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Characterising the Coffee-Banana Agroforestry Systems: an Entry Point for Promoting Coffee and Banana Growing in mid-Northern Uganda

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Abstract. This study was conducted in the mid-Northern Ugandan districts of Nwoya, Gulu, Lira, Apach and Oyam to characterise the coffee-banana agroforestry systems. Thirty fields with coffee-banana agroforestry systems were selected and the level of field and crop management determined. Additionally, five coffee and banana plants were randomly selected and assessed for pests and diseases. All fields had Robusta coffee type whereas cooking bananas were the dominant clone (45%). Field management was limited. More than 80% of the fields had no bands, trenches or cover-crops. Most of the fields were lowly weeded (46.7%) and mulched (60%). Intercropping was low with 20% having maize or cassava. Similarly, most fields were lowly inter-planted with trees (40%) with only 28 tree/shrub species and dominated by fruit trees; namely oranges (70%), mangoes (63.3%) and pawpaw (56.7%) of the total number of tree species observed in the systems. Generally, 40% of coffee fields had not been de-suckered, pruned or changed cycle. However, at least 35% of the coffee fields were highly pruned and their cycle changed. For bananas, more than 70% of the fields were not de-suckered, propped or their corms removed, but 63% of them had been de-leafed and de-budded at a low to moderate level. Leaf skeletonisers and coffee leaf rust were the most observed pest (77.3%) and disease (15.3%) respectively. Pest damage was limited in bananas, though black Sigatoka was the commonest disease observed (56%). It is concluded that the region has embraced the systems but there is need for farmers to be provided with the right species of coffee, banana and trees.

Keywords: Agroforestry-systems, cooking-bananas, Robusta-coffee.

INTRODUCTION

Coffee (both *robusta* and *arabica*) is the most important cash crop of Uganda, playing a vital part in the country's economy and livelihoods of its people (Musoli *et al.*, 2001). It contributes more than 3% of the Gross Domestic Product (GDP) and 18-20% of annual foreign exchange earnings valued at US$370 million in the coffee year 2015/16 (UCDA, 2016). The crop is grown by over 1.3 million smallholder households and provides employment to over 5 million Ugandans, through coffee-related activities along the value chain (Hill, 2005). In Uganda, coffee is traditionally grown in the central, western and eastern regions (Musoli *et al.*, 2001). However, the Government is aiming at accelerating coffee production from 3.74 million 60 kg bags in 2014/15 to 20 million 60 kg bags by 2020, through a number of strategies; including promotion of the crop in non-traditional growing regions particularly in the northern region (Mbowa *et al.*, 2014). Intense efforts by the

Uganda Coffee Development Authority (UCDA) are currently underway to distribute coffee planting materials to farmers in the region (UCDA, 2016).

Production of coffee in Uganda is mainly rain-fed (Mwaura and Katunze, 2014), making it vulnerable to climate variability (Mubiru *et al.*, 2012). This is more pronounced in marginal areas like northern Uganda, with a lengthy dry spell of 4-5 months (Mbowa *et al.*, 2014). This restrains coffee production to one season of the year instead of two seasons as in the traditional coffee growing regions like central Uganda (Mbowa *et al.*, 2014). It also dictates that the crop is grown under shaded conditions (Beer, 1987). Shade could be provided by bananas (Oduol and Aluma 1990; van Asten *et al.*, 2011) and/or trees (Kiyinji and Gwali, 2012; Bukomeko *et al.*, 2015). These coffee-banana agroforestry systems, therefore, present an opportunity for improving household income and food security, as well as mitigation for climatic adversities northern Uganda (Okorio *et al.*, 2004). The objective of this study was to characterise the coffee-banana agroforestry systems of mid-northern Uganda.

MATERIALS AND METHODS

Study Location

The study was conducted in five districts located in the mid-northern coffee growing sub-region; namely, Acholi sub-region (Gulu and Nwoya district) and Lango sub-region (Lira, Apac and Oyam districts). Acholi sub-region lies at 4°12"N, 1°29"S and 29°34"E, 35°0"N, with temperature range of 15-32°C. The sub-region has a generally flat topography, with predominantly sandy loam soils. It receives 800-1500 mm of rain per *annum* with a bimodal rainfall pattern from March to June (1st season) and July to November (2nd season; UITWG, 2014). On the other hand, the Lango sub-region lies between 2°17' 60.00"N and 33° 00' 0.00" E. It receives about 1000-1500 mm of rainfall per *annum* with temperatures of 25-35°C (Okwir, 2009).

Sample Farm Selection, Data Collection and Analysis

A total of 30 households practicing coffee-banana agroforestry systems were purposively selected for the study. In each sampled plot, a 25 m x 25 m transect was mapped out and data taken on the intensity of field and crop management of both coffee and bananas. In addition, 5 coffee plants and 5 banana mats were chosen randomly within the transect and scored for pests and diseases. For data analysis, descriptive statistics were used to obtain means, standard deviations and frequencies using Statistical Analysis System (SAS) software (SAS Institute, 2008).

RESULTS

Coffee Types and Banana Clones

Table 1 shows the coffee types and banana clones observed in the coffee-banana agroforestry systems of mid-northern Uganda. All the sampled fields had Robusta coffee, which was dominated by the clonal type (76.7%). On the other hand, the banana clones observed were dominated by the East African Highland Bananas (EAHB's), locally called 'Matooke' (45%), Pisang Awak (Kayinja, 22%) and Apple banana (sukali ndiizi, 18%).

Table 1. Coffee types and banana clones observed

Type/ clone	Use	Fields (%)
Coffee		
Clonal	Income	76.7
Elite	Income	23.3
Banana		
East African Highland Bananas (Matooke)	Cooking	45.3
Pisang Awak (kayinja)	Beer	22.3
Apple banana (sukali ndiizi)	Dessert	17.8
FHIA 17	Dessert	5.6
Bloggue (kivuvu)	Dessert	5.6
Gros Michel (bogoya)	Dessert	1.7
Yangambi-Km5	Dessert	1.0
Kisubi	Beer	0.7

Trees/ Shrub Species

Most of the fields were lowly inter-planted with trees/shrubs (40%; Figure 1). Only 28 tree/shrub species were observed in the coffee-banana agroforestry systems. These were dominated by fruit trees, oranges (70%), mangoes (63%) and papaya (57%, Table 2).

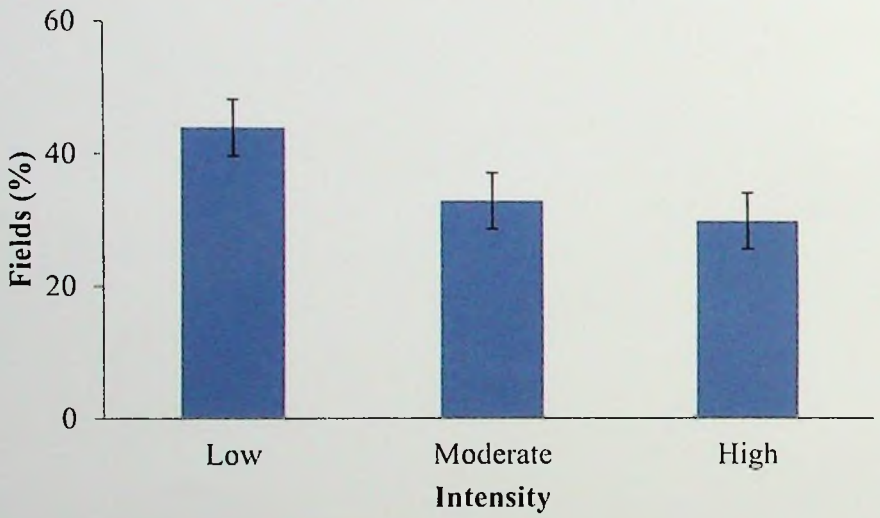

Figure 1. Intensity of inter-planting with trees/shrubs observed in the in the mid-northern Uganda coffee-banana agroforestry systems

Table 2. Tree/ shrub species observed

Family	Common name	Scientific name	Fields (%)
Rutaceae	Orange	*Citrus sinensis*	70.0
Anacardiaceae	Mango	*Mangifera indica*	63.3
Caricaceae	Papaya	*Carica papaya*	56.7
Fabaceae		*Albizia coriaria*	46.7
Moraceae	Jack fruit	*Artocarpus heterophyllus*	40.0
Moraceae	Natal fig	*Ficus natalensis*	36.7
Lauraceae	Avocado	*Persea americana*	33.3
Arecaceae	Borassus palm	*Borassus* spp	33.3
Caesalpinioideae	Cassia	*Senna spectabilis*	33.3
Boraginaceae	Large-leaved cordia	*Cordia africana*	33.3
Myrtaceae	Guava	*Psidium guajava*	33.3
Bignonaceae	Nile tulip tree	*Markhamia lutea*	30.0
Asteraceae	Bitter leaf	*Vernonia amygdalina*	30.0
Rhamnaceae	Umbrella tree	*Maesopsis eminii*	26.7
Annonaceae	Soursop	*Annona muricata*	23.3
Moraceae	Rock-elm	*Milicia excels*	20.0
Fabaceae	West African Albizia	*Albizia zygia*	20.0
Rosaceae	Red stinkwood	*Prunus africana*	16.7
Moraceae	Sandpaper tree	*Ficus exasperata*	16.7
Moringaceae	Moringa	*Moringa oleifera*	16.7
Rutaceae	Tangerine	*Citrus tangerina*	16.7
Proteaceae	Silky oak	*Grevillea robusta*	13.3
Meliaceae	Neem tree	*Azadirachta indica*	13.3
Myrtaceae	Eucalyptus	*Eucalyptus* spp.	10.0
Myrtaceae	Black plum	*Syzygium cumini*	10.0
Bignoniaceae	African tulip tree	*Spathodea campanulata*	10.0
Moraceae	Sycamore fig	*Ficus sycomorous*	10.0
Lamiaceae	Teak	*Tectona grandis*	10.0

Field Management Practices

Field management practices observed in the study area are summarised in Table 3. Most of the fields were poorly managed, with more than 80% of them having no manure, bands, trenches nor cover-crops. Also, most of the fields were lowly weeded (46.7%) and mulched (60%). Intercropping was generally lowly practiced (Figure 2), with 20% having maize or cassava (Table 4).

Table 3. Intensity of field management practices observed

Management practice	Intensity of practice			
	Not practicing	Low	Moderate	High
Weeding	6.7	46.7	40.0	6.7
Mulching	23.3	60.0	16.7	0.0
Manuring	90.0	6.7	3.3	0.0
Bands	96.7	3.3	0.0	0.0
Cover crops	83.3	13.3	3.3	0.0
Trenches	86.7	10.0	3.3	0.0

Low =1-25%; Moderate =26-50%; High =>50%



Figure 2. Intensity of inter-cropping observed

Table 4. Inter-crops in the region

Crop	Scientific name	Fields (%)
Cassava	*Manihot esculenta*	20.0
Maize	*Zea mays*	20.0
Cocoa	*Theobroma cacao* L.	16.7
Coco yams	*Colocasia esculenta*	16.7
Green vegetables	*Amarathus* spp	10.0
Beans	*Phaseolus vulgaris*	6.7
Tomatoes	*Solanum lycopersicum*	6.7
Groundnuts	*Arachis hypogaea*	6.7
Pineapple	*Ananas comosus*	6.7
Pumpkins	*Cucurbita pepo*	6.7
Cabbages	*Brassica oleracea* var. *capitata*	3.3
Cow peas	*Vigna unguiculata*	3.3
Eggplants	*Solanum melongena*	3.3
Millet	*Pennisetum glaucum*	3.3
Soy beans	*Glycine max*	3.3
Pigeon peas	*Cajanus cajan*	3.3
Bitter tomato	*Solanaceous aethiopicum*	3.3
Sesame	*Sesamum indicum*	3.3

Crop Management Practices

Crop management, at plant level was also poor (Table 5). Generally, 40% of coffee fields had not been de-suckered, pruned or their cycle changed. However, at least 35% of the coffee fields were highly pruned and their cycle changed. On the other hand, more than 65% of the bananas had not been de-suckered, propped nor their corms removed, but, 63% of them had been de-leafed and de-budded at a low to moderate level.

Table 5. Intensity of crop management practices observed

Management practice	Intensity of practice			
	Not practicing	*Low*	*Medium*	*High*
Coffee				
De-suckering	40.0	16.7	20.0	23.3
Pruning	46.7	3.3	13.3	36.7
Change of cycle	40.0	3.3	16.7	40.0
Bananas				
De-suckering	70.0	16.7	6.7	6.7
De-leafing	20.0	33.3	30.0	16.7
De-budding	20.0	33.3	30.0	16.7
Corm removal	93.3	6.7	0.0	0.0
Propping	80.0	16.7	3.3	0.0

Low =1-25%; Moderate =26-50%; High =>50%

Pests and diseases of coffee and bananas

Coffee was infested by a number of pests, with the most commonly observed being: leaf skeletonisers (77%), tailed caterpillars (58%), coffee berry borer (33%) and leaf eating beetles (32%). Disease incidence on coffee was generally low, with the most common diseases being coffee leaf rust (15%) and red blister disease (7%, (Table 6). On the other hand, pest damage was rarely observed on bananas, though, black Sigatoka was the commonest disease observed (56% Table 7). However, this study did not assess pests and diseases for the trees/shrubs.

Table 6. Pests and diseases observed

Constraint	Scientific name	Coffee trees (%)
Pest		
Leaf sketeltonisers	*Leucoplema dohertyi* Warren	77.3
Tailed caterpillars	*Epicampotera* spp	55.7
Coffee berry borer	*Hypothenemus hampei*	33.3
Leaf eating beetles		32.3
Leaf miners	*Leucoptera coffeina*	21.0
Weaver ants	*Oecophylla smaragdina*	8.7
Coffee berry moth	*Prophantis smaragdina* (Butler)	8.0
Spider mites	*Olygonychus* spp	0.3
Mealybugs	*Planococcus* spp	0.3
Termites	*Odontotermes* spp	0.3
Disease		
Coffee leaf rust	*Hemileia vastatrix*	15.3
Red blister disease	*Cercospora coffeicola*	6.7
Brown eye spot	*Cercospora coffeicola*	0.3
Coffee Wilt Disease	*Gibberella xylarioides* (*Fusarium xylarioides*)	0.3

Table 7. Diseases observed on bananas

Common name	Scientific name	Mats (%)
Black sigatoka	*Mycosphaerella musicola* (Mulder)	56.0
Fusarium wilt	*Fusarium oxysporum*	4.0
Banana xanthomonas wilt	*Xanthomonas campestris* pv. *musacearum*	3.5

DISCUSSION

Coffee Types and Banana Clones

Our study showed that all the sampled households were growing Robusta coffee, *Coffea canephora* (Table 1). The reason for this is that the mid-northern region is situated below 1400 m below sea level (Okwir, 2009; UTTWG, 2014), therefore suitable for growing this type of coffee (Musoli *et al.*, 2001). Most of the Robusta coffee observed was of the clonal type because the Uganda Coffee Development Authority (UCDA) has been promoting this type of coffee for some time (Mbowa *et al.*, 2014). On the other hand, the East African Highland Bananas (EAHB), commonly known as 'Matooke' dominated the banana clones observed in the region (Table 1). This could be attributed to NARO/NARL's efforts of promoting and distributing banana planting materials of this type of bananas in the region (Kubiriba *et al.*, 2016). Bananas have additional advantages of yielding throughout the year and needing less investment compared to other crops (Nyombi, 2013). Additionally, bananas are a source of shade to coffee when it is still young (van Asten *et al.*, 2011). However, the region needs suitable banana cultivars such as Kiwangaazi (a motooke hybrid) and the FHIA's - these cultivars can resist drought as well as pests and diseases (Nowakunda and Tushemereire, 2004; Tinzaara *et al.*, 2009).

Trees/ Shrub Species

A total of 28 tree/shrub species were observed in all the study fields (Table 2) and less than the 40, Ssebulime (2017) observed in the banana agroforestry systems of central Uganda. These tree/shrub species were dominated by fruit trees particularly oranges, mangoes and papaya (Agea *et al.*, 2010; Oryema *et al.*, 2013). Similarly, Ssebulime (2017) reported mangoes, *Mangifera indica* as one of the commonest trees/shrubs in banana agroforestry systems of central Uganda. The research challenge is therefore, finding the best-bet fruit trees that are compatible with both food and cash crops and which are less competitive but at the same time offering maximum soil fertility (Ssebulime *et al.*, 2017). However, basing on farmers' preference and scientific knowledge, NARO/NaCORI has identified and recommended three site-specific shade tree species (*Ficus natalensis*, *Albizzia coriaria* and *Cordia Africana*) for inter-planting in the coffee-banana systems of this region (Kagezi *et al.*, 2016a). These coffee-banana agroforestry systems therefore present an opportunity for improving household income and food security, as well as mitigation for climatic adversities in the region (Okorio *et al.*, 2004).

Field Management Practices

Management of the coffee-banana agroforestry fields was poor – with >80% of them with no manure, bands, trenches nor cover-crops, at the same time, lowly weeded (46.7%) and mulched (60%; table 3). Other practices like intercropping were lowly practiced (Fig. 1) - with 20% having maize or cassava (Table 4). The reason for this is in part due to the fact that both crops are not traditional in this region, implying that

farmers are just acquiring knowledge and skills of managing these biotic stresses (Mbowa *et al.*, 2014).

Crop Management Practices

The coffee plants were also generally poorly managed. Most of the coffee fields (40%) were not been de-suckered, pruned or their cycle changed whereas, >65% of the bananas had not been de-suckered, propped nor their corms removed. Low knowledge on the good agricultural practices (GAP's) has been identified as one of biggest challenges to coffee and banana production in northern Uganda (Zeweldu, 2014) and elsewhere (Wairegi *et al.*, 2010; Okech *et al.*, 2004). This problem is exacerbated by the limited availability of specialised coffee and banana extension support (Mbowa *et al.*, 2014).

Pests and Diseases of Coffee and Bananas

Leaf skeletonizers, *Epiplema doherty*i Warren (Lepidoptera: Epiplemidae) and the tailed caterpillars, *Epicampoptera* sp. (Lepidoptera: Erebidae) were the commonest insect pests observed in the mid-northern Uganda coffee-banana agroforestry system (Table 6). This agrees with studies in coffee-banana agroforestry systems in other regions of Uganda (Kagezi *et al.*, 2016b; Kobusinge, 2016) as well as other coffee systems in lower altitudes (Musoli *et al.*, 2001; Jassogne *et al.*, 2013). These insect pests feed on coffee leaves, reducing the photosynthetic area and thus the yield of the attacked coffee tree (Wrigley, 1988; Rutherford and Phiri, 2006). The high incidence of both these pests is the region is in part be due to farmers' lack of knowledge of the damage these pests cause as well as their management options (Kagezi *et al.*, 2016b; Kobusinge, 2016).

For the diseases, coffee leaf rust was the most commonly observed on coffee in the region. The disease is caused by a fungus, *Hemileia vastatrix* (Berkeley and Broome) and has been recognised to be important in Robusta coffee-banana agroforestry systems of other studied region (Kagezi *et al.*, 2016b; Kobusinge, 2016), as well as on Arabica coffee (Musoli *et al.*, 2001; Rutherford and Phiri, 2006). Severe cases of the disease cause serious defoliation that reduces the photosynthetic area and in turn, yields (Rutherford and Phiri, 2006). On the other hand, pest damage on bananas was rarely observed (Table 6). Similarly, low pest pressure was observed in coffee-banana agroforestry systems in other regions of Uganda (Kagezi *et al.*, 2016b; Kobusinge, 2016). The reasons for the low damage by the banana weevil, *Cosmopolites sordidus* (Germar), the most important insect pest of bananas are yet to be given. High damage by this insect pest is associated with extended droughts (Gold *et al.*, 2001), a common phenomenon the study area. Nevertheless, black Sigatoka was the commonest disease observed, agreeing with studies in coffee-banana agroforestry systems in other regions of Uganda (Kagezi *et al.*, 2016b; Kobusinge, 2016). This disease is caused by the fungus *Mycosphaerella fijiensis* and leads to serious yield reduction on bananas, particularly the EAHB's (Tushemereirwe, 1996; Tushemereirwe *et al.*, 2004). The high incidence of the disease in the region could therefore be in part due to the fact that most of the banana clones observed belonged to the susceptible EAHB's. This is coupled with farmers' lack of knowledge of the banana diseases as well as their management. Black sigatoka causes premature drying of leaves and thus reducing the functional leaf area resulting into incomplete filling of banana fingers and yield loss (Tushemereirwe *et al.*, 2004).

Nevertheless, the agroforestry systems have been reported to manage certain pests and diseases in coffee and other crops (Beer *et al.*, 1998; Tscharntke *et al.*, 2011; Pumariño *et al.*, 2015). Research should therefore gear more efforts towards optimising these

coffee-banana agroforestry systems for managing pests and diseases (Kobusinge *et al.*, 2016; Kobusinge, 2017).

Conclusion

In conclusion, Robusta coffee and the East African Highland Bananas (EAHB's) were the major coffee and banana types grown in the coffee-banana agroforestry systems of mid-northern Uganda respectively. Only 28 tree/shrub species were observed in the systems and dominated by fruit trees. Management at both field and crop level including pests and diseases was poor. Therefore, research and extension should put more efforts in farmer awareness as well as optimising these systems for managing pests and diseases of both crops.

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