

FARMERS' KNOWLEDGE OF THE BANANA (*MUSA SP.*) AGRO-FORESTRY SYSTEMS IN KIBOGA DISTRICT, CENTRAL UGANDA

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ABSTRACT

Banana is a major food and cash crop in Uganda, particularly in the central and southwestern regions. However, production is still below attainable yields and at the same time declining due to a number of reasons, with low soil fertility being paramount. Few farmers use inorganic fertilizers, with majority of them relying mainly on organic supplements including integration of trees/shrubs. However, trees and shrubs exist on banana farms in undefined numbers and composition, with no spacing and canopy management recommendations. Also, there is limited information on farmers' knowledge on these systems. A survey was, therefore, conducted on 70 randomly selected farms in Kiboga district, central Uganda to assess farmers' knowledge of, as well as identify trees and shrubs species and banana cultivars in their agro-ecologies. A total of 1,558 trees and shrubs belonging to 40 species and 21 families were recorded in the study area (52 trees/shrubs per banana plantation). These were dominated by Jackfruit, *Artocarpus heterophyllus* (15%), Natal fig, *Ficus natalensis* (10%), Albizia, *Albizia coriaria* (10%) and mango, *Mangifera indica* (9%). Further, 1,779 banana mats belonging to nine (9) cultivars and three (3) genome groups were observed growing underneath these four commonest tree species (2.6 banana mats per tree). The highest number of banana mats was observed growing underneath *F. natalensis* (54%) and *A. coriaria* (42%). Most (87%) observed banana cultivars belonged to the cooking East African Highland Banana (*Musa* AAA-EAHB) and dominated by *Ndibwabalangira* (21%). Farmers reported 25 benefits they derive from banana-trees/shrubs integration; with shade and firewood (38%), as well as income and timber (35%) being the main benefits reported. They also reported that the highest percentage of benefits was derived from *F. natalensis* (44%) and *A. coriaria* (32%). Of the four (4) most prevalent tree species, *A. coriaria* (100%) and *F. natalensis* (96%) were reported as good companion plant to bananas, whereas, *A. heterophyllus* (99%) and *M. indica* (97%) were regarded as bad companion plants. Farmers preferred a tree that allows light penetration (96%), is compatible with bananas and other crops (87%) and has easily decomposable leaves (83%). Therefore, *F. natalensis* and *A. coriaria* should be integrated in banana agro-systems for soil fertility improvement whereas; *A. heterophyllus* and *M. indica* be planted on farm boundaries. However, the best-bet spacing and pruning regimes for these trees should be determined to minimize the negative attributes as much as possible.

Key words: *Albizia coriaria*, *Artocarpus heterophyllus*, banana cultivars, benefits, companions, farmers' knowledge, *Ficus natalensis*, *Mangifera indica*, tree-species



INTRODUCTION

Banana is an important staple food and income source for more than 10 million rural and urban Ugandans [1]. The crop also provides feed for animals, medicine, serves cultural roles as well as industrial uses. Despite its importance, production is still below the attainable yields [2, 3]. Average highland bananas yields ($5\text{--}30 \text{ Mg ha}^{-1}\text{yr}^{-1}$) are below the estimated potential yield of over $70 \text{ Mg ha}^{-1}\text{yr}^{-1}$ [4]. This is mainly attributed to abiotic and biotic constraints with declining soil fertility being paramount [5, 6]. This is more pronounced in the central compared to the southwestern part of the country [7].

Contrary to commercial banana production in most parts of the world, few Ugandan banana farmers use mineral fertilizers to replenish soil nutrient stocks [8]. Instead, they rely on organic supplements [4], including integration of banana and trees [9, 10]. However, poor tree choice and canopy management practices may promote competition for light, nutrients, space and moisture, among others [11]. In addition, these systems are yet to be fully quantified and there are no recommendations on how to intercrop the bananas and the trees [3]. Trees and shrubs exist in infinite numbers and compositions on banana farms with no proper spacing and sequencing as well as canopy management recommendations. There is also limited information on farmers' knowledge on agro-forestry which poses serious challenges to the proper use of particular tree species for soil fertility improvement [12]. Such information is vital since socio-cultural settings are known to influence adoption and valuation of agro-forestry systems [13]

This study was, therefore, conducted in Lwamata sub-county, Kiboga district, central Uganda to: i) identify tree/shrub species and banana cultivars on smallholder farms, and ii) assess farmers' knowledge on the benefits of tree/shrubs-banana integration, and iii) determine the criteria used by farmers to classify a tree/shrub as 'good' or 'bad' neighbor to bananas.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Kisweeka parish, Lwamata sub-county, Kiboga District, central Uganda in 2012. The district lies between $1^{\circ} 30' \text{N}$ and $32^{\circ} 14' \text{E}$ at 1000–1200 m.a.s.l [14]. Farming is the major economic activity and about 80% of the district labor force is engaged in agricultural activities. The most predominant crops grown are bananas, beans, coffee, cassava, maize and sweet potatoes [15].

Sample selection and data collection

Lwamata sub-county was purposively selected for the study because bananas are predominantly intercropped with trees and/or shrubs [16]. Names of all the parishes in Lwamata sub-county were written on pieces of papers singly, folded and Kisweeka parish picked randomly. Then, the names of all villages in Kisweeka parish were written singly on pieces of papers and five villages were randomly selected, namely - Kisweeka, Kiryamuddo, Nabuzaana, Buyira and Nabyoto. A pretested questionnaire eliciting farmers' knowledge on the banana agro-forestry system was administered to 70 randomly selected farming households. From these, 30 households (6 per village) were



randomly selected for tree and banana profiling. In each banana plot, all the trees and shrubs taller than 3m in a 10 x 10m quadrant were identified at species level, counted and recorded [16]. In addition, the four (4) most prevalent tree/shrub species were identified and banana mats underneath identified by cultivar, counted and recorded.

Cultivar proportions were then determined by measures of cultivar abundance and explained by determining variety richness (number) and evenness (distribution). The cultivar richness and evenness were summarized using the cultivar diversity indices based on Shannon-Wiener diversity index [17].

$$\text{Diversity Index (DI)} = - \sum_{i=1}^s \alpha_i \ln \alpha_i$$

Where; s = number of cultivars
 α_i = the proportion of individuals or the abundance of the i^{th} cultivar;
 expressed as a proportion of the total sample
 \ln = natural logarithm

Data analysis

Data analyses were done in SAS v. 9.1 for Windows [18]. Descriptive statistics were used to obtain means, standard deviations and frequencies, and presented in tabular and graphic forms. The numbers of banana mats per cultivar as well as the number and species diversity of banana cultivars underneath four (4) most prevalent tree species were compared using a Chi square test.

RESULTS

Tree/shrub species and banana cultivars observed

Results showed that 1,558 trees/shrubs belonging to 40 species and 21 families were recorded in the study area (Table 1). This gives an average of 52 trees/shrubs per banana plantation. The four (4) most prevalent tree species observed were: - *Artocarpus heterophyllus* (15%), *Ficus natalensis* (10%), *Albizia coriaria* (10%) and *Mangifera indica* (9%). The dominant families were Fabaceae (23%) and Moraceae (20%) (Table 1).

Furthermore, 1,779 banana mats belonging to nine (9) cultivars and three (3) genome groups were observed growing underneath the four most prevalent tree species. Most (87%) of the observed banana cultivars belonged to the cooking East African Highland Banana (*Musa* AAA-EAHB). The number of observed banana mats varied significantly ($\chi^2 = 405.07$, $P < 0.0001$) across the cultivars; with the highest recorded for Ndibwabalangira (21%) (Table 2).

Results showed that the number of banana mats varied significantly ($\chi^2 = 1565.77$, $P < 0.0001$) among the four most prevalent tree species. The highest number of mats was observed underneath *F. natalensis* (54%) and *A. coriaria* (42%); whereas, the lowest (0.9%) was underneath *A. heterophyllus*. The species diversity of the bananas observed



underneath the four (4) most prevalent tree species was not significantly different across the tree species ($\chi^2 = 0.2574$, $P = 0.9678$). It was highest (2.09) underneath *F. natalensis* and lowest (1.34) underneath *A. heterophyllum* (Table 3).

F. natalensis and *A. coriaria* canopies supported all the nine (9) banana cultivars observed. Kibuzi and Mpologoma were not observed underneath *M. indica* and *A. heterophyllum*. Ndibwabalangira was the most abundant banana cultivar observed underneath *F. natalensis* (240 mats) and *A. coriaria* canopies (137 mats) whereas, Kayinja was the most prevalent underneath *M. indica* (20 mats) and *A. heterophyllum* canopies (6 mats; fig. 1).

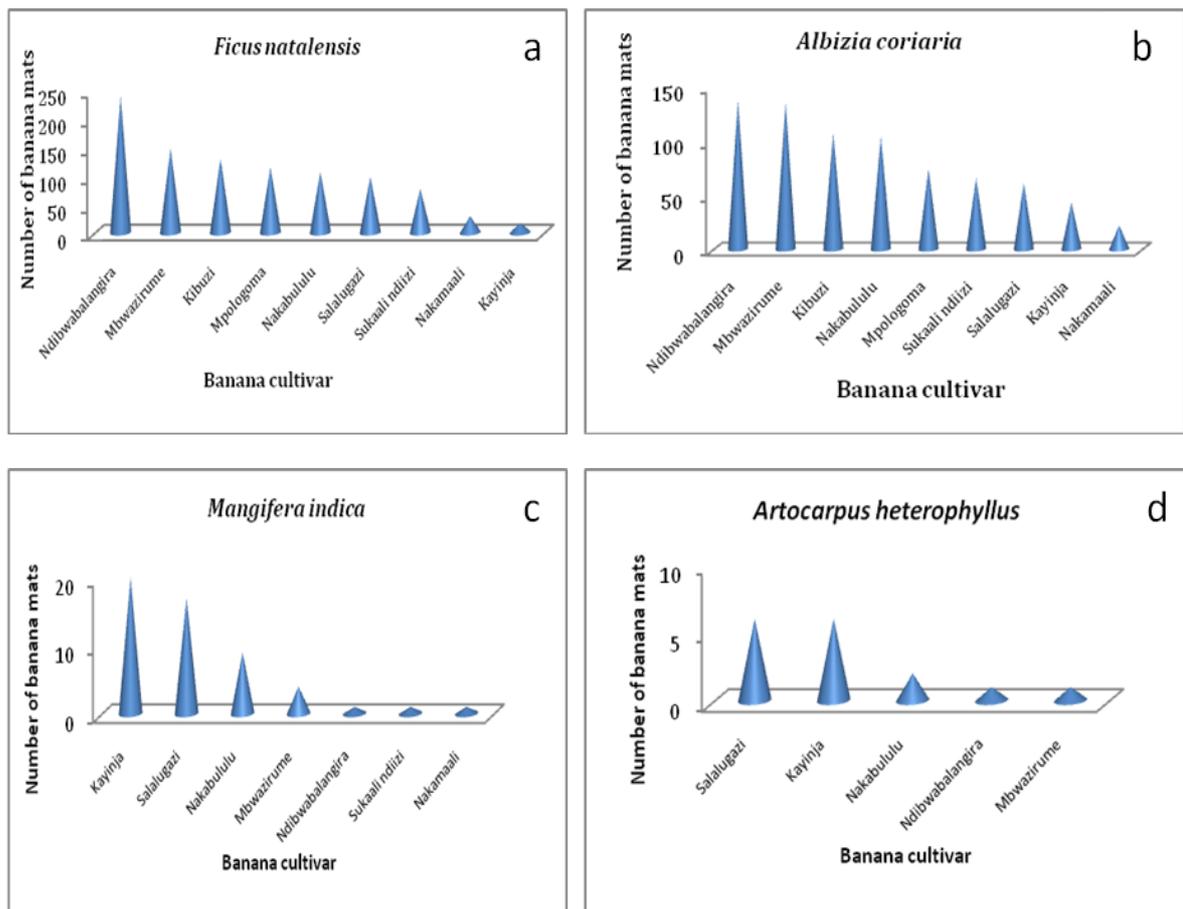


Figure 1: Occurrence of banana cultivars underneath the four most prevalent tree species; *Ficus natalensis* (A), *Albizia coriaria* (B), *Mangifera indica* (C) and *Artocarpus heterophyllum* (D) in banana plots of Kiboga district, Uganda

Farmers' knowledge of the benefits accruing from tree/shrubs-banana integration
Responses from the 70 farmers interviewed showed that 25 benefits were derived from trees that are inter-planted with bananas. The highest proportion reported that trees provide shade (38%) and play an important role in soil fertility improvement (25%). On the other hand, source of income was reported by the highest proportion (35%) of farmers

as the most important service accruing from trees, whereas, firewood (38%), timber (35%) and, food and fodder (30%) were the most important products derived from trees. Farmers reported that the highest percentage of benefits were from *F. natalensis* (44%) and *A. coriaria* (32%; Table 4).

Farmers' knowledge and definition of a good or bad companion tree/shrub species to bananas

All farmers (100%) reported *Albizia coriaria*, *Azadirachta indica*, *Calliandra calothyrsus*, *F. sycomorus* and *Sesbania sesban* as good companion plants to bananas. *Acacia hockii*, *Eucalyptus grandis* and *Pinus caribaea* were regarded as bad companion plants to bananas. Of the four (4) most prevalent tree species, farmers reported *A. coriaria* (100%) and *F. natalensis* (96%) as good companion plants to bananas, whereas, *A. heterophyllus* (99%) and *M. indica* (97%) were regarded as bad companion plants to bananas (Table 5).

Most farmers (96%) reported ability of the tree canopy to allow light penetration, the presence of bananas or other crops underneath tree canopy (87%), and small and smooth leaves (83%) as the criteria they use to classify a tree/shrub as good companion plants to bananas (Figure 2).

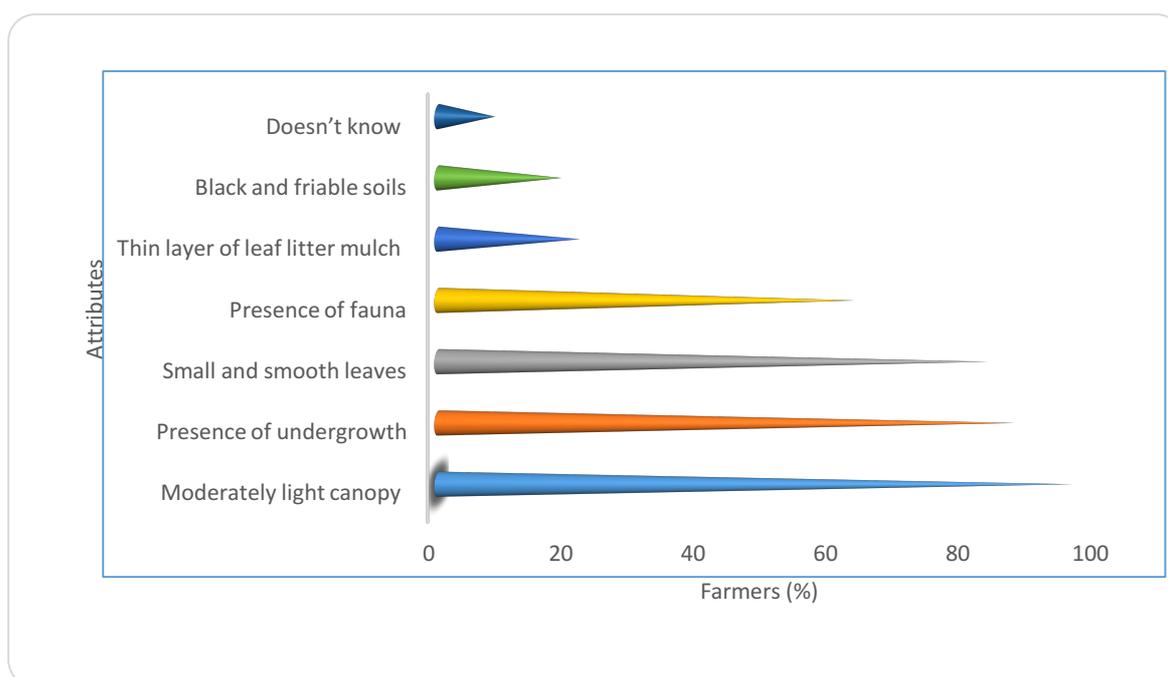


Figure 2: Criteria used by farmers in Kiboga district, Uganda to classify a tree/shrub species as good companion plants to bananas

Most farmers (97%) reported thick canopy densities, large and coarse leaves (86%) and no or few banana mats underneath their canopies (79%) as the criteria they use to classify a tree/shrub as bad companion plants to bananas (Fig. 3).

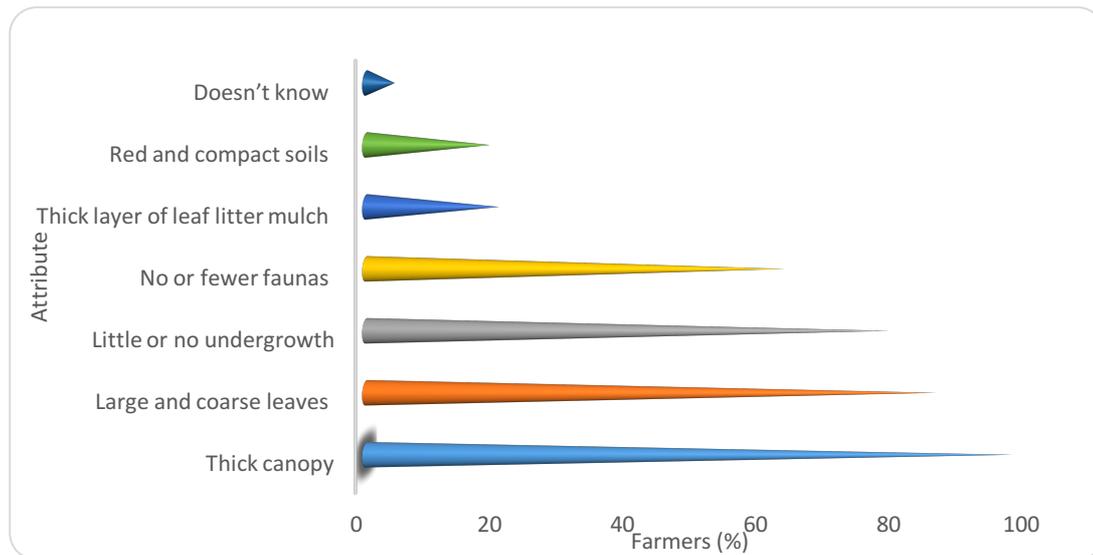


Figure 3: Criteria used by farmers of Kiboga district, Uganda to classify a tree/shrub as bad companion plants to bananas

DISCUSSION

Traditionally, farmers in Uganda often deliberately retain, maintain and plant trees with their bananas [9, 16]. Results from this study showed a high density of trees/shrubs in the study area, with an average of 52 tree/shrubs per banana plot. This concurs with other studies in central and eastern Uganda [19, 20]. Similarly, the 40 tree/shrub species observed in this study are in line with work done by Kiyangi and Gwali [19] and Isabirye [20]. In the present study, *Artocarpus heterophyllus*, *Ficus natalensis*, *Albizia coriaria* and *Mangifera indica* were dominant. In addition, these tree/shrub species were fairly diverse with a Shannon-Weaver index of 2.85, a result that was also reported by Isabirye [20] in eastern Uganda. Few banana mats were generally observed underneath the four (4) commonest tree species (2.6 mats per tree species) which tallies with observations by Dold *et al.* [21]. This could be a deliberate action by farmers to reduce competition for available resources. But this may offer opportunities, where densities can be increased, coupled with other supplemental nutrient sources and improved canopy management. In Uganda, farmers usually grow a range of cultivars (12–23) in their banana plots for food security, risk aversion and to derive a range of benefits [7, 22].

The East African Highland Banana (*Musa* AAA-EAHB) dominated the genomic groups observed, emphasizing their importance in central Uganda [7, 6]. This genomic group constitutes more than 70% of all the bananas grown in Uganda, contributing to the food security and income of both rural and urban population, particularly in the central and south-western Uganda. The banana cultivars in this study were dominated by Ndibwabalangira and Mbwazirume, agreeing with farmers' responses as reported by Mpiira *et al.* [16]. The highest number of banana mats and species diversity were observed underneath *F. natalensis* and *A. coriaria* whereas, the lowest underneath *A.*

heterophyllus and *M. indica*. Kayinja (Musa ABB) dominated the banana cultivars observed underneath *A. heterophyllus* and *M. indica* probably due to their ability to survive under more stressful conditions (poor quality leaf litter / soil fertility, thick canopy and reduced radiation penetration) as compared to the cooking East Africa highland bananas.

Farmers in Uganda have been integrating trees and crops for decades [23] due to a number of reasons. In this study, farmers demonstrated knowledge of the advantages and disadvantages attached to the agro-forestry systems [24, 25]. They cited 25 functions/services/products derived from the trees inter-planted with bananas, which were in agreement with the findings by Tabuti [26]. Farmers ranked provision of shade and soil fertility improvement as the most important functions accruing from trees. This corroborates with other findings [10, 12, 24]. *A. coriaria*, *F. natalensis* and *M. indica* were cited by farmers as the best for provision of shade, which agrees with other findings [25]. Farmers cited *A. coriaria*, *S. sesban*, *F. natalensis*, *C. calothyrsus* and *F. sycomorus* as the most important trees for improving soil fertility, agreeing with Nyombi *et al.* [10].

Farmers considered income as the most important service provided by trees [19, 27, 28]. However, this is contrary to Tabuti [26] who reported that smallholder farmers in eastern Uganda attached limited importance to trees as a source of income. Fruit trees and *E. grandis* were reported by farmers as the most important tree species that provide income, which was in line with Tabuti [26] and Nyamukuru *et al.* [29]. Farmers also identified firewood and timber as the most important products they derive from trees [30, 31], with *E. grandis* cited as the most utilized tree species for firewood. On the other hand, *M. lutea*, *A. coriaria* and *M. eminii* were the most preferred species for timber [32, 33]. Farmers cited *F. natalensis* and *A. coriaria* as having the highest number of functions/services/products delivered from them. This is in conformity with findings from other studies [12, 25]. The fact that these two tree species are multipurpose partly explains why they are the most abundant as well as most preferred by farmers in the study area.

Farmers were able to identify trees/shrubs that are either 'good' or 'bad' companions to bananas and to other crop species [34]. Of the four most common tree species, farmers cited *A. coriaria* and *F. natalensis* as 'good' companions, whereas, *A. heterophyllus* and *M. indica* were cited as 'bad' companions to the bananas. However, despite being regarded as 'bad', these tree species are predominant in farmers' cropping systems [34].

The decision to deliberately plant and/or maintain a tree/shrub species by farmers depends on the desirable or undesirable traits associated with the goods and services these trees provide [35]. In this study, farmers reported six (6) critical criteria they consider when classifying a tree/shrub as 'good' or 'bad' companion to bananas. Canopy density was the most important criterion considered by farmers when classifying a tree/shrub as 'good' or 'bad' for bananas [36]. In addition, compatibility of the tree species with bananas and other crops as well as small, smooth and easily decomposable leaves were also prominently reported criterion used by farmers [37].

CONCLUSION

From this study the following conclusions can be made:

1. Farmers in Kiboga district plant or maintain trees on their farms. An average of 52 trees/shrubs per banana plot belonging to 40 species dominated by *Artocarpus heterophyllus*, *Ficus natalensis*, *Albizia coriaria* and *Mangifera indica* were observed.
2. The highest number of banana mats was observed underneath *F. natalensis* and *A. coriaria*, whereas; Ndibwabalangira and Mbwazirume dominated the cultivars observed.
3. Overall, farmers cited 25 benefits derived from trees; but the highest number of benefits was registered for *F. natalensis* and *A. coriaria*.
4. Of the four (4) most prominent tree species, *F. natalensis* and *A. coriaria* were cited by farmers as 'good' neighbors to bananas; which is not surprising given the high number of mats underneath whereas, *A. heterophyllus* and *M. indica* were referred to as 'bad' neighbors.

It is, therefore, recommended that: -

1. *F. natalensis* and *A. coriaria* be integrated more into banana agro-systems for shade and soil fertility improvement,
2. On the other hand, *A. heterophyllus* and *M. indica* be planted on boundaries for other products and benefits such as firewood and timber among others,
3. However, the best-bet spacing and pruning regimes for both tree species should also be determined in order to minimize the negative attributes as much as possible.

ACKNOWLEDGEMENT

The authors are deeply grateful to the Austrian Development Agency for the research grant to Bioversity and partners to undertake this research. They also thank the farmers of Kiboga district for participating in this research.

Table 1: Tree and shrub species observed in the banana cropping systems of Lwamata sub-county, Kiboga district, Uganda

Family name	Scientific name	English name	Local name (luganda)	%	No.	Rank
Moraceae	<i>Artocarpus heterophyllus</i>	Jackfruit tree	Fenensi	15.3	239	1
Moraceae	<i>Ficus natalensis</i>	Natal fig	Mutuba	10.2	159	2
Fabaceae	<i>Albizia coriaria</i>	Albizia	Mugavu	10.0	155	3
Anacardiaceae	<i>Mangifera indica</i>	Mango	Muyembe	9.2	143	4
Bignoniaceae	<i>Markhamia lutea</i>	Bell Bean Tree, Nile Tulip Tree	Musambya	8.2	127	5
Fabaceae	<i>Calliandra calothyrsus</i>	Calliandra	Kaliyandula	6.7	104	6
Rhamnaceae	<i>Maesopsis eminii</i>	Umbrella tree	Musizi	6.6	103	7
Euphorbiaceae	<i>Jatropha curcas</i>	Jatropha	Kilowa	5.6	87	8
Caricaceae	<i>Carica papaya</i>	Pawpaw/papaya	Mapapaali	4.0	63	9
Lauraceae	<i>Persea americana</i>	Avocado pear	Vvakedo	3.8	59	10
Fabaceae	<i>Leucaena leucocephala</i>	Lead tree	Lucina	3.5	54	11
Moraceae	<i>Ficus sycomorus</i>	Fig-mulberry	Mukunyu	3.3	52	12
Moraceae	<i>Ficus mucoso</i>	Fig	Kabalira	2.6	41	13
Moraceae	<i>Milicia excels</i>	Rock-elm	Muvule	1.2	19	14
Myrtaceae	<i>Psidium guajava</i>	Guava	Mupeera	1.2	19	14
Fabaceae	<i>Sesbania sesban</i>	Sesbania	muzimbandege ya	1.1	17	15
Bignoniaceae	<i>Spathodea campanulata</i>	African tulip tree	Kifabakazi	1.0	15	16
Fabaceae	<i>Albizia zygia</i>	West African Albizia	Nongo	0.8	12	17
Moringaceae	<i>Moringa oleifera</i>	Moringa	Mulinga	0.8	12	17
Euphorbiaceae	<i>Ricinus communis</i>	Castor oil plant	Nsogasoga	0.5	7	18
Myrtaceae	<i>Syzygium cumini</i>	Black plum	Jambula	0.5	7	18
Rutaceae	<i>Citrus sinensis</i>	Sweet orange	Mucungwa	0.4	6	19
Moraceae	<i>Ficus ovate</i>	Fig	Mukokowe	0.4	6	19
Fabaceae	<i>Tamarindus indica</i>	Tamarind tree	mukooge	0.4	6	19
Moraceae	<i>Antiaris toxicaria</i>	False iroko	Kirundu	0.3	4	21

Meliaceae	<i>Azadirachta indica</i>	Neem tree	Nnimu	0.3	5	20
Fabaceae	<i>Erythrina abyssinica</i>	Lucy bean tree	jjirikiti	0.3	4	21
Moraceae	<i>Ficus exasperata</i>	Forest sandpaper fig	Luwawu	0.3	4	21
Pinaceae	<i>Pinus caribaea</i>	Caribbean pine	Payini	0.3	4	21
Asteraceae	<i>Vernonia amygdalina</i>	Bitter leaf	Mululuza	0.3	5	20
Mimosaceae	<i>Acacia hockii</i>	Wild acacia	Kasaana	0.2	3	22
Annonaceae	<i>Annona senegalensis</i>	Wild custard apple	Kisitaferi	0.2	3	22
Proteaceae	<i>Grevillea robusta</i>	Silky oak	Kalivaliyo	0.2	3	22
Sapindaceae	<i>Sapindus saponeria</i>	Soap tree	Muyiki	0.2	3	22
Rubiaceae	<i>Vangueria apiculata</i>	Triangle flowered wild medlar	Mutugunda	0.2	3	22
Fabaceae	<i>Brachystegia spiciformis</i>	Zebrawood	Musasa	0.1	1	23
Burseraceae	<i>Canarium schweinfurthii</i>	Incense tree	muwafu	0.1	1	23
Myrtaceae	<i>Eucalyptus grandis</i>	Eucalyptus	Kalitunsi	0.1	1	23
Fabaceae	<i>Gliricidia sepium</i>	Mouse killer	Muttamese	0.1	1	23
Tiliaceae	<i>Grewia mollis</i>	-	Nkomakoma	0.1	1	23

Table 2: Ranks of banana cultivars growing underneath the four (4) most prevalent tree species in Kiboga district, Uganda

Cultivar name	Genome group	Use group	Percentage	Number	Rank
Ndibwabalangira	AAA-EAHB	Cooking	21.3	379	1
Mbwazirume	AAA-EAHB	Cooking	16.2	288	2
Kibuzi	AAA-EAHB	Cooking	13.3	237	3
Nakabululu	AAA-EAHB	Cooking	12.5	222	4
Mpologoma	AAA-EAHB	Cooking	10.6	189	5
Salalugazi	AAA-EAHB	Cooking	10.2	182	6
Sukaali ndiizi	AAB	Dessert	8.1	144	7
Kayinja	ABB	Beer	4.8	86	8
Nakamaali	AAA-EAHB	Cooking	2.9	52	9

Table 3: Comparison of diversity of banana growing underneath the four most prevalent tree species in banana agro-systems of Kiboga district, Uganda

Trees species	Local name (Luganda)	Diversity index
<i>Ficus natalensis</i>	Mutuba	2.09
<i>Albizia coriaria</i>	Mugavu	2.02
<i>Mangifera indica</i>	Muyembe	1.45
<i>Artocarpus heterophyllus</i>	Fenensi	1.34
χ^2		0.2574
P value		0.9678

Table 4: Benefits derived from trees/shrub species as reported by farmers (n=70), Kiboga district, Uganda

Species	Functions									Services			Products											N	Rank		
	SF	SD	WB	EN	RF	LM	RM	LF	SS	IC	CU	GM	FW	TM	FD	FA	MD	CH	BC	PF	PC	SC	SB			SH	SFS
<i>Acacia hockii</i>	-	-	-	-	-	-	-	-	-	-	-	-	5.7	-	-	55.7	25.7	31.4	-	17.7	4.3	-	-	-	-	6	3
<i>Albizia coriaria</i>	100.0	95.7	24.3	-	-	-	-	-	-	61.4	-	-	2.9	81.4	-	-	-	1.4	-	10.0	-	-	-	-	-	8	2
<i>Albizia zygia</i>	-	40.0	-	-	-	-	-	-	-	-	-	-	10.0	34.3	-	-	-	-	-	-	-	-	-	-	-	3	6
<i>Annona senegalensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-	-	-	1	8
<i>Antiaris toxicaria</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	25.7	-	-	-	-	-	-	-	-	-	-	-	1	8
<i>Artocarpus heterophyllus</i>	-	-	-	-	-	-	-	-	-	92.9	-	-	8.6	12.9	100.0	68.6	-	-	-	-	-	-	-	-	-	5	4
<i>Azadirachta indica</i>	-	11.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	78.6	-	-	-	-	-	-	-	-	2	7
<i>Brachystegia spiciformis</i>	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	38.6	-	-	-	-	-	-	-	-	-	2	7
<i>Calliandra calothyrsus</i>	97.1	-	-	-	-	-	-	-	60.0	-	-	-	70.0	-	-	87.1	-	-	-	-	20.0	7.1	-	-	6	3	
<i>Canarium schweinfurthii</i>	-	2.9	10.0	-	-	-	-	-	-	12.9	-	-	-	-	65.7	-	-	-	-	-	7.1	-	-	-	4	5	
<i>Carica papaya</i>	-	-	-	-	-	-	-	-	-	44.3	-	-	-	-	95.7	8.5	-	-	-	-	-	-	-	-	3	6	
<i>Citrus sinensis</i>	-	-	-	-	-	-	-	-	-	78.6	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	-	2	7
<i>Erythrina abyssinica</i>	61.4	-	-	-	-	-	-	-	-	-	64.3	-	-	7.1	-	-	10.0	-	-	-	-	-	-	-	4	5	
<i>Eucalyptus grandis</i>	-	-	58.6	-	-	-	-	-	-	90.0	-	-	95.7	24.3	-	-	-	-	-	7.1	-	8.6	-	-	6	3	
<i>Ficus exasperate</i>	-	65.7	-	-	-	-	-	-	-	-	-	-	-	10.0	-	-	-	-	-	-	-	-	-	-	2	7	
<i>Ficus mucuso</i>	65.7	47.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7	
<i>Ficus natalensis</i>	97.1	94.3	7.1	-	-	-	-	30.0	-	-	12.9	-	51.4	5.7	-	90.0	-	-	25.7	35.7	-	27.1	-	-	11	1	
<i>Ficus ovata</i>	75.7	72.9	10.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48.6	-	-	-	-	-	-	4	5	
<i>Ficus sycomorus</i>	95.7	34.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7	
<i>Gliricidia sepium</i>	57.1	-	-	-	-	-	-	-	-	-	-	-	17.1	-	-	22.9	-	-	-	-	-	-	-	-	3	6	
<i>Grevillea robusta</i>	-	10.0	12.9	-	-	-	-	2.9	-	10.0	-	-	8.6	32.9	-	-	-	-	-	-	-	-	-	-	6	3	
<i>Grewia mollis</i>	-	-	-	-	-	-	-	-	-	-	-	-	15.7	-	-	-	-	-	-	-	-	-	5.7	-	2	7	
<i>Jatropha curcas</i>	-	-	-	-	-	40	-	32.9	-	-	-	-	-	-	-	-	-	-	-	-	88.6	-	-	-	3	6	
<i>Leucaena leucocephala</i>	40.0	-	-	-	-	-	-	-	10.0	-	-	-	8.6	-	-	68.6	-	-	-	-	2.9	-	-	-	5	4	
<i>Maesopsis eminii</i>	-	14.3	25.7	-	-	-	-	-	-	71.4	-	-	-	75.7	-	-	-	-	-	-	-	-	-	-	4	5	
<i>Mangifera indica</i>	-	81.4	-	-	-	-	-	-	-	97.1	-	-	-	-	100.0	20.0	-	-	-	-	-	-	-	-	4	5	
<i>Markhamia lutea</i>	-	-	-	-	-	-	-	-	-	54.3	-	-	12.9	87.1	-	-	-	-	-	-	71.4	-	5.7	80.0	6	3	
<i>Milicia excels</i>	-	-	-	-	-	-	-	-	-	24.3	-	-	-	55.7	-	-	-	-	-	-	-	-	-	-	2	7	
<i>Moringa oleifera</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.3	28.6	35.7	-	-	-	-	-	-	-	3	6	
<i>Persea americana</i>	-	-	-	-	-	-	-	-	-	92.9	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	2	7	
<i>Pinus caribaea</i>	-	-	-	4.3	1.4	-	-	-	-	41.4	-	-	-	38.6	-	-	-	-	-	-	-	-	-	-	4	5	
<i>Psidium guajava</i>	-	-	-	-	-	-	-	-	-	4.3	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	2	7	
<i>Ricinus communis</i>	-	-	-	-	-	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51.4	-	-	2	7	
<i>Sapindus saponeria</i>	-	8.6	-	-	-	-	-	-	-	-	-	18.6	-	-	-	-	-	-	-	-	-	-	-	-	2	7	
<i>Sesbania sesban</i>	100.0	-	-	-	-	-	-	-	50.0	-	-	-	15.7	-	-	81.4	-	-	-	4.3	-	17.1	-	-	6	3	
<i>Spathodea campanulata</i>	-	40.0	27.1	-	-	-	-	-	-	-	-	-	-	64.3	-	-	-	-	-	-	-	-	-	-	3	6	
<i>Syzygium cumini</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-	-	1	8	
<i>Tamarindus indica</i>	-	45.7	-	-	-	-	-	-	-	-	-	-	-	-	64.3	-	-	-	-	-	-	-	-	-	2	7	
<i>Vangueria apiculata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.6	-	-	-	-	-	-	-	-	-	1	8	
<i>Vernonia amygdalina</i>	-	-	-	-	-	-	-	-	-	-	-	-	32.9	-	-	72.9	98.6	-	-	-	-	11.4	-	-	4	5	
%																											
N	10	15	8	1	1	1	1	3	3	14	2	1	15	14	12	12	5	2	2	5	1	8	2	2	1		
Rank	4	1	5	9	9	9	9	7	7	2	8	9	1	2	3	3	6	8	8	6	9	5	8	8	9		

Key: **Functions:** SF=soil fertility, SD=shade, WB=wind breakers, EN=environmental restoration, RF=making rain, LM=marking boundaries, RM=raw materials for industries, LF=live fence, SS=soil stabilization; **Services:** IC=income, CU=cultural attachment, GM=traditional games; **Products:** FW=firewood, TM=timber, FD=food, FA=fodder, MD=medicine, CH=charcoal, BC=backcloth and craft, PF=poles for fencing, PC=poles for construction, SC=stakes for climbing crops, SB=stakes for popping bananas, SH=stakes for handles, SFS=stakes for debudding bananas. N=Number of farmers mentioning that specific tree species



Table 5: Tree/shrub species reported by farmers (n=70) as ‘good’ or ‘bad’ neighbors to bananas in Kiboga district, Uganda (Bold $\geq 50\%$)

Scientific name	English name	Local name (Luganda)	‘Good’		‘Bad’	
			%	Rank	%	Rank
<i>Acacia hockii</i>	Wild acacia	Akasaana	-	-	100.0	1
<i>Albizia coriaria</i>	Albizia	Mugavu	100.0	1	-	-
<i>Albizia zygia</i>	West African Albizia	Nongo	40.0	7	60.0	19
<i>Annona senegalensis</i>	Wild custard apple	Kitaferi	35.7	10	64.3	16
<i>Antiaris toxicaria</i>	False iroko	Kirundu	11.4	18	88.6	8
<i>Artocarpus heterophyllus</i>	Jackfruit tree	Fenensi	1.4	24	98.6	2
<i>Azadirachta indica</i>	Neem tree	Nnimu	100.0	1	-	-
<i>Brachystegia spiciformis</i>	Zebrawood	Musasa	18.6	16	81.4	10
<i>Calliandra calothyrsus</i>	Calliandra	kaliyandula	100.0	1	-	-
<i>Canarium schweinfurthii</i>	Incense tree	Muwafu	35.7	10	64.3	16
<i>Carica papaya</i>	Pawpaw/papaya	Mapapaali	38.6	8	61.4	18
<i>Citrus sinensis</i>	Sweet orange	Mucungwa	5.7	21	94.3	5
<i>Erythrina abyssinica</i>	Lucy bean tree	jjirikiti	54.3	4	45.7	22
<i>Eucalyptus grandis</i>	Eucalyptus	Kalitunsi	-	-	100.0	1
<i>Ficus exasperate</i>	Forest sand paper fig	Luwawu	37.1	9	62.9	17
<i>Ficus mucuso</i>	Fig	Mukunyu	41.4	6	58.6	20
<i>Ficus natalensis</i>	Natal fig	Mutuba	95.7	2	4.3	24
<i>Ficus ovata</i>	Fig	Mukokowe	82.9	3	17.1	23
<i>Ficus sycomorus</i>	Fig mulberry	Kabalira	100.0	1	-	-
<i>Gliricidia sepium</i>	Mouse killer	Muttamese	41.4	6	58.6	20
<i>Grevillea robusta</i>	Silky oak	Kalivaliyo	14.3	17	85.7	9
<i>Grewia mollis</i>	-	nkomakoma	4.3	22	95.7	4
<i>Jatropha curcas</i>	Jatropha	Kilowa	32.9	11	67.1	15
<i>Leucaena leucocephala</i>	Lead tree	Lucina	40.0	7	60.0	19
<i>Maesopsis eminii</i>	<i>Umbrella tree</i>	Musizi	7.1	20	92.9	6
<i>Mangifera indica</i>	Mango	Muyembe	2.9	23	97.1	3
<i>Markhamia lutea</i>	Bell Bean Tree, Nile Tulip Tree	Musambya	8.6	19	91.4	7
<i>Milicia excels</i>	Rock elm	Muvule	25.7	14	74.3	13
<i>Moringa oleifera</i>	Moringa	Mulinga	35.7	10	64.3	16
<i>Persea Americana</i>	Avocado pear	Ovakedo	37.1	9	62.9	17
<i>Pinus caribaea</i>	Caribbean pine	Pine	-	-	100.0	1
<i>Psidium guajava</i>	Guava	Mupeera	42.9	5	57.1	21
<i>Ricinus communis</i>	Castor oil plant	Nsogasoga	37.1	9	62.9	17
<i>Sapindus saponeria</i>	Soap tree	Muyiki	2.9	23	97.1	3
<i>Sesbania sesban</i>	Sesbania	muzimbandegeya	100.0	1	-	-
<i>Spathodea campanulata</i>	African tulip tree	Kifabakazi	21.4	15	78.6	11
<i>Syzygium cumini</i>	Black plum	Jambula	30.0	12	70.0	14
<i>Tamarindus indica</i>	Tamarind tree	mukooge	27.1	13	72.9	13
<i>Vangueria apiculata</i>	Triangle flowered wild medlar	Mutugunda	32.9	11	67.1	15
<i>Vernonia amygdalina</i>	Bitter leaf	Mululuza	37.1	9	62.9	17

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