COMMERCIAL FORESTRY IN SEMI-ARID KENYA

The case of *Melia volkensii*

By Jan Vandenabeele (Better Globe Forestry Ltd) and James Kimondo (KEFRI)

Presented during the First Kenya Commercial Forestry Investment Conference, held by KEFRI during 23-27th November 2021, in KEFRI HQ, Muguga, Kenya.

Abstract
Over 80% of Kenya is considered arid and semi-arid. Tree species choice for commercial forestry is limited in these areas, all the more for species able to produce timber. To date *Melia volkensii* is the best choice in terms of rotation, yield and quality of timber, though other commodity species can be considered.
This paper looks at various aspects of *M. volkensii* including:

- silvicultural characteristics, with fast initial growth and wide-spreading branches requiring sufficient light;
- management schedule for the species in a plantation lay-out, with emphasis on pruning and thinning, where 3 different thinning densities are being considered;
- management schedule for the species in an agroforestry lay-out, characterized by wide spacing (minimum 7x7m), with pruning followed by lopping of branches to compress the canopy diameter and allow more light for intercropping.

The paper also reviews yield and financial information on *M. volkensii* timber produced in an agro-forestry system of 100 trees per ha in a rotation of 18 years, producing a tree with 45cm DBH and commercial height of 5.5m, resulting in a log of $0.585m^3$ and an MAI of $4.063m^3$/ha/y. A stumpage fee of 10,000Ksh per tree is compared with potential income from timber, and current quality and availability of *M. volkensii* timber is briefly discussed.
Up-scaling the currently low presence and quality of *M. volkensii* agro-forestry systems will need investment, for which carbon sequestration money is suggested.

1. *Melia volkensii*: silvicultural characteristics

Botanically, *M. volkensii* belongs to the Meliaceae family, and grows in East Africa, principally in Kenya, and to a lesser extent in Somalia, Ethiopia and Tanzania. It prefers well-drained loamy sands although it has been observed occasionally growing on clayish soils (e.g. on the foot slopes of the Chyulu Hills, Makueni County). The preferred Mean Annual Rainfall (MAR) varies between 350mm and 900mm. It thrives in areas with high temperatures, ranging between 14 and 35 degrees Celsius. This means the species is well adapted to arid and certainly semi-arid conditions.
It is fast-growing, both in height and diameter, notably before the age of 10 years, after which growth in height slows down considerably. The tree can attain heights of up to 20m (Beentje, 1994), but this depends on the site quality. Site quality is related with MAR and total heights of 12m are reached after 10 years in Tiva (Ndufa *et al*, 2018). In the same study, DBH of 25cm is mentioned at the age of 11 years, for Kibwezi. In the wild, some individuals with a DBH of 50cm have been encountered, but this could not be related with age. However, overmature individuals can develop root rot.
The rotation of the species is not yet well known, with farmers felling their trees between 10 and 12 years, while Better Globe Forestry expects to harvest at year 20 for plantations, and between 15 and 20 years in agro-forestry set-up.

It is a light-demanding species, with light foliage and wide spreading branches that can give a canopy projection on the ground of 15m diameter or more. This corresponds to roughly a circular surface area of about 180m^2. It responds well to pruning, although epicormic shoots can appear around the pruning scars. In the wild, the species occurs both as a shrub or a tree because of genetic degradation as a consequence of overharvesting superior individuals in any area. Once established, it can stand heavy destruction though it sprouts from its root system to form a bush.

Despite its fast growth, it produces a durable, mahogany-type high-value timber that is resistant to termites.

2. *Melia volkensii* plantations

Routine establishment practices consist of land preparation, pitting, weeding and mulching, occasionally watering, and protection against livestock (goats!). In this respect there are few differences with other species. This chapter will discuss two aspects peculiar to *M. volkensii*, which are pruning and thinning.

Currently, spacing of 4x4m or a density of 625 trees per hectare, is the generally accepted planting practice, although spacings of 3x3m (1111 trees/ha) are also encountered. This corresponds to a growing space of 16m^2 and 9m^2 respectively and results in an almost complete halting of growth after 4-5 years because of lack of light. Due to limited knowledge on the need to thin and therefore reluctance to carry it out, most melia plantations in many areas are characterised by thin stemmed individual trees. Furthermore, most farmers consider thinnings as a waste of money due to the high cost of seedlings and the need for high quality maintenance.

2.1. Pruning

Better Globe Forestry Ltd has adopted the below pruning schedule, with the objective to achieve a branch-free bole of 5m by end of year 4 with knots restricted into a central core of 10cm. On good sites, 5.5m – 6m long logs can be achieved.

A schedule of ten pruning cycles is realised to this effect, with the early ones worked from the ground, while from year 2 onwards a ladder is required to do pruning in height (tables 1 and 2).

It is important to prune around the top of the tree, to avoid top-heavy canopies and stimulate the leading shoot. This is often a problem with farmers, who stop pruning when they cannot reach the branches from the ground, resulting in commercial, branch-free, stem lengths of 2.5-3m, constituting a heavy loss of income.

As can be seen from table 1, pruning is intensive in the first years after establishment, and can stop after 4 years.

Table 1: General pruning schedule

Pruning	Age (yrs)
1st	1
2nd, 3rd, 4th	2
5th, 6th, 7th	3
8th, 9th, 10th	4

Table 2: Pruning schedule with heights

Pruning	Age	Tree height	Pruning height
1st	6-12 months	1-2m	not defined

2nd	13-16 months	2-3m	1m branch-free
3rd	17-20 months	3-4m	1.5m branch-free
4th	21-24 months	4-4.5m	2m branch-free
5th	2-2.3 years	4.5-5.5m	2.5m branch-free
6th	2.3-2.7 years	5.5-6m	3m branch-free
7th	2.7-3 years	6-7m	3.5m branch-free
8th	3-3.3 years	7-7.5m	4m branch-free
9th	3.3-3.7 years	>7.5m	4.5m branch-free
10th	3.7-4 years	>7.5m	5m branch-free

Considerations:

- Remove one of the leaders among those with double leaders
- Remove deformed main stems
- Remove branches with diameter above 1" (2.5cm) while small branches should be left
- Avoid excessive pruning leading to sprouting of epicormic shoots
- Avoid top-heavy trees prone to bending by wind

During the first two years, the removal of branches is selective, following the above considerations, and does not imply cutting all branches along the stem simultaneously, like the traditional pruning of a pine tree. Instead, it is common practice to leave small branches alongside the stem for the next pruning cycle, and to concentrate on the top of the young tree which reacts to pruning by forming many branches there, that have to be reduced in number.

2.2. Thinning

For the development of a diameter (DBH) of at least 40cm, and a branch-free height of 6m, by the age of 16 to 20 years, the species needs sufficient light, for which thinnings are required. So far no known published research work has been done in this field.
A mock first thinning in BGF's Kiambere plantation (altitude 750masl, MAR 813mm) in Oct 2013 on a stand of 400 trees of 4 years old gave the following data (table 3):

Table 3: results of a mock first thinning at 4 years in Kiambere

parameter	Before thinning	After thinning	difference	difference %
DBH (cm)	11.9	12.1	+0.2	2%
Basal Area (m^2)	6.89	5.54	-1.35	20%
Commercial height (m)	5.40	5.51	+0.11	2%
Volume (m^3/ha)	26.6	21.67	-4.9	18%
Trees/ha	625	472	-153	24%

Average DBH of the felled trees was 11.1cm, useful for poles. Volume calculation assumed a taper (shape) of 0.7. The thinning intensity was 24% in number of trees, and a 20% reduction in Basal Area (m^2), which was at 6.89m^2/ha before the thinning, with canopy closure. Research has to establish whether this figure can be considered as a threshold, indicating the need for a thinning intervention.

From this exercise, and field observations, the below thinning schedules are proposed, for a rotation of 16 (-20) years (tables 4-6). The growing area per tree (in m^2), gives the space in which the tree can develop its canopy to capture more light, and the area to spread its rooting system without competition. This is translated in the last column into the diameter the canopy is able to achieve. The true measure of a thinning, the reduction in Basal Area, cannot be given, but as a percentage it will be lower than the percentage of number of trees cut.

Table 4: Option 1: opening the stand gradually

Age (yrs)	trees/ha	Trees cut/ha	% cut	Growing area/tree (m^2)	Canopy diameter (m)
1	625	-	-	16.0	4.0
4	469	156	25%	21.3	4.6
8	311	158	25%	32.2	5.7
16	-	311	50%	-	-

Table 5: Option 2: heavy first thinning

Age (yrs)	trees/ha	Trees cut/ha	% cut	Growing area/tree (m^2)	Canopy diameter (m)
1	625	-	-	16.0	4.0
4	419	206	33%	21.3	4.9
8	324	95	15%	32.2	5.6
16	-	324	50%	-	-

Table 6: Option 3: two heavy thinnings

Age (yrs)	trees/ha	Trees cut	% cut	Growing area/tree (m^2)	Canopy diameter (m)
1	625	-	-	16.0	4.0
4	419	206	33%	23.9	4.9
8	261	158	25%	38.3	6.2
16	-	261	42%	-	-

The last option will give the trees with the biggest diameters, but with less trees at the end of the rotation.
However, none of these hypothetical thinning schedules have ever been carried out with results compared at the end of the rotation.

3. *Melia volkensii* in agro-forestry lay-out

This is planting of trees in a farmer's field at a wide spacing, not less than 7m apart, ideally following contour lines with anti-erosion works (e.g. fanya chini), where soil dug out of the ditch is heaped in a bund at the down-side. The planting is done just below the bund, to allow the roots to tap into the water present in the soil after rains, built up by run-off captured and infiltrated in the ditch. The 7m spacing translates into a growing space of 49m^2, allowing a maximum of 200 trees/ha. Again, optimum spacing is not known, and could be as low as 100 trees/ha.
Often the trenches are more than 7 m apart, e.g. 10m, and spacing can be flexible, not confined to a square lay-out, like 10x5 or even 10x10m, as long as the minimum growing space is close to 50m^2.
This allows for intercropping during the first 5-8 years, after which an intervention has to take place to have more light reaching the soil, to benefit crops. Notably in year one, it is not advisable to have crops like maize, sorghum or millet, but a legume like cowpeas and green grams to avoid shading the melia tree seedlings. Even so, ploughing has to respect a minimum distance

(0.5m) away from the seedling, to avoid root damage. Alternatively, perennial grasses can be sown, for hay production.
The pruning schedule as explained above, can be applied, but after 5 years, the branches have to be lopped, to compress the diameter of the canopy. Lopping is defined as cutting branches some 30-100cm away from the stem, after which twigs will sprout from around the cut surface, but grow in a more upright manner with reduced spreading.
This is traditionally done by farmers in Ukambani, to obtain fodder for livestock during the dry season. An additional benefit is the production of firewood (of bigger diameter than pruning products).
Another farmer practice is to "top" the tree, meaning to cut off the stem at the point of first branching, and actually eliminating the whole canopy, with the intention of "fattening" the tree. Obviously, tree growth is affected, but branches sprout at the top and regrowth takes place. No research has been done on this, but field observations indicate that taper might diminish, with the stem getting a more cylindrical shape.
It is clear that thinning is not required in this lay-out.

4. Yield and financial information

4.1. Present situation

Except for areas like lower Embu (Kiritiri and its environs), sale of *M. volkensii* trees in the countryside is relatively rare though the timber remains a favourite for most users. In effect, undersized, crooked and inferior quality trees are being sold in the local market. Typically, the price of the tree is negotiated individually with the seller, and the tree is split with a chainsaw into timber of various sizes. Prices (stumpage) can vary between 5,000 - 10,000Ksh per tree.

Timber prices vary considerably from place to place (e.g. Kitui town, Kibwezi…) and the timber itself is often of low quality, with scars from poor pruning, patches of whitish sapwood and rough surfaces and uneven widths because of the chainsaw. Seasoning is not done, and warped planks are a common sight. The table below therefore is only indicative. Mahogany from DRC (also produced by chainsaw although from bigger trees) is 60-70% more expensive (table 7), and although the trees themselves are free (poached from the rain forest), costs soar because of transport distances, corruption and illegal taxations. Chances are that DRC timber will be priced out of the market once more melia timber is available.
Cypress on the other hand is cheaper.

Table 7: timber prices of melia vs DRC mahogany (and cypress)

timber size (inches)	Ksh/ft			details
	melia	DRC mahogany	cypress	
2x2	70	-		
2x3 (Z)	100	-		
3x3 (Z)	120			
2x4 (Z)	110	-	70	
6x1 (Z)	100	160	50	common size for DRC timber
6x2 (Z)	220	300	110	common size for DRC timber
8x1 (Z)	130	-		very rare for melia
8x2	200	-		very rare for melia
10x1	160	-		very rare for melia

(Z): Zombe Wood Furniture Ltd, Kitui town, Nov 2021

4.2. Agro-forestry model

The below table gives an estimate for trees planted in an agro-forestry system, at 100 trees/ha, subjected to good management practices as described above, and with a rotation of 18 years. Waiting 18 years though is a long time for any farmer and he will be subject to serious pressure to sell whenever the tree reaches a DBH of 35cm or so.
Assuming ideal circumstances as stated in the table, as well as the sales price of the standing tree, the stumpage cost of one cubic meter of wood is 17,000Ksh (table 8). The Mean Annual Increment (MAI) might be low, at 4m^3/ha/year, but this is an agroforestry system which generates additional income streams from annual crops or perennial grasses, while the maturing trees consistently accumulate value over the years (annual equivalent value of 22,000 Ksh).

Table 8: stumpage cost of wood on farm in an ideal agroforestry set-up

Item	Unit	Quantity	Details
avg vol/tree	m3	0.585	DBH 45cm, comm height 5.5m, taper 0.7
rotation	years	18	variable 15-20 years
trees/farmer	nr	100	on 0.8 ha (2 acres)
vol/farmer	m3	58.511	on 0.8 ha (2 acres)
MAI	m3/ha/yr	4.063	
stumpage cost/tree	Ksh	10,000	variable
value for farmer	Ksh	1,000,000	at stumpage cost
annual equivalent value	Ksh	21,930	at 10% average annual interest rate
cost/m3 of wood	Ksh	17,091	at stumpage cost

4.3. Processing

An investment in a small-sized stationary sawmill with an annual capacity of processing 7,000m^3 of logs would require some 100,000 USD, including land, simple infra-structure, electricity and water supply and miscellaneous. Such a sawmill would rely on approximately 5-6,000 farmers with agro-forestry systems as described.

When processing with a bandsaw at a conversion rate of 40%, which is better than with a chainsaw, about 4 trees are required to obtain one cubic meter of timber, and the corresponding stumpage cost of 1 cubic meter of timber is 43,000Ksh, without including felling, transport, sawing, and other costs.

Table 9: stumpage cost of timber per m^3

item	unit	quantity	details
conversion	%	30	chainsaw
conversion	%	40	bandsaw
timber/tree	m3	0.234	with bandsaw
trees/m3 of timber	nr	4.27	
cost/m3 of timber	Ksh	42,727	

It is beyond the scope of this article to analyse the functioning of such a sawmill, but the table below gives an idea of profitability. It shows the possible output in timber from a 45cm DBH log of 5.5m length, into different sizes of planks, by using a bandsaw and trained personnel. When combined with the market prices of table 7, the total value of the timber amounts to 26,000Ksh, which is more than double the stumpage price of 10,000Ksh. The difference, clearly, is in the cost of farmer organization, value adding and the profit that can be made.

Table 10: Potential processed timber and its price from a 5.5m log of 45cm diameter

size "	quantity	ft	price Ksh/tree
2x4	4	17	7,480
2x3	2	17	3,400
1x8	2	17	4,420
1x10	4	17	10,880
TOTAL			26,180

5. Up scaling agro-forestry tree planting

Presently, there is no consistent policy or guidelines in place to advice farmers at the County level how to go about planting sufficient volumes for sawmilling. To reach commercial levels as explained above (5-6000 farmers for a sawmill of 7000m^3 logs/year capacity), investment and capacity building is required. The likely institutions that come to mind are Kenya Forest Service, Kenya Forestry Research Institute and the County governments. In the past, some donor agencies have significantly contributed to capacity building of the farmers regarding planting of melia (Belgian Technical Cooperation through ARIDSAK and INREMU, JICA through CADEP and its predecessors). Currently, private companies like Better Globe Forestry and KOMAZA are partnering with farmers to plant melia. Least but not least, numerous farmers mostly small holders have also engaged in the practice.

This is however not sufficient, and not because of lack of farmers. It also is not because of lack of the right environment, although this can contribute to seedling mortality. Largely, it is because of <u>lack of investment</u>, in farmer organization, capacity building and seedling production. This can be addressed as follows:

1) Farmer organization: for many purposes, farmer groups are the ideal vehicle. One group typically is comprised of 25-30 members; hence 200 groups are required, with farmers near each other to cut down on logistics.
2) Capacity building: the question is not the content nor nature of the capacity building, which are all known, it is its organization. Which kind of extension services are we talking about and who will pay for it?
3) Seedling production: presently seedling production is not of the required quality, neither of the appropriate price for the small-scale farmer. More quality seeds must be made available at affordable price, and stronger seedlings must be produced. Seedlings are commonly sold at 50Ksh/piece, while their production costs approximately 20Ksh. This price must come down, as the average farmer can't afford it.

Quite some carbon would be sequestrated in the up scaling, so that is maybe the way to go. As per an algorithm in a KEFRI publication (Ndufa *et al*, 2018), one tree of 45cm diameter would be able to fix 0.56 tonne in its biomass, both above and below ground. Prices of carbon money are variable and keep on changing, but at a price of 10 USD per tonne, such a tree is worth 5.6 USD or 616 Ksh. As the carbon money is paid in advance (at least partly), this is amply sufficient to produce the seedling, plant it, and manage it for some years.

6. Conclusions

While the potential for commercial timber production in semi-arid Kenya is undoubtedly present, and based on a species, *Melia volkensii*, that is adapted for the purpose; management techniques notably thinning need more fine-tuning and more planting needs to be encouraged.
Agroforestry with melia shows good promise and must be up scaled. This shall provide the basis of enhancing the currently poorly developed processing as now there is not enough trees around.

Semi-arid places in general have no tree planting culture, and serious capacity building and cheaper seedlings are required to encourage farmers to engage in commercial melia planting.
This article has concentrated on some technical aspects like pruning and thinning and provided information on yields for an agroforestry system at 100 trees/ha where trees are bought at a stumpage fee of 10,000Ksh/tree. It has also attempted to analyse prices that show that agro-forestry plantations of melia are profitable, both for investors and for farmers.
Required investment for up scaling agro-forestry tree planting can be sourced through carbon sequestration funding.

References

- Beentje H., 1994. Kenya Trees, shrubs and lianas. National Museums of Kenya.
- Ndufa JK, Miyashita H, Kigwa B, Auka S, Muturi G, 2018. Estimating biomass and carbon stocks of *Melia volkensii* plantation in drylands landscapes of Kenya. In: Proceedings of International Conference on the "Project on Development of Drought Tolerant Trees for Adaptation to Climate Change in Drylands of Kenya" held at KEFRI Muguga, 13-16 February 2017, p106-116. KEFRI.