

Utilization of indigenous tree species for improve land productivity and household income

End-of-Project Report

Bernard Fungo, Gerald Ongodia, Jude Sekatuba, Susan Nansereko, Kenneth Eryau and Richard Akelem



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EXECUTIVE SUMMARY

Agroforestry ranks high among the significant initiatives in improving Sustainable Land Management (SLM). Indigenous tree species for integration in agroforestry systems stands a high chance of success because these species are already adapted ecologically, and are socially accepted compared to foreign species. Therefore, the aim of this study was to improve our understanding of how selected indigenous trees can be managed to improve land productivity and income of small-holder farmers in Uganda. The desired result is to increase the use of indigenous trees species for increased productivity of cropping systems.

A household survey was conducted to assess the conservation and use values indigenous tree species. Based on this study, four indigenous tree species were selected for further investigation. The selected trees species include *Makhamia lutea*, *Albizia coriaria*, *Cordia africana* and *Faidherbia albida* were selected from three agroecological zones (Humid eastern highlands in Mbale and Bududa, sub-humid eastern plains of Tororo and Lira, and the semi-arid Karamoja).

Cordia africana was been investigated for its potential to provide shade in coffee-banana cropping systems with field studies conducted in Bududa and Mbale districts in eastern Uganda. Generally, coffee productivity was better in terms of size, succulence and quantity of the berries per bush; and overall bush vigour under *C. africana* tree shade as compared to where there was no tree shading. Crown pruning of *C. africana* shade trees was the most plausible management practice that farmers were practicing on their farms.

Faidherbia albida is a species that has been widely reported to have important soil fertility benefits. However, it has been reported to have a highly restricted distribution with the niche being found only along banks of rivers and streams. The tree species is thus being investigated for its distribution in the Karamoja region of Uganda and for its potential to be included in future scaling-up to other dry lands areas in the country. Using ecological information from literature, spatial interpolation techniques were used to develop a map showing that 44% of Uganda is suitable for integrating *F. albida* in agroforestry systems.

Makhamia lutea was investigated to determine the optimum distance between the tree and the crops is not well-known. Fifteen paired plots with and without Makhamia were planted with maize and the influence of the tree on maize yield was measured. The yield of maize was not affected by Makhamia but the soil organic matter 15% higher in Makhamia compared to non-Makhamia plots.

For *Albizia coriaria*, the challenge is to quantify the contribution of soil quality improvement to the yield of crops under appropriately prune the canopy to a level of openness needed to optimize yield of beans. A field trial comparing beans under Albizia tree and those away from the influence of the tree but similar environment showed that the yield of beans was 30% higher, indicating that the soil improvement

properties of the leguminous *Albizia* can be used to improve the yield of beans in semi-arid parts of Uganda.

Albizia coriaria is another leguminous tree that improves soil fertility and does not compete with shallow-rooted crops such as beans. The challenge is the heavy crown that requires appropriate pruning to allow enough light through the canopy. Appropriate canopy openness needs to be determined.

Results from this project show that indigenous tree species have the potential to contribute to improve the productivity of agricultural land and income of farmers. The challenges that needs to be addressed in order to realize the full potential of agroforestry with indigenous tree species include how to disseminate information on appropriate tree management practice that farmers need to undertake to optimize tree-crop interactions; testing options for integrating unconventional tree species in new practices such as *Maesopsis eminii* I coffee-banana agroforestry and *Faidherbia albida* in semi-arid area outside the natural range in Uganda.

A number of publications were developed including one peer-reviewed journal article, three technical reports, a training manual on shade management for yield optimizing in coffee-agroforestry systems and a brochure on the distribution range of *Faidherbia albida* in Uganda were developed.

1.0 INTRODUCTION

Integration of trees with crops is well-known for its benefits including provision of goods such as fuel wood, fruits, timber, fodder and services such as microclimate modification, water purification, wind breaks, carbon sequestration and soil improvement (Ramachandran et al., 2012). So far, agroforestry has mainly been a crop system and a tree system side by side. However, a new paradigm is required where trees and crops are selected and managed together. For example, shade-tolerant crops adapted to particular tree species, Trees and crops with non-overlapping roots, and Trees and crops with temporally differentiated ecological requirements (e.g. dry and wet season). Although there are many tree-crop-animal combinations, some work well while others do not. Therefore, selection of appropriate tree species is an important step towards realizing successful agroforestry practice.

Integration of indigenous tree species stands a high chance of success because these species are already adapted ecologically, and are socially accepted compared to foreign species. Therefore, the aim of this study was to improve our understanding of how selected indigenous trees can be managed to improve land productivity and income of small-holder farmers. The desired result is to increase the productivity of cropping systems in Uganda through integration of trees on-farm. Since its inception in 2012, the project has assessed four indigenous tree species which include *Makhamia lutea* and *Albizia coriaria* in semi-arid Tororo and Lira districts, *Faidherbia albida* in the dry land Karamoja region and *Cordia africana* in humid eastern Uganda.

Makhamia lutea has potential to improve soil fertility if planted in intercrop with maize, but root competition can downplay this benefit. Therefore, the optimum distance between the tree and the crops is not well-known. *Albizia coriaria* is another leguminous tree that improves soil fertility and does not compete with shallow-rooted crops such as beans. The challenge is the heavy crown that requires appropriate pruning to allow enough light through the canopy. Appropriate canopy openness needs to be determined. Similarly, *Cordia africana* has been investigated for its potential to provide shade in coffee-banana cropping systems with field studies conducted in Bududa and Mbale districts in eastern Uganda. *Faidherbia albida* is a species that has been widely reported to have important soil fertility benefits. However, it has been reported to have a highly restricted distribution with the niche being found only along banks of rivers and streams. The tree species is thus being investigated for its distribution in the Karamoja region of Uganda and for its potential to be included in future scaling-up to other dry lands areas in the country.

2.0 OBJECTIVES OF THE PROJECT

The general objective of the project was to improve our understanding of the management practices that optimize tree-crop interactions to achieve higher land productivity and household income. The specific objectives were;

1. Assess socioeconomic attributes of indigenous tree species and their contribution to land productivity and crop yields.
2. To evaluate tree management practices that optimize yield of companion crops in silvicultural agroforestry systems.
3. To enhance the capacity of farmers in tree management practices to improve productivity of tree-crop interactions

3.0 PROJECT OUTPUTS

3.1 Socioeconomic attributes of indigenous tree

This study assessed the indigenous tree species conservation and Use Values in the Kyoga plains and the highland ranges Agro Ecological Zones of Uganda. A semi-structured questionnaire was used to capture primary data from a total of 422 household heads.

The results showed that most of the local communities in Eastern highland ranges prefer planting and retaining indigenous tree species in crop fields, while deliberate tree planting in the vicinity of family compounds (homestead) was predominant in the Kyoga plains (Fig. 1).

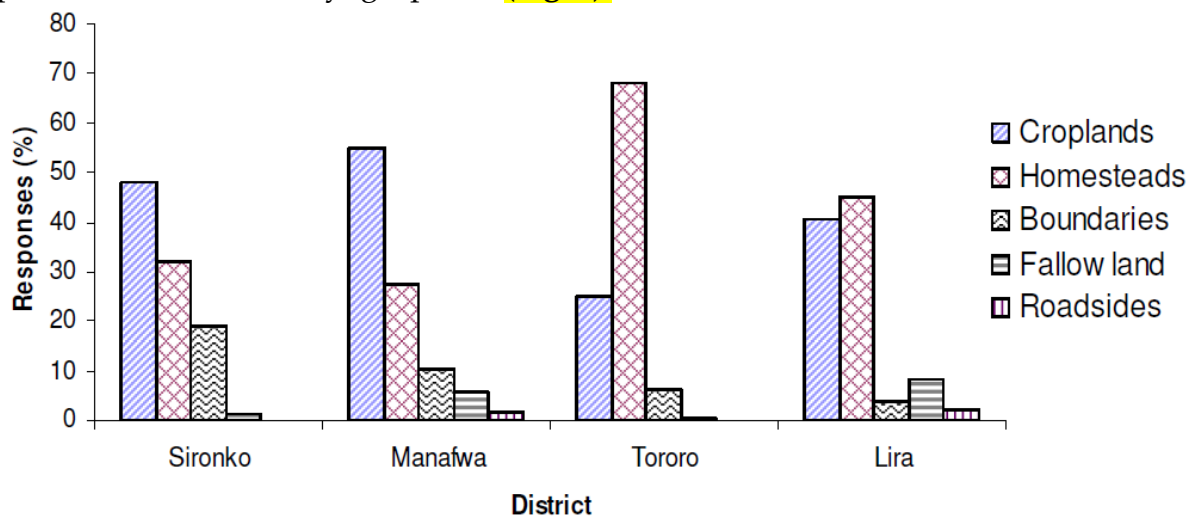


Fig.1: On-farm distribution of indigenous tree species in the Kyoga plains and the highland ranges Agro Ecological Zones of Uganda

Indigenous tree species mode of establishment, propagation and management options significantly differed across the four study sites (Table 1).

Table 1: propagation, establishment and management of indigenous trees species in the Kyoga plains and the highland ranges Agro Ecological Zones of Uganda

District	Establishment method (%)		Propagation method (%)				Tree species management (%)				
	Planted	Retained	Seed	Seedlings	Stem cuttings	Wildings	None	Prune	Coppice	Fence	Weed
Sironko	19.8	80.1	10.9	56.6	17.1	15.4	73.3	13.5	12.7	0.5	0
Manafwa	29.9	70.1	10.4	57.2	12.9	19.4	32.7	48.2	1.8	0	17.3
Tororo	56.9	43.1	14.4	20.3	9.7	55.5	52.7	42.1	4.7	0.5	0
Lira	55.4	44.6	17.1	27.2	2.4	53.3	37.9	51.2	9.4	1.2	0
Total (%)	42.1	57.9	13.9	39.9	8.8	37.3	45.8	41.6	7.9	0.7	4.0
χ^2	438.17		817.76				1080.81				
P-Value	0.002*		0.001*				0.001*				

*Significant at 1% significance level

The overall tree species Use Value Indices generally correspond to the number of uses of a particular tree species and vary between 2.4 and 0.2. Our study findings show rather a narrow range between the highest and least use value, implying that communities generally valued a particular tree species for at least more than one preferred use. Local communities prefer protecting naturally growing indigenous tree seedlings than planting. They facilitate tree regeneration when the benefits of their investment are guaranteed and the economic value such trees can provide to the household. Therefore, while evaluating indigenous tree species for relative importance and use, the end objectives of such evaluation must be critically examined in the light of the interest of the different tree resource user groups.

3.2.0 Tree management practices that optimize yield of companion crops

3.2.1 On-farm management options of *Cordia africana*

A combination of methods Focus Group Discussions (FGDs) (Fig. 2A), individual farm household interviews and farm reconnaissance walks were used to identify existing management practices of *C. africana* trees in Bududa and Mbale districts. The aim was to gain insights into applied management options that farmers were using to manage *C. africana* shade trees in their farms. A face to face inquiry with the farmers on coffee yield trends, based on their harvest records, under application of the management practice of *C. africana* shade trees on coffee and in non-tree shading conditions was conducted. A spherical densiometer was used to estimate the level of application of management practice on *C. africana* shade trees on coffee (Fig. 2B).



Fig. 2: Methods used to collect information on management practices of *Cordia Africana* in Bududa and Mbale districts: A-Focus group discussion with farmers in

Bududa district; B- Estimating *C. africana* shade tree crown management intensity using a spherical densitometer

The existing management practices (Table 2) of *C. africana* trees that farmers were include branch/crown pruning, lopping, weeding, manuring and pollarding. Other management practices on cordia trees were thinning especially where wildlings were congested and staking of the Cordia trees at early stages of establishment. The most prevalent management practices of *C. africana* shade trees were weeding, crown pruning and manure application while the least were lopping and pollarding.

Table 2: Management practices for *Cordia africana* tree used by farmers in Bududa and Mbale district, eastern Uganda

Management practice	Frequency	Percent
Crown pruning	46	31.3
Lopping	8	5.4
Pollarding	10	6.8
Weeding	51	34.7
Manuring	32	21.8
Total	147	100.0

Generally, coffee productivity was better in terms of size, succulence and quantity of the berries per bush; and overall bush vigour under *C. africana* tree shade as compared to where there was no tree shading (Fig. 3). Crown pruning of *C. africana* shade trees was the most plausible management practice that farmers were practicing on their farms.

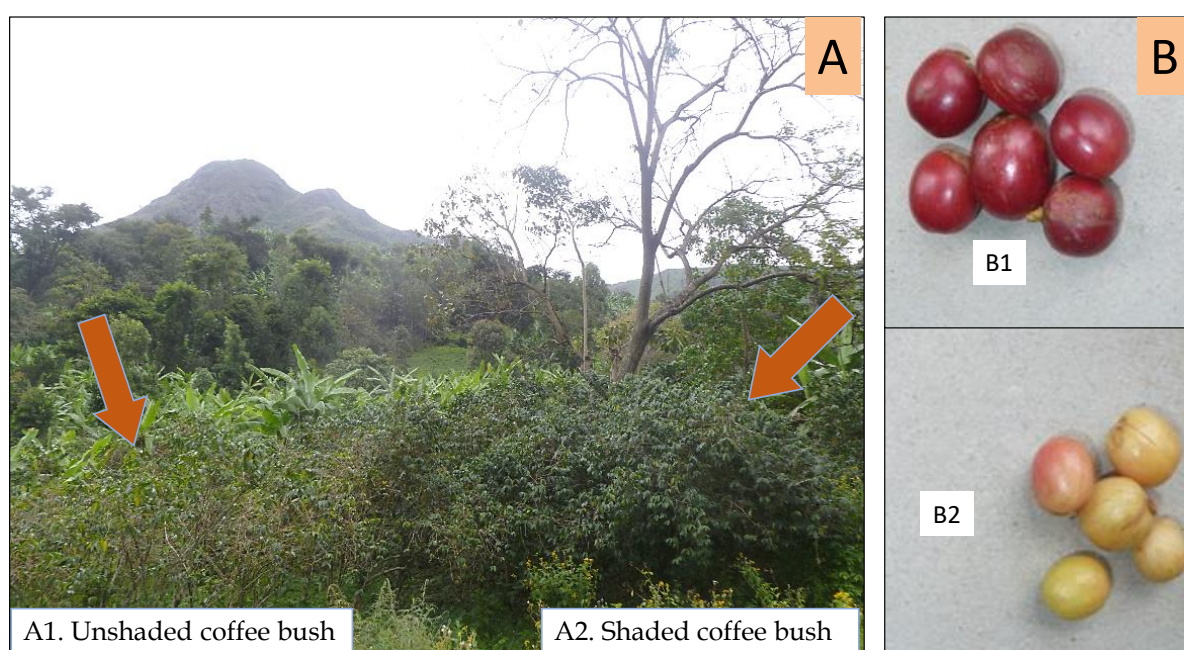


Fig. 3: Influence of shade on coffee growth and yield; A; Less vigorous plants away from *Cordia africana* (A1) compared to those under. B; bush vigour; A; Coffee berries under *C. africana* tree shade (B1) and coffee berries under no tree shade (B2).

Between 41 and 60% level of crown pruning of *Cordia africana* shade trees was developed as the ideal pruning regime for *C. Africana* shade. At this crown pruning intensity, optimum coffee yield was 26kg of fresh coffee beans per coffee tree and net coffee output improves by 36.6%.

3.2.2 *F. albida* for land productivity enhancement

The study was conducted in the seven districts of the Karamoja sub region namely Nakapiripirit, Amudat, Napak, Moroto, Kotido, Kaabong and Abim (Fig. 4). This has been reported to be the natural range of this tree. With the help of district officials (Natural Resources, Forestry and Environment officers) helped in identifying local contacts that provided more precise information about the location of the trees. Specific niches in the sub counties where the species was most likely to be found within each district were visited. At the sub county level, sub county chiefs and LC chairpersons helped to make local arrangements for field guides and Focus Group Discussions (FGDs).

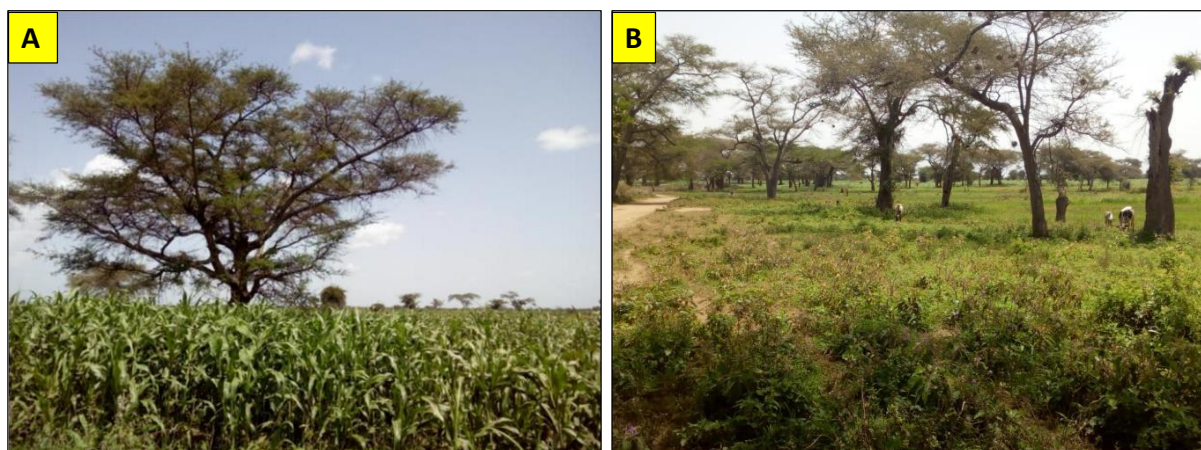


Fig. 4: *F. albida* trees use located in various land-use systems in the Karamoja region. A- Sorghum growing and B-Grazing animals under *F. albida* trees in Karamoja, Uganda

With the help of the field guides, coordinates of *F. albida* trees were taken. In some cases, the number of trees was small enough to conduct complete census. Otherwise, tree population was done using 1 km x 1 km plots. Thirty individual trees were selected purposively so that soil samples could be taken to assess the fertility gradient between soil under *F. albida* canopy and areas with no tree canopy. For a tree to be selected, it should have been at least 10 meters in crown diameter, ≥ 15 m height. The ground below the canopy must have been reasonably homogeneous and with a nearby area with no tree from where a control soil sample could be taken (Fig. 5).



Fig. 5: Soil sampling under *F. albida* trees in Nakapiripirit district. A-Takin soil samples using an augar. B-Labeling and packing soil samples for transport to the laboratory.

With the help of the identified local contacts, between 10 and 15 individuals were selected to participate in the FGD (Fig. 6). Using a local translator, information was collected from the participants using a semi structured interview guide. In each district, one Focus Group Discussions (FGD) was organized in one Sub County where *F. albida* was found to be most abundant.



Fig. 6: Focus Group Discussions during identification of use-values of *F. albida* in Rupa Sub Coun (A) and Town Council South (B) in Moroto District

Using ecological information from literature, spatial interpolation techniques were used to integrate information on climate, soil properties, hydrological properties, terrain and infrastructure to map out suitable sites for intergrading *F. albida* in agroforestry systems at a national level.

A map based on the field survey (Fig. 7A) shows that *F. albida* is found in all the seven district of the Karamoja sub region (Amudat, Nakapiripirit, Napak, Moroto, Kotido, Kaabong and Abim). Based on the GIS analysis, a national map has been developed that indicates suitable sites for integrating *F. albida* in agroforestry systems (Fig. 7B).

An estimated 44% of the agricultural land is suitable for *F. albida* agroforestry countrywide.

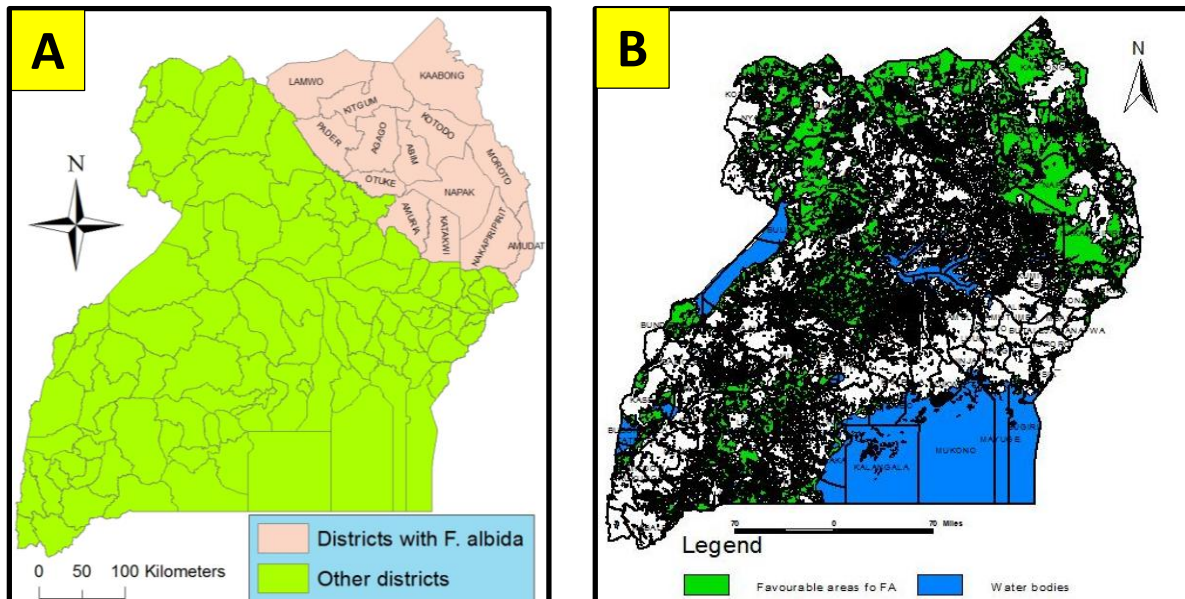


Fig. 7: Map of Uganda showing the sites where the study was conducted (A) and GIS-based suitability areas for intergrating *F. albida* in agroforestry systems (B).

From the discussions, several use-values of the species were some of the main use-values include the following;

- The pods are used feed livestock (mainly cows and goats) (Fig. 8A, B and C)
- Use of the fallen trees and branches for fuel wood
- Where crops are grown under *F. albida*, it is said that the yields are higher than those where no *Faidherbia albida* is located
- Several wooded materials are made such as utensils, stools (Fig. 8D)
- It was also reported that expectant women from some clans sit under the tree when performing cultural practices and for this reason the value the tree immensely.



Fig. 8: Various uses of *F. albida* by the community in Moroto District: **A** – Pods gathered for export to Kenya where they use them for human consumption; **B&C** Animals are fed on pods, said to promote multiple deliveries in goats and boost milk production in cows; **D**–Various wooded tools made from the tree including Calabash for drinking, traditional knives and drums.

4.0 COMMUNICATION/DISSEMINATION

The following material have been developed under the project;

Peer-reviewed articles:

- Buyinza J., Agaba H., Ongodia G., Eryau K., Sekatuba J., Kalanzi F., Kwaga P., Mudondo S. and Nansereko S., 2015. On-farm Conservation and Use Values of Indigenous Trees Species in Uganda. *Res. J. Agric. and For. Sci.* 3, 19-25

Technical Reports:

- Effect of *Cordia africana* shade on yield of coffee-banana in a humid farming system, eastern Uganda.
- On-farm distribution and utilization of *Faidherbia albida* in north-eastern Uganda: Implications for conservation

Brochures

- *Faidherbia albida*: Ecological range in Uganda
- *Faidherbia albida*: Utilization and management in Karamoja, Uganda

5.0 CONCLUSIONS AND LESSONS LEARNED

5.1 Conclusions

Integration of trees within farms was a common practice in the coffee-banana farming system in the Mt. Elgon region. Most frequently, *C. africana* trees were used for shade provision on coffee bushes and this was attributed to its fast growth and the ease of access of planting material. Tree management aspects are critical in optimizing farm productivity e.g. crown pruning of *C. africana* shade to ideal levels of 41-60% improves coffee productivity by an optimum of 36.6%. The trees benefit from certain management aspects like weeding and manure application, especially at later stages of growth, which are usually targeted for the crops.

We found that *F. albida* is restricted to areas around rivers and streams in the Karamoja region. Where it occurs, it provides significant benefits to communities where the tree is found. We also found that no deliberate management is implemented by farmers to ensure survival of the species. Perhaps the most limiting factors for the propagation is the fact that the fruits are highly desired for use as animal feed, thereby limiting establishment. However, the strict norms restricting the cutting of the tree by some communities has allowed already-established trees to survive and produce seed.

Overall, our findings suggest that farmers are aware of the benefits associated with indigenous tree integration within their farming systems, however it is important that farmers have the knowledge on the appropriate tree for a desired purpose as well as the need to acquire skills on tree management aspects for realization of their full potential in enhancing farm productivity.

5.2 Lessons learnt

There is limited diversity of trees on farm. There is need to diversify fast-growing indigenous shade tree options for integration in the coffee-banana growing zones of Uganda. Having other options of shade trees will reduce household vulnerability to effects of pest outbreaks, climatic stress, food insecurity and price fluctuations (Tscharntke *et al.*, 2011).

As evidenced from this study, some tree management aspects e.g. root pruning are largely unknown to the farmers. This underscores the need to design educational

programs to enhance farmers' capacities and skills in a range of tree management options as well as conserving shaded agroforestry systems (Bos *et al.*, 2007) for improved productivity.

In order to ensure survival of *F. albida* in Uganda, efforts are needed to increase on-farm planting. For this to be possible, planting in other parts of the country where the tree does not exist but has suitable agro-climatic conditions, should be encouraged. National germplasm/provenance trials need to be established to determine the potential of *F. albida* to contribute its many benefit to other potential agroecological zones in Uganda.

6.0 REFERENCES

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