Small doses of the tisane were administered to relieve abdominal pain in one case. Another uncorroborated claim was that the pulp of the fruit can be applied as a poultice, to feet with thorns embedded in them. After one day and night the thorn is drawn to the surface, enabling it to be removed.
When questioned, one herbalist was adamant that no-one could be badly affected by taking "too much" *M. volkensii* medicine. This contrasts, but does not necessarily negate the opinion that overdose can be fatal (Kokwaro, 1993).

M. volkensii is also used in the treatment of livestock. Sick hens, or those suffering from liver complaints, can be "cured" by administering the tisane. When mites become a problem in the hen coop, chopped *M. volkensii* leaves can be spread on the floor to kill the parasites. Daily applications of the infusion throughout the coop, over the period of a week, is the most effective method of dealing with the mites.

One farmer, though unaware of other livestock cures, felt that *M. volkensii* might prevent goats "getting sick from worms" as the goats that ate the leaves were "so healthy".

7.5 Other Uses

In two cases it was mentioned that sap can be used as a glue. Apparently Kalulini Secondary School use the sap as glue in art classes. Another farmer "melts" the sap and uses it to stick the metal head of arrows to the wooden shaft as this prevents the wood splitting or breaking.

The study found that the traditional log beehives in the area were frequently made from *M. volkensii*. The beekeepers apparently prefer to use a torch of *M. volkensii* to smoke the bees out as this will not go out and can be swung to rekindle the torch and keep it smoking. Unfortunately this piece of information was collected on the last day in the field and therefore remains uncorroborated.

One farmer believed that *M. volkensii* extract was one of the active ingredients in mosquito repellent coils as she used to burn leaves to keep mosquitoes out of the house in the evenings.

Three farmers (7.5 %) were refusing to harvest their trees for timber as the need for shade near the house was currently greater than the family's requirement for timber.

7.6 Productivity

7.6.1 Tree growth

The initial tree heights over the first five years can be seen to exceed farmer seedlings when the research trees are observed (Fig. X). Tree height in itself does not give a satisfactory correlation, which was not improved upon when means where plotted. From the trend line plotted it can be seen that the single stemmed trees on sandy soil tend to be taller than the multistemmed trees in the first ten years. The few data points for trees on volcanic soils do not confirm the farmers perception that they grow slower than the trees on the sandy loams. The wide variation within the data set prevents any firm conclusions being drawn. The fact that farmer tree heights overtook that of the unpruned research trees was an apparent anomaly if it were not considered that the research trees were planted at a much closer spacing.

In Figure Xa the height difference of single and multiple stemmed trees in the field and the single stem KEFRI trees indicate that while there plenty of variation, the single stemmed trees in farmers fields are on average taller than the multistemmed trees until ten years of age. Further study might find this trend does not hold true.

The comparison between the *M. volkensii* grown by farmers and on various research trials shows that irrespective of climatic and soil differences the research

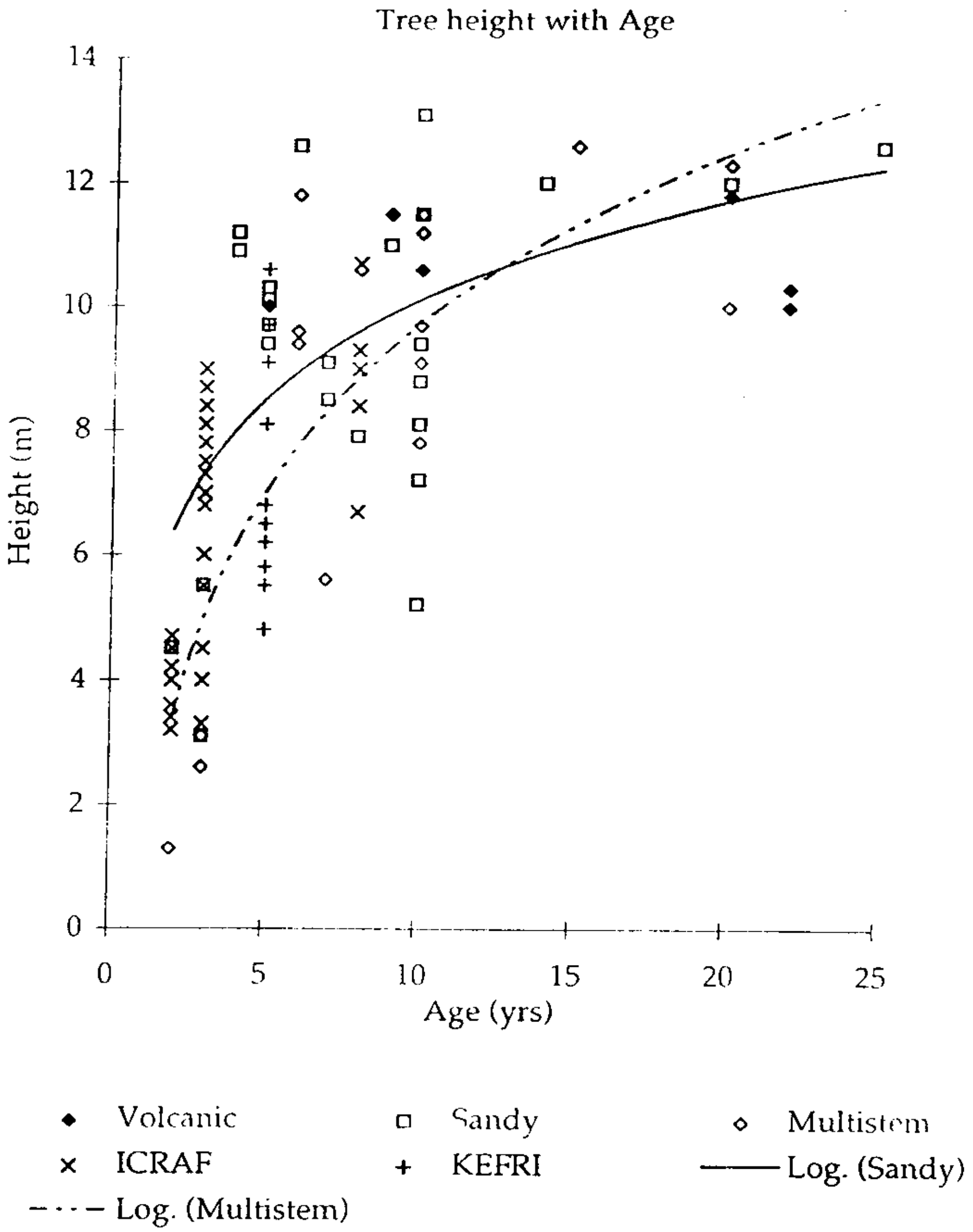

Tree height with Age
14
12
10
8
6
4
2
0
Height (m)
0
5
10
15
20
25
Age (yrs)
Volcanic
Sandy
Multistem
ICRAF
KEFRI
Log. (Sandy)
Log. (Multistem)

Figure X

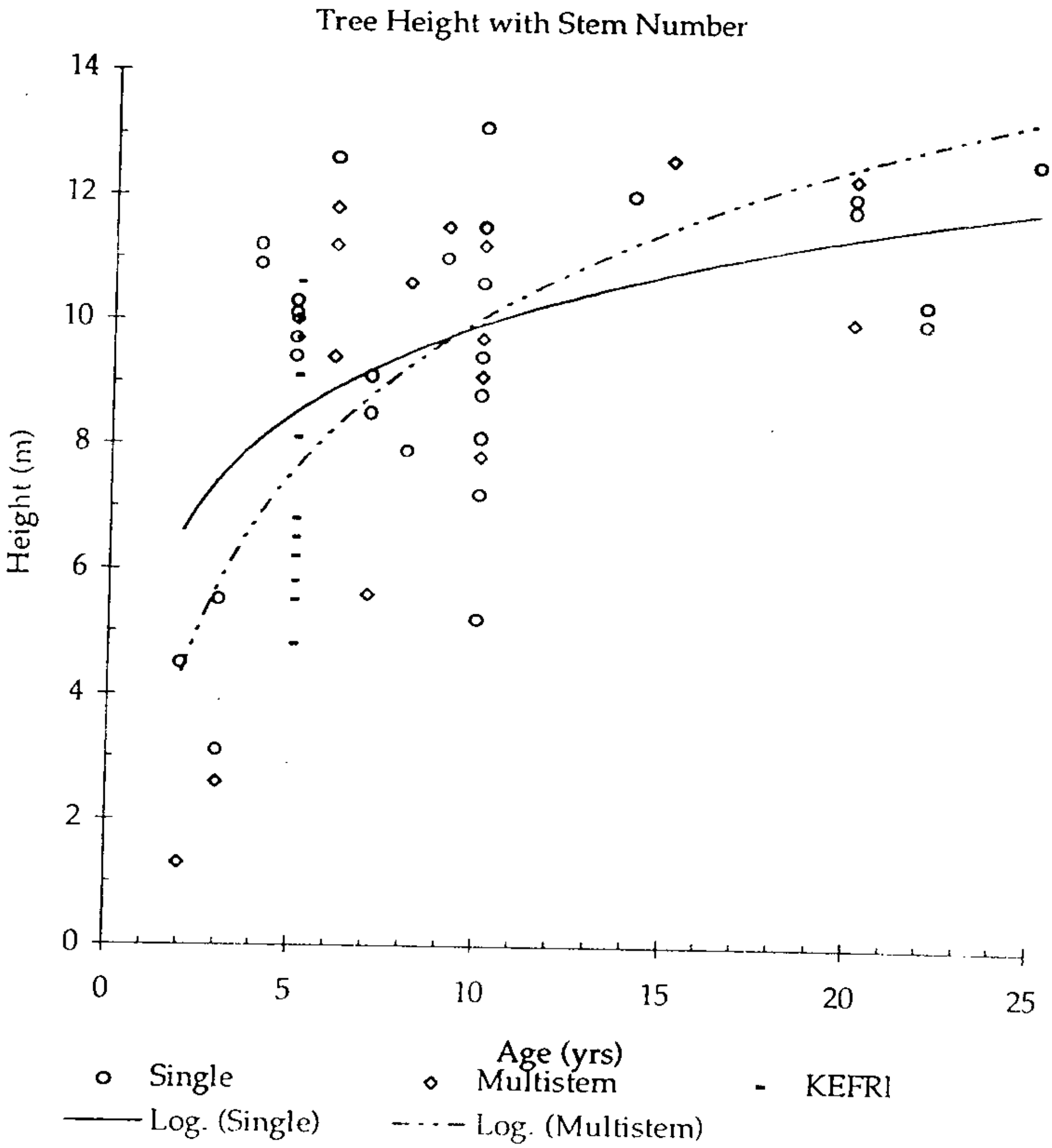
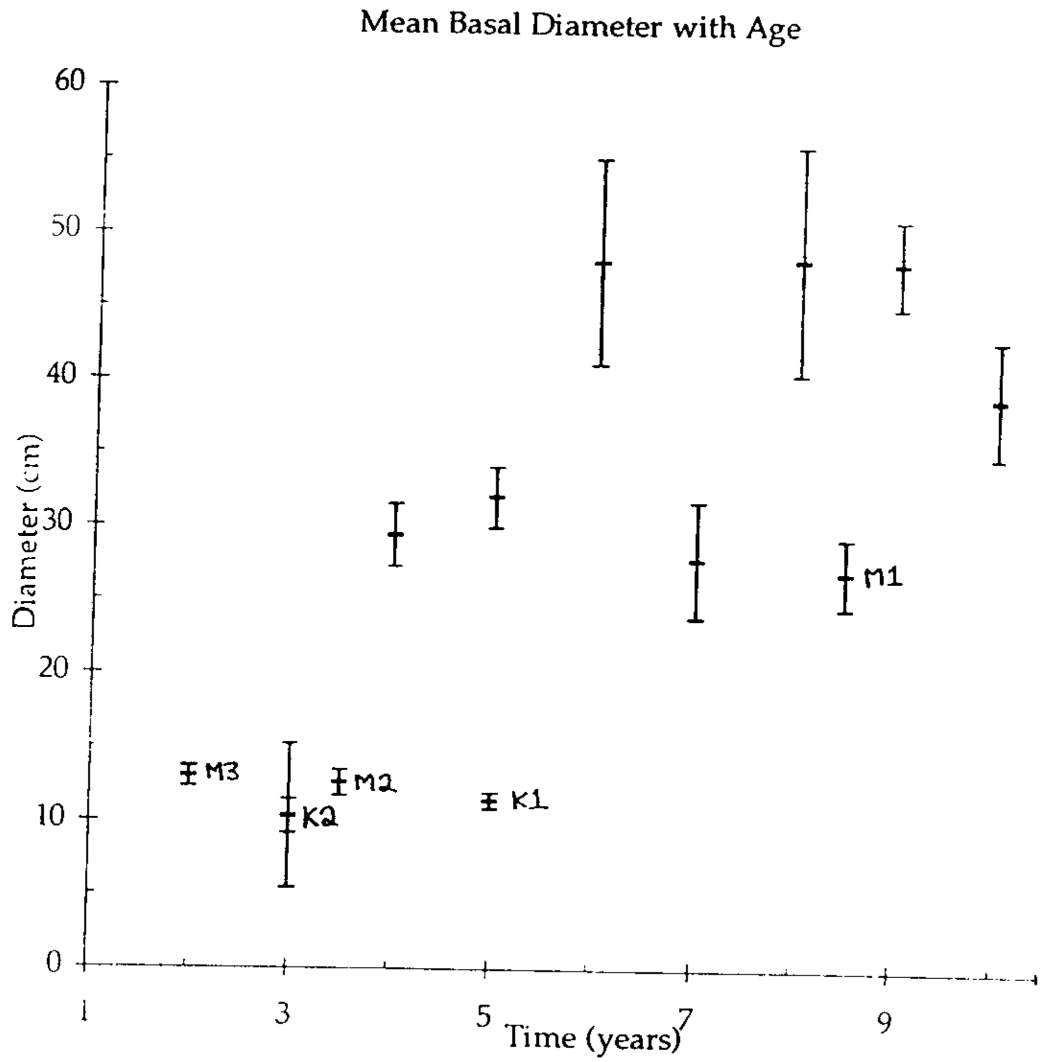

Tree Height with Stem Number
Height (m)
0
2
4
6
8
10
12
14
Age (yrs)
0
5
10
15
20
25
Single
Multistem
KEFRI
Log. (Single)
Log. (Multistem)

Figure Xa



Farmers (Kibwezi)

K1 KEFRI (Kibwezi)

K2 KEFRI/ JICA (Kitui)

M1 ICRAF (Machakos) 1988
M2 (Machakos) 1993 RAC Experiment
M3 (Machakos) 1994

Figure XI

centres achieve greater growth rates in the first couple of years, but a lower overall stem increment (Fig. XI). The mean values were used to reduce background noise in the data. The apparent low stem increment in the late 1980's (age 8 & 9) data does not show a reduction in overall stem size but is the product of accumulative climatic and management variables unique to that subset of trees. It would have been ideal to have annual data for trees since planting, but this could not be a reality when working in the field. The variability in stem productivity (standard errors) was found to be lower on the more homogeneous research sites, when compared to the variability of environment and levels of management in the farmers field. Several processes can be attributed with these differences.

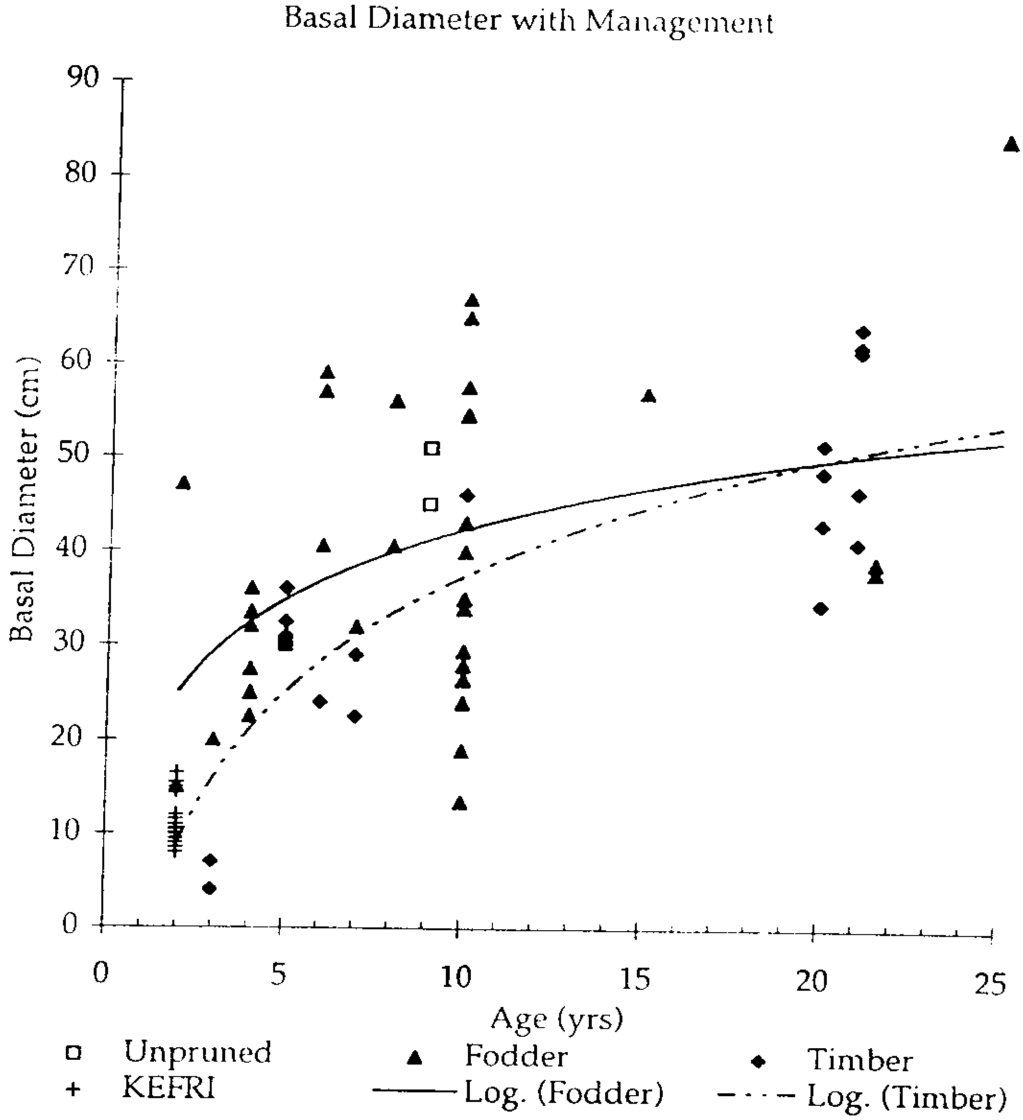
During farm visits very few farmers had *M. volkensii* planted in lines, and these tended to be on field boundary bunds. Trees 1-10 (Appendix II) were planted with an mean 'between tree' distance of 8.9 m, with the closest trees (5 & 6) being just 6 meters apart. In most cases, especially with trees retained in the shambas, the spacing was generally greater than 15 m. This is compared with ICRAF's 'Root and Competition' trial where trees were at a 1 m spacing and other trials at Machakos where the spacings were 4 m. KEFRI's Tiva planting was for the purpose of examining root development and the trees were roughly 5 m apart. KEFRI's Provenance trial at Kibwezi was planted in a grid with 2.5 by 2.5 m spacings. Only one farmer was found to have planted seedlings at 3 metre spacings along a field boundary, but this was in order to compensate for any mortality during the long dry season after the April planting.

The result of the wider spacing would be the expectation of a greater mean annual increment (MAI) which was achieved by farmers, compared with the research trials. The trees grown on research plots at a higher stocking rate will have a much lower MAI, which will continue to increase over more years than those grown in the shambas. The boles of the trees produced would be more cylindrical and noticeably less tapering than those grown at a wider spacing (Huxley, 1987).

An obvious comparison to make was stem productivity with respect to management. Figure XIa shows no clear trends in productivity between the unpruned trees, those pruned exclusively for timber, those used for fodder and the relatively unmanaged trees at the KEFRI, Kibwezi site. It had been expected that the severe defoliation used during fodder production would result in a reduction in stem productivity compared with those managed for timber. The trend lines indicate that if the difference were significant the inverse would be true.

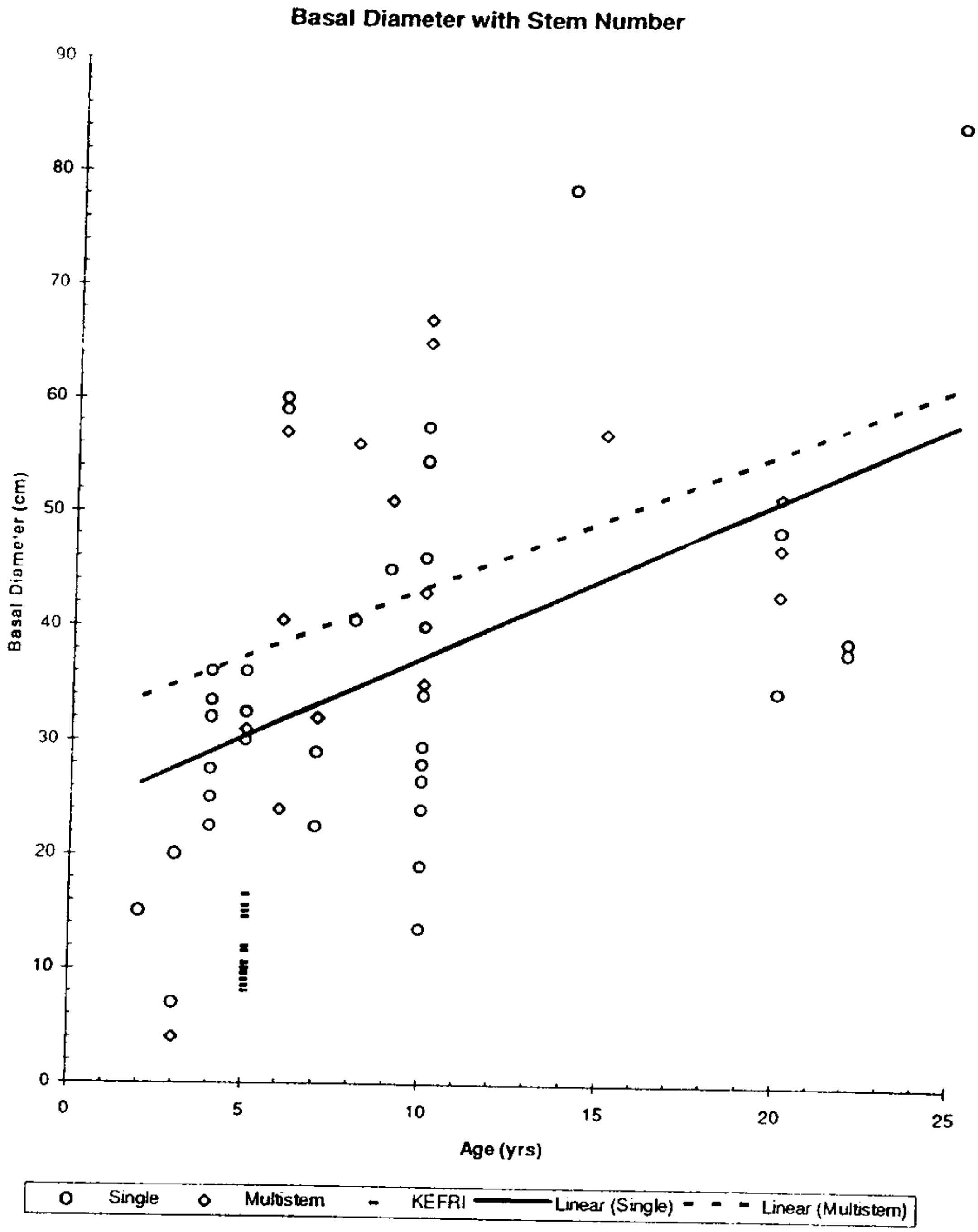
Figure XIb shows no clear trend but it would appear that the average basal productivity of the multi-stemmed trees is slightly higher than that of the single stemmed trees. This is the only indication obtained that management practices do in fact affect the productivity of *M. volkensii*.

The differences in farmer and research management of the trees make straight comparisons difficult. While research stations set up trials to study certain aspects of *M. volkensii* growth and development, the farmers are most interested in the highest value product which is timber. Trees grown at a wide spacing with the basal branches pruned produces quality timber with a shortened time to maximum MAI (Huxley, 1987). As farmers harvest trees once a certain diameter has been reached, this results in a shortened rotation.



Basal Diameter with Management
Basal Diameter (cm)
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Age (yrs)
Unpruned
Fodder
Timber
KEFRI
Log. (Fodder)
Log. (Timber)

Figure XIa



Basal Diameter with Stem Number
Basal Diameter (cm)
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Age (yrs)
Single
Multistem
KEFRI
Linear (Single)
Linear (Multistem)

FIGURE XIb

In the new trials at ICRAF the planting of seedlings at a few months old and the fact that the seedlings are then watered when possible for the first dry season could explain the high initial growth rates recorded. In reality few farmers can do this (Chapter 6.2.2) but regular weeding constitutes no extra work when the trees are within the shamba. While farmers place importance on careful weeding of the trees both of the KEFRI trials remained unweeded after the first few years. In Kibwezi this was "once the canopy was deemed to be developed to a stage where weed species would be precluded at a level which would not cause undue competition". The differences in weeding and the spacing could account for the low basal diameters of older trees on the research plots.

7.6.2 Timber Volume

When *M. volkensii* is harvested for timber the external layer if immature white wood is removed. Though farmers estimated that the layer was "no more than an inch thick" when mature trees were harvested, it was not possible to obtain a quantitative rate at which this layer decreased with increasing age. To take this fact into account, any calculated timber volumes would have to be adjusted. The straight boled stem was observed to usually account for approximately 50 % of the height of all trees, except where the crown had been severely lopped. It would be difficult, but necessary, to incorporate the 6 - 8 top branches into any calculation of timber production.

As trunk timber volumes would be a something of an underestimate of productivity and mid-diameters were not recorded in the field, volume estimates have not been attempted here. Subsistence systems characteristically make use of everything as being of some value and the usage of *M. volkensii* was found, in this study, to be no different. Farmers generally make use of much more wood than can be anticipated, irrespective of management practices. Small diameter 'canes' are used for making chairs and hen coops, while any other branches and twisted pieces of wood are dried and used for firewood.

7.7 Economic Value

In order to estimate the 'real' economic value of a *M. volkensii* values and volumes would have to be assigned to every product utilised during the life time of the tree.

Timber would be the easiest product to value as it is generally harvest on one occasion. Timber from 'Itula' and other species including *M. volkensii*, are sold at 277/= (Kenyan shillings) per m^3 by the forestry department to customers such as the Makindu Handicraft Co-operative, Mbui Nzau. As an indication, a 4 m trunk length with a mid-diameter of 40 cm would produce 0.5 m^3 of timber (Forestry Commission Field Book 11) which would be valued at 138/=. These dimensions are a little less than the farmers preferred harvest measurement but infer that the Kenyan Forestry Department might be selling *M. volkensii* below the local market value.

In one case a "mature tree" was said to produce "four woods" which would each be sold for 150/= per 2.5 metres of timber in Kibwezi (60/= per m). In Kitui, where *M. volkensii* is more scarce, one carpenter was buying planks at 30/= per foot, or 90/= a metre. It was not possible to relate either of these figures into to cubic measures of timber but gave a timber value of 600/= for a 'mature' tree (not including other products such as fodder) over a ten to fifteen year rotation. In September 1996, 87 Kenyan shillings was £1, so a mature tree worth 600/= would cost £4.

One farmer estimated that a *M. volkensii* managed on a three year coppice was worth 344/= when harvested, carved and sold as pestles, mortars and ugali spoons at the local market. Each of the coppiced trees had more than 3 stems and was growing strongly on the (nutrient rich) site of an old goat boma. Assuming this was correct, over ten to fifteen years each of his *M. volkensii* coppices would be worth 1032 - 1720/= at current prices. This farmers coppiced rotations appear to be the best investment for his farming system when compared with the timber value of a 'mature' tree and taking into consideration the households lack of fodder or firewood requirement.

During the course of this study the value of fodder was not attained. A couple of farmers fed 4 - 10 goats from one 'mature' tree, but this could not be related to a volume of fodder. The frequency with which fodder is pruned is dependant on the severity of the dry season so it was not even possible to ascertain how many trees were pruned, or with what severity to feed the goats in the long dry season.

It would be slightly easier to estimate the production of firewood if it were sold, as in rural areas firewood is valued per 'manageable human load'. In reality this is the amount one woman can carry as men are not supposed harvest fuel wood. One 'manageable woman load' is dependant on the density of the particular species and tends to vary between 15 and 25 kilograms. Firewood from indigenous species is more expensive than that from exotics (pers. comm. Patrick Muthoka). Although firewood can be bought, it is generally collected as dead branches from the scrub or forest by the women farmers.

As the sale of charcoal had just been prohibited in the Kibwezi area it was not possible to find anyone willing to tell a 'mzungu' (white) the price a sack of charcoal. Various conversations in the field determined that "mureereshwa" and thorn trees are used to make good charcoal, beyond that it was difficult to find out which species were felled for fuel. Apparently charcoal costs 140 - 160/= per 90 kg sack, depending on the success of the bargainer (pers. comm. Patrick Muthoka).

Despite there being insufficient data to estimate the value of some of the farmers timber trees from the field data collected (Appendix II & the semi-structured interviews) none of the farmers who grow *M. volkensii* were in any doubt as to the value of their multipurpose tree.

7.8 *Melia volkensii* and Other Trees Planted and Grown

In the course of the study 18 farmers (45 %) spoke about the reasons for growing trees other than *M. volkensii* (11 planters, 6 retainers & 1 non-adopter). The majority of those farmers, some with as little as two cultivated acres, were retaining and planting fruit trees. Most of the species were planted as seedlings purchased at nurseries and tended to be exotics (Appendix IV). The next most valued characteristic required from trees was that of shade or a windbreak (25 %). In most cases the trees planted as windbreaks were planted near the house and were also valued timber or fruit species.

In theory, it can be expected that the direction of the survey would affect the answers obtained. In this case it was a pleasant surprise that timber species (with its long term benefits) were not valued very highly (only above medicinal tree products) despite the preoccupation of the survey with a timber species. Regardless of the value of products harvested once after a decade (timber) the small farmers who survive in such a harsh environment value tree products that can meet immediate needs throughout the year, such as fruit, fodder and firewood.

The bao ranking game (Appendix III) provided a brief glimpse of farmer and carver perceptions of species important to them. Both group were allowed to select their own species, which clearly reflected their different emphasis on the products required. The fact that both groups choose Dalbergia and Melia enabled their responses to be compared and verified to some extent. In both groups exotic species were ranked highly. This could be explained as the seedlings and information of exotic species are readily available through the extension services. Neither group ranked *M. volkensii* as amongst their preferred trees. But in both cases aspects found to be important in the planting decision, such value as fodder and timber were ranked highly.

A teacher and an extension worker both proffered the view that when there have been several exceptionally dry seasons the poorest farmers turn to charcoal burning as a survival mechanism. Both individuals felt that this practice was causing the loss of undervalued indigenous species locally and not just the loss of fast growing exotic species, as suggested by Tiffen, Mortimore and Gichuki (1995).

7.9 Summary

- Timber is the main reason for adopting *M. volkensii*, with a good colour, important termite resistance and high economic value for farmers.

- Fodder and firewood are important and highly utilised secondary products.

- *M. volkensii* is used in many medicinal 'cures', as glue and in apiculture.

- Field measurements did not confirm farmer perceptions that trees on volcanic soils grow more slowly than those on sandy soils.

- From the mean basal diameters farmers were shown to obtain greater tree growth than on the research station, due to different spacing and management.

- Farmer management was not shown to have a significant difference on field tree growth.

- Coppicing can be more economically valuable than timber production over the same time scale.

- Although a minority of farmers grow *M. volkensii* there was no doubt as to the value of the tree in their farming system as a source of products and income.

- Indigenous trees are lower down farmers priorities than fruit and shade or exotic trees.

CHAPTER 8: NON-ADOPTERS of *M. volkensii*

During the course of the study six 'non-adopter' farmers were interviewed. Further chance meetings during the study broadened the range of reasons why farmers did not wish to retain or plant *M. volkensii*. There were four emergent reasons which where accompanied by several interesting statements of justification.

8.1 Lack of knowledge

Two of the farmers (33 % of non-adopters spoken to) knew that "mukau *(M. volkensii)* is an important tree" and that "the timber is good, but (they have) never tried to plant it" as "people don't know how to plant or manage mukau". One farmer had cut down all the mukau in her seven acre shamba "as the crops around it were doing badly because of the shade and the soil was not good". Unfortunately, the lady later realised that *M. volkensii* was of importance, when she started hearing about it from other farmers. The farmer was unable to rectify her mistake as the remaining stumps had shown no signs of resprouting. This could mean that the trees were mature or that they were felled during the height of the dry season.

8.2 *M. volkensii* is "expensive in effort"

"Many farmers (50 % of non-adopters spoken to) know (mukau) is a good hard timber, but don't grow it as it is expensive in effort and takes time to mature. It is not a good tree as it has a low survival rate, which causes a lot of work, so very few prefer it". "You can plant them, but in this dry season the soil is too hot and dry and they would be difficult to grow as the tree would need water and management." "As the tree grows well in the area naturally, why should effort be spent trying to grow it on the shamba?"

In several cases, the fact that the tree grew naturally was perceived to be its only means of growth. One woman said that though "mukau *(M. volkensii)* is a good tree, (it is not grown) as there are no mukau around and it is sometimes dispersed by goats, but the goats don't go as far as the mukau." So as "they grow best in the forest, especially in the rainy season (when) no one gets tired" there is no need to find a way of planting mukau. This view point is hardly surprising considering the amount of hard work required to grow sufficient food for the family under such harsh and variable conditions.

One should note that though there is piped water in the area, most people are without access to clean, tapped water. It is perceived that the investment of time and effort is greater than the known benefits, as the results will not be realised for 8 - 10 years. The focus on short term needs, which excludes the investment of the labour required to plant and manage a tree, is a well documented outcome of precarious subsistence lifestyle (Harrison, 1987 & Unruh, 1994).

8.3 Shamba size.

Five of the farmers (83 % of the non-adopters) cultivated less than 2.9 acres and, in general, their view was that "trees are important, but when you have only a little land, if you plant trees where would you plant food?" As a result, when seedlings were found they are weeded out as "the shamba is too small for (farmers) to grow (mukau) with the crops". This view was off set by one farmer who "love(s) trees very much, and needs another small plot where trees can be planted very well". Locally, it is recognised that trees are an important source of food and shade, and necessary as a windbreak. The remaining farmer was planting trees, as less than three acres was sufficient for his family's food requirements, but he was not planting *M. volkensii* as it is too difficult to grow.

8.4 No reason to plant *M. volkensii*

This final reason is simple, yet obvious. As one farmer summed up: "why would you plant the tree if you don't know any benefits of mukau *(M. volkensii)*, and there aren't any around". Similarly another farmer had "never been told about it, so (she has) had no interest in it".

Despite many claiming ignorance of the uses or benefits of the tree four of the farmers knew that the timber was "good". In terms of everyday objects, "it can be used to make the pestle and mortar for maize", and one farmer knew the tree provided goat fodder. Three of the farmers (50 % of the non-adopters) had heard it could be used to cure malaria, amongst other possible medicinal uses. In one case it was claimed that "witches use it to cure aches and pains", though this might only indicate its use by the local herbalists or 'wise women'.

There are undoubtedly many other reasons which singly or multiplyy result in a farmers decision not to try planting or adopting *M. volkensii* on his or her shamba. It would seem logical that with fewer or no livestock the smaller farmers in the area would not value the tree as highly as richer farmers also require fodder.

Timber trees, such as *M. volkensii*, seem to be perceived as a luxury by many farmers who, by necessity have to focus on the short term production of food for their subsistence survival. While these farmers could profit from the personal use or sale of *M. volkensii* timber many of them will never be able to 'invest' in their own tree.

8.5 Summary

- Shamba size will prevent the poorest households with below average sized shambas from planting any trees.
- The labour investment required is too great for many farmers to adopt the tree.
- The lack of knowledge of the tree, or of how to plant and manage it excludes some farmers from even deciding not to grow *M. volkensii*.

CHAPTER 9: CONCLUSIONS

Farmers

At present *M. volkensii* is grown by a minority of the farming community in the Kibwezi area. From this study the management of the tree has been tailored by the need to fit the tree into the farming system, regardless of any effect on tree productivity of which the farmers exhibited no perception. The management of this multi-purpose tree incorporates both the men's decisions (which include planting, pruning and harvesting for timber) and the women in the responsibility of weeding, tending the crops, feeding livestock and caring for sick children (Chapter 6.1.1). By implication, the thoroughness of weeding affected the survival of tree seedlings within the shamba (Chapter 6.2.3). Generally, both the men and women farmers possessed a reasonable knowledge of management the tree. While there was plenty of variation in the management knowledge, the similarities in the timing of various practices where heavily influenced by the HH and the pressure of short term needs on the household.

Land and Tree Tenure

It can be concluded that farmers cultivating less than two acres in this area did not or could not even afford to plant fruit or shade trees, which the farmers rank above timber species such as *M. volkensii*. The tree was owned by an individual with household needs having priority over the economic value of the timber.

Where farmers had only a few trees, timber was only sold if an excess of household requirements was harvested (Chapter 6.1.2).

Agricultural System

The agricultural system in Kibwezi is dynamic, adapting to meet the needs of the population with changes in their economic situation. Within that system the management of *M. volkensii* has and is being altered as farmers knowledge and perceptions of the tree changed with time and experience. Short term requirements of fodder, firewood or construction timber can force harvesting decisions to be changed. In fact it could be seen that "reality is multiple, changing and transactional" (Ely, 1991). Older farmers concluded that there had been a decline in the number of *M. volkensii* in the area over recent years, although this decline had not yet reached the levels that were observed around Kavisuni, Kitui district. This decline was attributed to the increasing value of the timber and the increasing number of shambas. As the younger generation access education and extension services there is an increased likelihood of new techniques being adopted and the dissemination of new ideas (Chapter 6.1.3).

The agricultural constraints were found to be drought, soil erosion, time required for cultivation and finance (Chapter 6.1.4). In the face of this, *M. volkensii* is a drought resistant tree that is fast growing despite the soil conditions.

Farmer management

The management system has been locally derived from the farmers main requirement for timber, and this is not time consuming as it dove tails with the local agricultural calendar (Fig II & III).

Propagation

It was no surprise that the propagation of *M. volkensii* caused farmers some problems. Having spoken to 15 farmers who had planted *M. volkensii* it was found that 10 of them had planted seeds with the use of seed treatments. These ranged from burning to seed coat removal with a panga. It can not be said that farmers in Kibwezi do not plant *M. volkensii* (Chapter 6.2.1). Despite the difficulties and the low success of planting untreated seeds, some farmers still planted seeds in the hope that they could grow one or two trees of this highly valued timber species.

Fencing

Fencing *M. volkensii* was practised by 30 % of farmers in this study because of the damage goats could inflict on the tree. This practice is time consuming but necessary on farms where goats were allowed to browse free-range within the shamba. On other farms the tree retaining the tree within the shamba protected it from both goats and passers-by (Chapter 6.2.4).

Pruning

Pruning was the single most important management practice, ensuring the production of straight knot-free timber. Mature trees were perceived to shade crops excessively and so the canopy was thinned prior to the rains at the beginning of each season (twice a year). The trees were pruned for livestock fodder from early September through to November and in March/ April with varying degrees of severity. It would appear that *M. volkensii* is 'unaffected' by severe defoliation. From the field measurements there was no indication of a reduction in basal growth with differences in pruning or management. Therefore, from this study it can only be concluded that the tree has some degree of resiliant to severe pruning and the productivity of this fast growing species remains relatively unaffected, which confirms the perceptions of some of the farmers.

Farmers perceive that pruning the canopy has a beneficial effect on the crops, which is likely to be due to the trees reduced water requirement (Ong et al, 1991). The unseen competition for water would partially account for the fact that farmers perceive 'shade' to be the problem caused by the tree.

Coppicing

In this study coppicing was not found to be commonly used on *M. volkensii* in the Kibwezi area. In the majority of cases coppiced trees were maintained as such after the young tree had been damaged by goats. Only 5 % of the farmers had set out to manage the species as a short rotation coppice (Chapter 6.2.6).

Harvesting

In cases where the mature tree was not being harvested for timber for another year or so farmers expressed the wish that the tree had been located on the field boundary where it would affect fewer adjacent crops. As most farmers retain trees or seedlings in situ they do not make a management decision about the location of the tree.

Tree/ Crop Interaction

Two farmers (5 %) were experimenting with crops that would flourish in the shade of the *M. volkensii*. As neighbours follow the example of respected members in the community, the most effective way to spread new developments is through the farmers themselves. It could be concluded that this is proof that the management of *M. volkensii* and its place within the agricultural system was still being developed. The successful use of shade tolerant crops adjacent to the tree would reduce the problems resulting from its use in the system.

Tree/ Soil Interactions

Whilst 35 % of farmers mentioned that the tree affected the soil only 5 % felt that the leaf fall resulted in a mulch which enriches the soil (Chapter 6.4.1). None of the farmers perceived the tree as having any below ground interaction with the crops.

Pests and Diseases

One surprising conclusion was that termites were reported to destroy *M. volkensii* seedlings. According to farmers clean weeding of seedlings ensures that dead plant material is kept away from the seedling which prevents termite attack. This management practice could result in an increased seedling survival in 'on-farm' trials in other areas.

Tree Physiology

Farmers verbalised no knowledge of the trees physiological processes or perceptions of the timing of such processes, indicating that the indigenous knowledge of the species is limited to the management for the products.

Products

The production of valuable termite-resistant red heartwood timber was the main reason for farmers to grow of the tree. Timber was harvested when required, though farmers attempted to leave the tree until it was 10 - 15 years old, when the white outer-timber was less than one inch in depth (Chapter 6.2.7). Very few of the trees were grown exclusively for timber, and in these cases it was due to the lack of livestock or a lack of knowledge of any other products. In an area where livestock is important, the production of green dry season fodder was (not surprisingly) highly prized. The remaining twisted branches were used as firewood which is a perennial household requirement.

M. volkensii was also used for a variety of human medical cures and to treat chicken mites with reported success. The minor products of glue, log bee hives and shade all add to the economic value and usefulness of this tree to subsistence households.

It can be concluded from this study that *M. volkensii* has great potential (Blomley, 1994) as it is a locally valued timber and an important source of dry season fodder. The tree fulfils a variety of other needs in the small holdings of Kibwezi. It should be noted that the shambas that were larger than the average 2.8 hectares tended to be the ones where *M. volkensii* was adopted.

Non-adopters

It can be concluded from this study that the main reason for not planting or adopting *M.volkensii* is restricted shamba size. The next most important reason which farmers gave was "lack of knowledge"; both the lack of knowledge of useful products (other than timber) and the knowledge required to plant and manage the tree.

In several cases the women stated that they could not differentiate between *M. volkensii* seedlings and seedlings of another tree. From this study it can be concluded that as the women are responsible for clean weeding the crops, an ability to identify useful tree species from the seedlings would enable them to decide whether to retain species such as *M. volkensii*. Further to this, the ability to transplant and care for tree seedlings would mean that trees could be retained but planted on the edges of the shamba. The majority of adopters perceived this as the only solution which would reduce the effect of annual crops while the tree could retain the benefits of protection and weeding from being in the shamba.

As farmer groups have been successfully set up in the Kibwezi area the network required for increasing the farming communities knowledge and assisting them to improve the management system of *M. volkensii* is in place. From the farmers comments it can be concluded that some of them are aware that other farmers have more knowledge of management practices than themselves. Five farmers (12.5 %) specified that if they could successfully transplant root suckers they would have greater opportunities to control the tree within their cropping system. Extension workers will be vital in the dissemination of vegetative propagation techniques currently being developed by the research institutes to a farming community who are eager to learn how to improve on their management and production of *M. volkensii*.

CHAPTER 10: RECOMMENDATIONS

M. volkensii is a highly valued tree in the Kibwezi area that could be utilised by all but the poorest farmers. Some farmers are currently propagating and managing the tree but there are many areas in which more knowledge would enable them to improve their system and allow them to make informed decisions. With more knowledge of *M. volkensii* farmers would be able to manage this multipurpose tree so that it is more compatible with crops, which is necessary in a sustainable agroforestry system.

The following recommendations are based on the perceived gaps in both conventional and indigenous knowledge. Further scientific or field study could address some of the areas in the light of farmers perceived problems and requirements.

Propagation

If the farmers could be shown the timing and technique required to successfully transplant seedlings within their shambas this would enable more farmers to adopt *M. volkensii* and decide where to place their trees within the agroforestry system. Transplanting wildings must be possible, and more successful than the seed germination rate, as seven of the farmers (17.5 %) interviewed in this study had successfully transplanted wildings onto their shambas over the years.

Training women farmers how to identify different trees from seedlings would allow the women to decide when and where to retain indigenous tree species.

KEFRI (Tiva) are currently propagating *M. volkensii* by removing sections of previously damaged root and treating them over a water bath for two weeks before planting. As four farmers had unsuccessfully and repeatedly tried to transplant root suckers the dissemination of a successful technique is likely to be adopted by innovative farmers and would increase the planting options available to the community.

Management and Production

As farmers tend to retain *M. volkensii* within the shamba a clearer understanding of the effects of management on the tree and its productivity could enable it to be more successfully incorporated into the farming system.

Scientific study might be required to ascertain whether fodder production significantly reduces timber production or affects the length of the minimum rotation. If either were found to be the case farmers might be best advised to manage individual *M. volkensii* for separate products.

If fodder production does not affect the rotation length, the best timing (by age or size) for the first fodder harvest taken from *M. volkensii* could result in greater productivity from farmers trees.

It would seem questionable whether the present biennual pruning does not significantly affect subsequent fodder or timber productivity when the practice is often so severe. During the course of this study farmers showed no signs of having any concept that there was a level at which the harvesting pressure affected the time span between prunings to a point where the time span became insufficient for the sustainability of their management system.

Field measurement might be sufficient to establish whether a coppiced rotation of less than six years would produce more fodder than a single stemmed pollard. If this were the case the development of a short rotation coppice could provide sufficient fodder while maintaining a small tree or bush with the benefit of a minimal cost to the surrounding crops.

An indication of the annual production of fodder in the field, and a rough idea of the amount one goat can consume would assist farmers in managing the number of trees available with respect to their dry season fodder requirements. This would be in contrast to current practice which is the defoliation of one or two trees.

M. volkensii is known to be a fast growing drought resistant tree. The knowledge of the potential annual production of fodder or other products and the management or economic cost of achieving that could affect the field production of *M. volkensii*. In Machakos one farmer had used fertiliser round the trees (to prevent competition with the maize) and had watered them. The initial stem elongation was impressive and likely to reduce the time to first fodder harvest, but might also have reduced the final timber quality. In Kibwezi very few farmers would be able to use inputs to alter tree productivity but improved non-labour intensive management techniques might well be adopted if the benefits were understood and realistic.

Further farmer experimentation of crops grown in the shade of *M. volkensii* might significantly improve the compatibility of this tree with their farming system. An improved understanding of the tree/ crop interaction might enable the extension workers to assist farmers in the choice and management of crops and with the dissemination of farmer developments within the community.

Pests and Diseases

It would be interesting to see whether termites are a significant cause of *M. volkensii* seedling loss as mentioned by farmers in Machakos, Kitui and Kibwezi. Simple experiments could establish whether clean weeding prevents termite problems in seedlings. If the termite problem was found to affect the productivity of older *M. volkensii*, where the damage was observed to be 'superficial', the need to prevent termite damage in the early stages might need to be explained to farmers.

The identification of the cause of the superficial bark flaking observed on *M. volkensii* in the Kibwezi area would result in a series of questions. If the problem was found to affect the survival or productivity of the tree the development of low technology practices might be required to enable farmers to prevent the cause or minimise the effects on their trees.

Medicines

While the verification of many of the medical uses of *M. volkensii* infusions and tisanes would require the field observations of a medic, the efficacy of a *M. volkensii* infusion in treatment of chicken mites and *M. volkensii* smoke in repelling insects could be investigated quite readily. If the results substantiated the efficacy of the treatments their use could be extended to other rural areas. The low cost treatment of chicken mites would be appreciated by both large and small scale farmers.

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ADDENDIX I

(Formal Interview)
CONFIDENTIAL
On Farm Interviews

Summer 1996
Interviewer;
District;
Village;

Date;

Name: M/F Age: Rel. to Household Head (HH)

N.B Alternatives in brackets are for interviewer only and not for the farmer.

2.0 Education
2.1 How much schooling have you (the respondent) had? Primary, secondary, post secondary, adult education?
2.2 How much schooling has the HH had? P, S, pS, A ?
2.3 How many people are there in the household?
2.4 How many of them are in school, and what grades?
2.5 How many of them help on the farm? (overlap?)

3.0 Land
3.1 Do you have a title deed for the land you farm? If not, who owns the land?
3.2 Is the land you have inherited (father to son), rented, bought by the HH, owned by yourself, your son, other?
3.3 How many acres does the household have?
3.4 How many acres does the household cultivate?
3.5 Do you rent or borrow land from anyone? If so, how many acres?
3.6 Do you rent or lend land to other relatives or people? If so, how many acres?
3.7 What is the topography of the land? (steep, hilly, flat, etc.)
3.8 How long does it take to walk to your furthest field? (5, 10, 20 mins, not sure)
3.9 Are your fields scattered, quite a distance, not too far, all nearby?
3.10 Do you employ extra labour? (continually, seasonally, rarely, never)
3.11 Do they get paid from the harvest or in cash?
3.12 Do you or your family work on others land? (regularly, seasonally, rarely, never)
3.13 Do they send their pay back to the household?

4.0 Trees
4.1 Have you planted trees on your farm?
4.2 What species and why?
4.3 Have you planted trees this year?
4.4 What products do you harvest from your trees? and in what quantities, what was sold? (firewood, timber, poles, fodder, fruit, green manure, medicine, other)

4.5 Where do you retain/ plant trees? (boundaries, home gardens, fields, communal land, mixture)
4.6 Where do you get tree seeds and seedlings from? anywhere else?

5.0 Melia volkensii (Mukau)
5.1 How many Mukau do you have? (many, several, one, none)
5.2 How many of them were retained or planted as seeds/ seedlings?
5.3 When was it planted? (month, year)
5.4 When did you first plant Mukau? (year)
5.5 Why did you choose this species?
5.6 What benefits has it provided? (soil, soil water, shelter, fodder, fuel, insecticide, timber)
5.7 What is the most important benefit? (and the next? etc.)
5.8 What problems have you had with Mukau?
5.9 Would you plant it now? (essential, preferred, useful, avoided)
5.10 Do the crops near the tree grow the same as the rest of the crops? (if not, what differences)

6.0 Non-adopters
6.1 Do you have or plant trees on your farm?
6.2 If so, what species do you have?
6.3 Which is the most important species? (and the next etc.)
6.4 What products do you harvest from them?
6.5 How much of the products do you harvest? (amount/ time)
6.6 Do you sell any of the products harvested? (who sells)
6.7 If so, who benefits from the money? (Household Head)
6.8 Do you know the Mukau tree?
6.9 Have you ever had it on the farm, or thought about planting it?
6.10 If so, expand? What differences did it make to your farm?
6.11 Do you know anything about the potentials or problems of the tree?
6.12 If you had more land, would you wish to plants trees? What species?
6.13 Would you prefer to have trees or no trees on your farm? (woodlot or forest product)

7.0 Management
7.1 Which household member decides when (seasonally) to plant and harvest Mukau?
7.2 Who is responsible for looking after the tree?
7.3 How was it propagated? (wildings, seed, seedlings)
7.4 What pruning, if any, do you do? When and how much? Do you use the prunings?
7.5 What age is the tree when you start harvesting the required products?
~~7.6 Which household member decides what and when to harvest?~~
7.7 Do you harvest manage one Mukau for one or several products?
~~7.8 What products do you obtain?~~

7.9 How do the products compare to similar products from other sources?
7.10 Do you know what quantity of products you harvest? (time scale)
7.11 Do you harvest sufficient for the household requirements?
7.12 Do you sell any of the products? Where?
7.13 Who benefits from the sale? (seller, HH)
7.14 Do you plan to plant more trees (inc. Mukau)
7.15 What would you grow (trees/ crops) if you had more land?

8.0 Crops
8.1 What annual crops do you plant?
8.2 When do you plant and harvest the crops?
8.3 What crops do you sell for cash? (quantity/ time)
8.4 Do you harvest enough for the family? if not where do you get the rest?
8.5 Do you know how much of each crop you harvested last year?
8.6 Was last you a year of very good, good, average or poor yields?
8.7 How often do you get good yields? (how frequent are 'bad' years?)
8.8 Do you ever try new types of maize (etc.)? If so did you see a difference in quality /quantity? Do you have much contact with extension workers?
8.9 What kind of fertilisers do you use on your fields? (manure, green man., chemicals)
8.10 What crops do you apply fertilisers to?
8.11 What inputs do you buy every season? and how much do you spend?

9.0 Soils
9.1 Is the soil on the farm good, average, poor, not sure?
9.2 What problems do you have with the soil?
9.3 Do you cultivate with a plough or with a hand hoe?
9.4 Do you ever add a mulch? if so what?

10.0 Livestock
10.1 What types of livestock do you own? (cattle, goats, sheep, poultry, rabbits)
10.2 Whose property are they? (HH, purchaser, other)
10.3 Who cares for the livestock?
10.4 Do they graze on your own land? rented? communal? mixture?
10.5 Are they free range, herded, stall fed or does this change seasonally?
10.6 Is the grazing local? expand?
10.7 Do you buy inputs for the livestock? (grain, fodder, medicines)
10.8 What products do you sell? (eggs, milk, meat, young)
10.9 Do the livestock affect the crops or tree seedlings?
10.10 What is your most important problem on the farm? and the next?...
10.11 What solutions have you tried?
10.12 How does what you do differ from the farming your parents did?

Casley & Lury (1981), Ely (1991), Abel & Prinsley (1991), McCracken, Petty & Conway (1988) and Martin (1995).

On Farm Data **APPENDIX II**

Code	Tree No.	Basal Diam.(cm)	D.B.H (cm)	Height (m)	Age (yrs)	Comments
A	1	19	8	5.2	10/6?	
A	2	40	17, 18, 21	9.7	10?	T Ms
A	3	28	20.5	8.8	10?	
A	4	-	-	-	10?	Cut
A	5	29.5	22.5	-	10?	T
A	6	13.5	23	7.2	10?	
A	7	34	24.5	9.4	10?	
A	8	26.5	21	8.1	10?	
A	9	40	28.5	11.5	10?	
A	10	24	17	-	10?	T
ZB	11	30	26	9.4	5	
B	12	36	27	9.4	5	
B	13	32.5	27	10.1	5	
B	14	30	20	9.7	5	
B	15	32.5	25.5	10.3	5	
C	16	25	18.5	-	4	
C	17	32	25	-	4	
C	18	33.5	25.5	11.2	4	
C	19	22.5	19.5	-	4	
C	20	27.5	20.5	10.9	4	T
C	21	36	31	-	4	
ZC	22	67	45, 32	11.5	10~	T Ms
ZC	23	65	38	11.2	10~	T Ms
ZC	24	57.5	37	9.4	10~	T
ZC	25	43	25	7.8	10~	T Ms
ZC	26	35	25, 26	9.1	10~	T Ms
D	27	33.5	28	11.2	-	T
D	28	45	18, 25	12	-	T Ms
D	29	35	28	10	-	
E	30	45	33	11	9	
ZD	31	78.5	61	12	>14	
ZE	32	51.5	31, 36	10	20	T Ms
ZE	33	22.5	18	8.5	7 ~	
ZE	34	48.5	41	12	20	T
ZE	35	29	19	9.1	7~	
ZE	36	43	33	10	20?	Ms
G	37	34.5	26	11.8	20	B V
ZF	38	7	4.5	3.1	3	
ZF	39	4	3.5	2.6	3	Ms Coppice
H	40	51	27.5, 25	11.5	9	Ms Flaky V
I	41	40.5	30	7.9	8?	
I	42	56	33, 26	10.6	8?	T Ms 6 x 7
I	43	32	11	5.6	7	Ms
I	44	20	17.5	5.5	3	Flaky
ZG	45	60	23.5, 27.5	11.2	5/6	T Ms 5 x 6

On Farm Data

APPENDIX II

Code	Tree No	Basal Diam. (cm)	D.B.H (cm)	Height (m)	Age (yrs)	Comments
Wild	46	49.5	42	9.1	-	on common land B
ZH	47	28	18.5	7.8	-	
ZH	48	16	13	5.8	-	T B
ZH	49	-	3,6,2.5,2.4	4.8	-	T Ms Flaky, C15 stems
ZH	50	43.5	40	12.6	-	Being Felled
ZH	51	57	37	9.7	-	T 8 x 6
ZI	52	84.5	68.5	12.6	64~	T
ZI	53	17	11.5	5.2	-	B
ZJ	54	15	8	4.5	2	
ZJ	55	40.5	17, 23	9.4	6	T Ms Flaky
ZJ	56	57	28, 34.5	12.6	15	Ms 5 x 6
J	57	38	30.5	10.3	22	V
J	58	39	44	10	22	B V
ZK	59	45	33	10.6	-	
ZL	60	62	64	11.3	-	
ZM	61	39	27	10.6	-	T
ZM	62	33	36	11.2	-	
ZN	63	33	17, 18.5	10	-	T Ms
ZN	64	33	36	10.6	-	
ZO	65	40.5	28	10.9	-	
ZO	66	-	-	1.3	2?	C 10 stem
ZO	67	14	3, 4, 6	3.1	-	T Ms
ZQ	68	46.5	25.5, 22	11.5	matu.	T Ms
ZR	69	59	53.5	12.6	6~	T 6 x 7
ZR	70	57	20x2,17.5x2	11.8	6~	Ms Flaky
ZS	71	31	16.5, 18.5	10	5	Ms Flaky 5 x 6
ZU	72	47	29,26,cut x2	12.3	20	Ms Flaky
ZV	73	41	26.5	7.5	-	B
ZV	74	64	50.5	12.9	-	T Ms B
ZV	75	41	18.5, 20.5	8.8	-	Ms
ZV	76	61.5	46	12.6	-	T
ZW	77	27	11.5	4.1	-	Ms B
ZW	78	16.5	14.5	6.5	-	
ZW	79	33	34	6.9	-	Ms
L	80	46	40.5	10.6	10	V
ZX	81	46	42	11.2	-	T B 8 x 5
ZX	82	55	53	10.6	-	T
Z	83	54.5	42.5	13.1	10	10 x 8
M	84	24	18, 16	9.4	6	Ms Flaky

Key

T - Termites (superficial)
MS - Multi-stemmed
B - Browsed
Flaky - Bark flakes

4 x 5 - Canopy dimensions at 90° (in m)
V - Tree on Volcanic soils
C 10 stem - Coppiced with 10 stems
? (farmer not sure) ~ (approx.) - (no data)

APPENDIX III

Ranking of Tree Species Using the Bao Game

Tree Species; *Acacia tortilis*, *Brachylaeria huillensis* (Muhugu), *Cassia siemea*, *Dalbergia melanoxylon*, *Jacaranda mimosifolia*, *Leucaena leucocephela*, *Melia volkensii*, *Olea africana*, *Prosopsis juliflora*, *Terminalea mantaly*, Mango, Itula

"Kithito cha Kivuthini" Farmers Group

Categories

1) speed of growth
2) survival
3) termite resistance
4) drought resistance
5) crop compatibility
6) soil improvement
7) fruit as fodder
8) leaves as fodder
9) medicine
10) firewood
11) timber use/ value
12) hardness

	Leuc.	Acacia t.	Dalberg.	M. volk.	Cassia	Termin.	Pros. j
1	4	4	3	5	3	5	4
2	5	4	3	5	5	5	4
3	5	5	5	5	5	1	5
4	5	5	1	0	4	1	3
5	5	4	5	0	1	0	0
6	5	0	0	0	4	0	0
7	5	5	1	5	1	0	0
8	5	5	5	4	1	5	0
9	5	5	0	5	0	0	0
10	1	4	5	0	1	1	0
11	0	0	4	5	2	0	0
12	2	4	5 ←	3 ←	2	2	0
Σ	52	45	37	37	29	20	8/60

Makindu Handi-craft Cooperative of Carvers

Categories

1) wood colour
2) hardness/ ease of carving
3) termite resistance
4) timber durability
5) water resistance (spoons)
6) cost - could not do

	main timbers used				lighter wood		
	Olea	Dalbergia	Brachy.	Itula	M. volkensii	Jacaranda	Mango
1	5	4	3	2	1	1	1
2	4	5	3	1	1	2	1
3	5	5	5	5	5*	1	1
4	5	5	5	5	5	1	1
5	5	5 ←	5	1	1 ←	1	1
Σ	24	24	21	14	13	6	5 /25

* white wood susceptible to termites. (method pers. comm. Steve Franzel)

5 = performs well 1 = performs poorly 0 = do not know

APPENDIX IV

Tree Species Planted and Retained by Farmers

Common name	Botanical name	Use
Makorobia (Avacado)	*Pesea Americana*	Fruit
Pawpaw		Fruit
Mango		Fruit/ Carving
Guava		Fruit
Lemon		Fruit
Mukunga manga		Fruit
Mjohoro (Swahili)	*Delonix regia*	Eat Pods & Roast Flowers
Kithumula	*Talmerindus indica*	Fruit/ Charcoal
Mgunazi		Food
Mzabibu (grape ?)		Fruit
Mukwasa		Flavour Porridge/Shade
Matomoko (Makulo)	*Annona senegalensis*	Fruit/Fodder
Mtae	*Morus alba*	Fruit/ Fuelwood
Mwarubaini (Swahili)	*Azardiracta indica*	Medicine/ Shade
Muthulu	*Croton megalocarpus*	Shade/ Hen Medicine
Mchora	*Cassia siemea*	Shade
Mukengeka		Shade
Musalakwe	(*Moringa oleifera*?)	Fruit
Mutmuyo/ Kiukali walu		Fruit
Mulaa	*Acacia tortilis*	Fodder
	Leucaena leucocephala	Fodder/ Soil Enrichment
	Prosopis tortilis	Fodder/ Fencing
Mzambarau	*Syzgium cuminii*	Fruit/Timber
Masanducu		Timber/ Measles Cure
Mukulia		Timber
	Jacaranda mimosifolia	Timber(termite resistant)
Itula		Timber(termite resistant)