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Agronomic, pests and economic factors influencing sustainability of banana-coffee systems of Western Uganda and potentials for improvement

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Abstract

In Uganda, banana (*Musa* spp) and coffee (*Coffea* spp) form the economic base for a big population of small-scale farmers and provide environmental protection. However, their production is currently declining. The two crops are grown in association as intercrops or adjacent monocultures but little information exists on biological and socio-economic complementarities and antagonisms between them; thus complicating interventions to reverse the decline. In view of the above, Participatory Rural Appraisals (PRAs) and diagnostic studies were conducted in 2003 to: (1) Determine management practices, constraints and market effects on the production of banana and coffee, (2) Elucidate farmers' perceptions on production and management constraints and (3) Derive hypotheses for further participatory research. The information was obtained through group and key informant interviews, discussions and farm assessments at three sites in Mbarara district, South-western Uganda. The studies showed that pests and diseases, declining soil fertility, poor management and lack of good markets are the main causes of the decline. Key banana pests were banana weevil and nematodes affecting local (AAA-EA) cooking and brewing types and fusarium wilt affecting exotic (ABB, AB and AAA) brewing and dessert types. Coffee suffers mainly from coffee wilt. Banana and coffee mutually benefit each other but also compete for resources. Banana provides shade and mulch for young coffee while coffee provides husks for banana nutrients and mulch at sites closer to the coffee factories. Regular application of coffee husks in banana plantations lowers the incidence of banana weevil pest and gives bigger bunches. The antagonistic aspects of the system include coffee depletion of soils and banana shading of older coffee plants. Lack of liquidity among farmers, arising from poor markets, leads to poor crop and pest management. Revamping farmers' organizations for marketing purposes would improve farm gate prices and hence improved liquidity for reinvestment in the system.

Key words: Banana pests and diseases, cropping systems, socio-economics, soil fertility.

Introduction

Banana and coffee form the economic base for majority of small-scale farmers in Uganda. The two crops are grown in association as intercrops or adjacent monocultures. The East African highland-cooking banana (AAA-EA), which covers the largest area, doubles as a primary food and leading cash crop. Coffee is looked upon for long-term seasonal cash boom. As perennial tropical crops, they produce year-round canopy that provides ground cover and minimizes soil erosion. However, yield trends of the two crops over the last 20 years suggest that the production systems are declining and hence a threat to food security and rural economy. For example, banana yields in Central Uganda have declined resulting into a shift in major production to South-western Uganda (Gold *et al*, 1999). Major problems associated with the decline have been reported as small size of holdings, which leads to over-exploitation of resources and insufficient cash (Hoekstra *et al*, 1991), pests and diseases, declining soil fertility and socio-economic factors (Gold *et al*, 1999). Most of the research activities have often looked at the crops independently and not the system under which they are grown and the interactions associated with it, hence limited information on how to intervene and reverse the decline in the system. It is important to generate information about the system on; (i) the interaction (socio-economic, agronomic, pests and diseases) of these two crops, (ii) how best these systems can be established, developed and improved

This paper reports the results of a Participatory Rural Appraisal (PRA) and diagnostic survey that were conducted at three sites Mbarara district, South-western Uganda with the following objectives:

(1) To determine shifts in management practices, constraints and market effects in the production of banana and coffee, (2) To elucidate farmers' perceptions on production and management constraints and (3) To derive hypotheses for further participatory research.

The survey covered community issues, farming systems and crop management, germplasm, socio-economic, soils, pests and diseases and post harvest.

Materials and methods

The method adopted involved pre-survey tours to select the sites, development and pre-testing of a checklist for the key-informant and group interviews, PRA and diagnostic survey.
Site description and selection

Mbarara District is located 200 km South West of Kampala, the capital of Uganda. The surveys were conducted at three sites in the western part of the district, representing a cross section (North – South transect) of the cropping zone. The zone receives an annual rainfall (received in two seasons, March - May and September – December) ranging from 700 mm to 1200 mm (average being 900mm). Site one was at Nyarubungo Parish, Bukiro Sub County in Kashari County situated about 50 km West of Mbarara town (the district capital), 7 km off the main Mbarara-Ibanda tarmac road. The access earth road was passable by motor vehicles only during the dry season. The nearest marketing centres were Bukiro and Bizibwera (4 km and 7 km away, respectively).

Site two was at Ndaija Parish in Ndaija Sub County in Rwampara County, about 40 km South West of Mbarara town along Mbarara-Kabale tarmac road. The nearest two markets were Nyeihanga and Buteraniro situated 4 km and 6 km away respectively. The access earth roads are poor. Each of the markets had a coffee factory. Site three was at Kihani Parish in Kikenkye Sub County in Ibanda County. It is situated about 60 km North West of Mbarara town, 7 km off Mbarara-Ibanda tarmac road. The access earth road is passable throughout the year. The nearest market (Igorora) is 7 km away along the Mbarara-Ibanda road.

Demography, infrastructure and market access

Site three had the highest population density, 286 persons/ km^2 (6,114 households), followed by site two, 233 persons/ km^2 (4,982 households) and site one with 79 persons/km^2 (2,628 households). Generally women were more than men. At site three populations were women - 16,091 and men 14,812. At site two women were 12,726 and men were 12,154. At site one, women were 6,720 and men were 6327.

The PRA

Information was obtained through group and key informant interviews. A checklist guided the group interviews at all sites. The local Agricultural Extension Officers in collaboration with the local administration and opinion leaders/group chairpersons mobilized farmers for the PRAs. Attendance was open to all farmers. Meeting at site one was held in a church (Nyaruhangu Church of Uganda). Sites two and three meetings were held at the Sub County headquarters. Further, individual farmers were visited on their fields and interviewed verbally to verify some of the constraints reported by the group.

Attendance was 55 at site one, 15 at site two and 65 at site 3. Male and females attended in almost equal ratios at all sites. The interviews were conducted in local language. The local extension officer served as the interpreter. The survey team solicited opinions from as many farmers as possible to avoid domination of the meeting by a few individuals during the group interviews. A free discussion was permitted on the different topics raised. Where a consensus could not be reached, a poll by show of hands was taken to make a conclusion. Ranking of priorities for example importance of different crops/enterprises and constraints was done by a show of hands. Opinion of the majority prevailed. The group interviews took 3 to 5 hours.

Key informants (Sub-ounty heads, village elders and group chair persons) were interviewed separately to verify information from the group interviews and to obtain some details like government policies, population data etc. that could not be clearly reported by the groups.

Diagnostic survey

A detailed diagnostic survey was conducted at site 2, which was predominated by banana-coffee intercropping and had coffee factories, hence accessibility to use of coffee husk in the production system by the farmers. Thus the site provided opportunity to compare monoculture and intercropping systems of production and to observe the interactions. The objectives of the diagnostic survey were (1) to verify farmers' reports and (2) to determine relationships between cropping systems, management practices and pests and diseases.

Farm selection

Sixty farms were randomly selected using ballot papers from 5 villages (Ndaija I 10 farms; Ndaija II 10 farms; Nyindo 15 farms; KyesikaI 10 farms and Kyesika II 15 farms). Number of farms selected from each village depended on the population density.

Characterization of the farms

Each farm was mapped out and subdivided into plots according to crops grown, cropping system adopted, and management practices employed on different parts of the farm. Each plot was classified according to the intensity of various management practices (intercropping, manure application, mulching, weeding, desuckering, deleafing, sanitation and soil and water conservation). The intensity of each practice was rated as, none, light, or intensive. Soil fertility was rated as very poor, poor, medium, good, and very good. Types of mulch and manure used and frequency of application was recorded

Data on banana pests and diseases were collected on weevils (using Gold *et al*, 1994 method), nematodes (using Speijer and Gold, 1996 method), black sigatoka, fusarium wilt using Orjeda (1998) methods and banana streak virus. Coffee pests and diseases recorded were coffee wilt, leaf rust, mealybugs and aphids.

Banana yields were estimated using bunch weights. Coffee yields were estimated by asking the farmer the quantity (bags/

tins) of dry berries harvested in the last two years.

Data analysis

Data from PRA study were summarized using descriptive statistics. Data from diagnostic survey on pest densities and damage levels were analyzed using SAS (SAS Institute Inc., 1990). Management practices (intercropping banana with coffee, manure application, and mulching including type of mulch) and bunch weights formed the major variables. Variables that were recorded as percentages e.g. weevil damage and root necrosis (nematode damage) were transformed using Arcsine transformation; x_ =100*arcsine (sqrt(x+0.5)/100*22/28). Data recorded as counts e.g. nematode population density were transformed using square root.

Results

Farming systems

Crop production was the dominant system at all the surveyed sites. The cultivated crops are presented in Table 1. Livestock rearing varied among the sites but was generally minor because of land scarcity.

Food crops

The East African Highland cooking banana (AAA-EA) was considered as the major food crop at all sites (Table 1). Sweet potato was ranked second in sites one and two and fifth in site three. Millet was ranked second in site three, third in site one and fourth in site two. Beans were important at all sites, as they are eaten with bananas, sweet potato or millet. Other food crops were cassava, Irish potato, maize and groundnuts. The ranking had not shifted in the last ten years at all sites.

Cash crops

Banana was ranked first as cash crop at sites one and two and third at site three (Table 1). Coffee was second at sites two and three and third at site one. Beans was ranked first at site three, second at site one and was of no importance at site two. Tomatoes were ranked third at site two but were not important at other sites. Other cash crops were millet and groundnuts at site one, pineapples and passion fruits at site two, ground nuts and maize at site three. Shifts in ranking ten years ago were only recorded at site two where coffee was the leading cash crop followed by bananas and tomatoes. There were no shifts at other sites.

Food security and market/cash income were the main factors that influenced the ranking of cash crops. For example, bananas as main food also has a high and readily available market at sites, one and two, which are near the main tarmac road and within collection radius for the Mbarara and Kampala markets. Site three was remote from the main banana collection radius and hence, lower prices were observed. Beans, which are also important food, had better market value than banana and were ranked first above coffee. They had also a better transport cost/market value relationship than other crops, and a long shelf life, which contributed to their role as cash crops in remote places. Vegetables and fruits were an important market option in site 2, which is closest to Mbarara market for such perishable products.

Banana types and their importance

Table 2 shows the patterns of banana production at the three sites. Cooking banana (AAA-EA) (*matooke*) cultivars were the major type of bananas grown at all sites, followed by local brewing type (*embiire*) (AAA-EA), large desert bananas (*bogoya*) (AAA) and, to a smaller scale, small desert or apple bananas (*sukali ndizi*) (AB). Shares of each type shifted across sites. At site one, about 75 % of the bananas grown were *matooke*, about 10% were *embiire*, 10% were *bogoya*, and about 5 % were *sukali ndizi*. At site two, *matooke* held about 80% of production share, *bogoya* 10% and the rest was shared equally by *embiire* and *sukali ndizi*. At site 3, between 40% and 60 % of the bananas grown were *matooke*, followed by *embiire* (20-30 %), which was seen as very profitable at this site, *bogoya* (10-20 %), and *sukali ndizi* (10%).

Agronomic aspects of the banana-coffee system

Farmers reported that best soils were allocated to banana while poor soils were allocated to coffee at all sites. More land was allocated to banana than coffee at all sites due to food security. Farm sizes were generally small. At site one farms ranged from 0.25-47 ha (mean = 1 ha). Site two farms ranged from 0.1 – 1.7 ha (mean = 0.5 ha) and site three ranged from 0.1 – 1.6 ha (mean = 0.5 ha).

Site one reported three production systems; (a) Banana or coffee monoculture was 54%, (b) banana-coffee intercrop 8%, (c) Intercropping of more than two crops, i.e. banana, coffee and annual crops (beans, cassava, maize, groundnuts, pumpkins) 38%. The ratio of banana**:**coffee on intercropped plots was about 1:2. Farmers at this site usually set aside separate plots for banana monoculture. Usually most of bunches from monoculture plots are for sale and most of bunches from the intercropped plots are used for domestic consumption because they tend to be small and do not have a good market value. Therefore banana covered a larger area at site one than coffee and was better managed than coffee monoculture.

Three systems were also reported at site two; (a) banana or coffee monoculture – 17% of the participants, (b) banana + coffee intercrop – 41%, and (c) banana + coffee + beans – 42%. In most cases bananas density was higher than that of coffee (banana: coffee ratio 3:1) because it is the staple food and also provides cash. However, coffee density was higher than banana density on poor soils.

Site three reported two systems, banana or coffee monoculture (70%), and intercropping banana + coffee (30%). The ratio of banana: coffee was 15:4 in the intercropping because coffee suppresses banana.

Benefits from banana-coffee intercropping

Reasons given for intercropping were: (1) to maximise on space and labour resources utilization, all sites; (2) limited land, all sites; (3) to replace an old banana plantation on a poor land, sites one and two; (4) bananas provide nutrients/ moisture for young coffee, sites one and two; (5) banana provides shade and mulch for coffee, sites one and two; (6) coffee husk is used for soil fertility maintenance, sites two and three; (7) banana-coffee intercrop looks beautiful, site one;

Constraints to banana-coffee intercropping

It was reported at all sites that coffee mines the soil and kills banana after some time. Hence intercropped plots eventually turns into coffee monoculture. Time taken for bananas to die out in the intercrop depends on management and soil fertility but takes about 5 to more than 10 years. As mentioned above, at site one, farmers usually plant a separate plot for banana monoculture to ensure that they do not miss banana because of intercropping while at site two banana is maintained at a higher ratio than coffee.

Management of the banana-coffee production systems

Banana monoculture

At all sites, more attention was given to banana than coffee because of food security. Management of old plantations involved desuckering, hand weeding, application of manure, mulching and sanitation (shredding spent corms and pseudostems in the plantation as mulch). Differences among sites with regard to banana management were mainly in the percentage of farmers carrying out a particular practice and the materials used (Table 3). All farmers at all sites desuckered (keeping 3-5 suckers per mat) and weeded. Sanitation was done by 15 % at site one, 30 % at site two and 20 % at site three. Farmers at all sites relied mainly on banana residues and annual crop residues for mulching an old plantation. A few added external mulch. At site one 80% reported mulching using banana residues only. Less than 10% added external mulch. Similarly less than 10% applied farmyard and/or compost manure.

At site two, 85% of participants mulched with banana and beans residues generated from the plantation. Only 10% reported us of coffee husk. The number using coffee husk was higher (about 80%) 5 years ago when the local coffee factory was working, but use of husk reduced when the factory stopped. It was reported at site two that farmers also depended on coffee husk as manure because of lack of animals. Currently less than 15% apply manure.

Mulching at site three was similar to that at site one. However, more farmers (20%) applied farmyard/compost manure compared to less than 10% at site one.

Management of new plantation varied from site to site depending on resource availability and interaction with extension services. At site one, average spacing was 3m X 3m in the monoculture system although there was variability from farm to farm ranging from 2m X 3m to 3m X 4m. Suckers (planting materials) were collected from farmers' own old plantations or neighbours' plots and planted without treatment (paring). Annual crops to cover the ground and maximise on space until first harvest were intercropped in new plantations. At site two spacing and handling of planting suckers was the same as at site one but some farmers planted beans or groundnuts first, and then planted bananas in the new field, while a few planted bananas without cultivation then sprayed herbicide because of couch grass weed. At site three farmers had received a longer established extension service. At this site, new banana plantations were established in bean fields. About 25% of them treated the suckers (paring) before planting. They were also aware of new banana cultivars.

Coffee monoculture/mono-cropping

Traditional robusta coffee variety predominated all the sites. Arabica variety was grown at site three only. But even at this site it formed only 25% of the plantations. Improved clonal (robusta) coffee was grown in small quantities at all sites (30% at site two, 10% at site 3 and 5% at site one) (Table 4).

New coffee plantations received better attention than old plantations because they were established as intercrops with either bananas or annual crops (especially beans). Common practices at all sites were: (a) new land was cultivated to remove permanent weeds. Planting holes were prepared at a spacing of 3 X 3 m. Arabica coffee was spaced at 2.5m X 2.5m. The size of planting hole was not specific, some farmers made it 30 cm X 30 cm, while some made it 60 cm X 60 cm holes. About 30% of the farmers at site three added manure into the planting holes but others did not. At other sites the holes were filled with topsoil only without any manure. The spaces were then planted with beans or other annual crops. All planting was done at the beginning of the rains; (b) some farmers started new coffee plantations in banana plantations. In such cases a new banana plantation was established as above. After one cycle, coffee seedlings were planted at the base of each banana mat. Banana provided support to the young coffee to establish by providing shade and moisture (especially during the dry season) and eventually died out leaving a well-established coffee. This was often done on poor soils; (3) new coffee plantations were also established in old banana plantations, which had declined due to soil fertility. A similar procedure as above was followed to plant new coffee seedlings.

Use of certified seedlings (from Uganda Coffee Development Authority (UCDA)) to establish new coffee plantations was highest at site two (70 %) and low at sites one and three (25 % and 30 %) respectively, where most farmers used wild seedlings from their old plantations or from neighbours (Table 5)

It was reported across all the sites that proper management of old coffee plantations (as per agricultural extension workers' recommendations) were weeding, manuring, pruning, mulching, training, stumping/changing crop cycle.

At site one the farmers implemented none of these except stumping (using a machete). Old coffee plantations were neglected because of lack of resources, which was as a result of low coffee prices. Priority was give to bananas. At site two farmers only reported weeding, pruning and changing cycle after 20 – 25 years. About 50% of the participants changed the crop cycle using a machete (Table 5). Weeding and pruning were casually observed. At site three the farmers reported the following practices: weeding, pruning, mulching, bending plants for easy harvesting, spraying pesticides and construction of soil and water conservation ditches. However, these were also casually implemented. Only one person sprayed coffee. Manuring of old coffee plantations was not done at any site.

Banana-coffee intercropping

As mentioned above, coffee in the banana intercrop received better attention than coffee monoculture because of the value attached to bananas at all the sites. Two kinds of intercropping of banana and coffee were reported: (a) temporary intercrop - a situation where the ultimate goal of the farmer was to establish coffee in the plot and used banana to enhance the establishment of young coffee. In this situation, both the banana and coffee were planted in the ratio of 1:1. The spacing was 3m X 3m. Some farmers planted the crops in alternate rows while some planted the whole field with bananas and then planted coffee at the base of the banana. Such plots received normal banana management practices described above, except sanitation was minimum since the farmers expected bananas to die out after some times leaving coffee as a monoculture; (b) Permanent intercropping - a situation whereby the farmer intended to keep the two crops together permanently. Usually banana was the favoured crop and the ratio of banana to coffee was tilted. It ranged from 3:1 to 6:1. The spacing between bananas remained 3m X 3m and between banana and coffee were about 3.5m to 4m. There would be 3-5 rows of banana alternated by a single row of coffee. In some cases there were patches of coffee in the banana plantations instead of regular patterns as reported above. These followed soil fertility gradient in the plot. Coffee tended to occupy sections of low fertility.

General soil fertility management

The farmers listed only organic methods of soil fertility management in handling soil fertility issues at all site. Fertilizers were not used at all sites. Resource availability and exposure to extension services played an important role on steps taken at each site. At site one, farmers listed, (i) farmyard manure, (ii) compost manure, (iii) sanitation practice in bananas, (iv) natural plant products (thithonia and entarahando), and (v) soil erosion control measures (planting grass along the perimeter of the field, construction of water and soil conservation contour bunds, zigzag arrangement of banana stems across the field and making trash lines using annual crops residues). Farmers applying soil and water conservation practices were 40%. Site one had had an extension officer for a longer time (3 years) concentrating on land soil fertility management. It is through him that they learnt the use of natural plant products.

Site two relied mainly on coffee husk for soil fertility management because of lack of animals. Soil erosion control technologies listed in site one was rare at site two and only casually put in place. The Extension officer had just moved to site (2 months only). Site three relied more on farmyard manure for soil fertility management. Soil erosion control and water conservation practices were also common compared to site two.

Intercropping systems management was quite complex. Some farmers planned their systems to minimise labour inputs while maintaining soil fertility. For example one farmer, visited by the survey team, had beans grown in his banana plantation by the day labourers, mostly women. The bean crop did not belong to the farmer. The day labourers took the grains quasi as a salary, while the banana plantation benefited through the application of labour and bean residues were used as mulch.

Constraints to the banana-coffee system

Market (low fluctuating prices) for both bananas and coffee was the common leading constraint at all sites followed by pests and diseases. Declining soil fertility was third at sites one and two and fourth at site three. Poor management was ranked third at site three (Table 6). Poor management was associated with lack of resources including equipment/tools and labour. Shortage of land was ranked high among the constraints but it was given a low priority in this PRA because of the survey objectives.

Pests and diseases of bananas

Banana weevil was listed as the leading pest constraint in banana at all sites. Crop sanitation was reported as the key control method available at all sites. Keeping the mulch away from the banana mat was also listed but was not unanimously accepted. Effect of coffee intercrop on the banana weevil was not known and in fact at sites one and two it was reported that weevil damage was higher in banana-coffee intercrop because management in that system was usually low, banana plants was usually weaker in the coffee intercrop and hence more vulnerable to weevil attack. However, it was reported at site two (where use of coffee husk was popular) that weevil damage was usually lower whenever coffee husk was applied in the plantation. Fusarium wilt was second to banana weevil, attacking the dessert bananas at all sites. Some farmers thought that it was the same organism causing wilt in coffee. *Matooke* wilt was reported at site three only (Table 7).

Pests and diseases of coffee

Coffee wilt disease was a common problem at all sites. At site one 20% of the participants had coffee wilt in their fields and 30% at sites two and three. However, it was ranked second at site one, third at site two and fourth at site three. It was reported that the spread was about 10% or less in the plantations. Scales & mealy bugs were first at site one, and second at sites two and three. Coffee berry borer was third at

sites one and three. Site two did not report coffee berry borer. Die back was unique to site two only and it ranked first. Coffee stem borer was reported at site one only where it was ranked third. (Table 7).

Economic aspects of the banana-coffee system

The most important economic relationship *between* the two crops was that they provide seasonal liquidity (especially coffee) for their mutual benefit on management. During the whole year, banana sales provide liquidity for hiring labour for banana and coffee management; coffee provides liquidity for banana management during the coffee-harvest season. There are of course many other economic aspects that apply for banana and coffee growing independently and are listed below.

Economic functions of banana and coffee respectively as mentioned by the farmer

Comparing the mere cash revenues of banana and coffee showed that coffee generally seemed to be the slightly more profitable than banana Table 8. At site one coffee yielded between Ush.1,500,000 and Ush.3,460,000 per ha per year in cash, while banana yielded between Ush.990,000 and Ush.2,470,000 per ha in cash on the same unit area. But if the additional amount of food from banana was valued and added, the picture changed. It was reported that 15 to 50 % of the harvest was consumed at home. This added a value of about Ush.370,000 to Ush.790,000 to the economic yields of banana, which made banana about as profitable as coffee, although slightly less. It can thus be assumed that farmers consider banana to be more profitable than coffee for the sake of liquidity and food security, but at current prices coffee is more profitable. A similar picture was reported at sites two and three. Thus the economic functions of the two crops go beyond profitability.

Whereas coffee provides cash even from marginal sites, it is also seen as a saving device and a source of funds for investments that have to be made once a year. Banana gives cash, but also provides food security. Another major economic function of bananas is that they can be harvested throughout the year and thus provide a continuous flow of liquidity. Finally, banana provide by products like leaves that can be used as mulch, animal feed and fibres. This underlines the preference for banana to coffee by most farmers. Most of the farmers stated even if coffee prices rose, banana would still be cultivated for provision of continuous regular liquidity needs and to assure food security. However, farmers reported that they would continue keeping coffee in their plots even if prices fluctuate because coffee requires very little attention compared to banana.

Marketing, post-harvest and processing of banana and coffee

Farmers were asked about the products marketed, the organisation of banana and coffee marketing, problems with marketing, price developments and seasonality of the two products and post-harvest and processing.

In general, the farming systems at the survey sites can be considered as both market and subsistence oriented. All the harvested coffee was usually sold for cash, while other crops like beans, 50 % of the harvest were marketed. In the case of banana, 50 to 85 percent of the harvest was sold, depending on the site and the relationship between land endowment, land productivity and the nutrition requirements of the owner and his or her family.

The way the farm produce was marketed was homogeneous across the sites. Generally, products (banana and coffee) are sold at the farm gate at all sites except at site one where coffee was sold both at the farm and at an open local market to traders. Brokers go around the farms and negotiate the price on behalf of the traders. As soon as there is agreement on the price, the crops are cut (in the case of the banana) and then sold on the spot. The marketing system is depicted in Fig. 1.

The problems the farmers encountered in the marketing system were (1) farmers' lack of market information. Only the brokers and or traders knew banana prices in Kampala. The farmers had to take what they were offered by the brokers. This depresses the prices the farmers earn from their product, as "the buyer determines the price"; (2) brokers demanded re-negotiation of prices to be paid brokers in-kind (i.e. with bunches), whenever, farmers delivered their bananas directly to the collection centres; (3) theft during the high price season; (4) default in payment, and losses of cut bunches while waiting for brokers to come. The problems encountered in coffee marketing were basically similar; weak marketing position being the main problem facing the farmers.

Bananas, especially *matooke*, prices showed a significant seasonality. While during most of the year, from September to March, prices ranged from Ush.2,000 to Ush.3,000 per bunch (depending on size and quality of the bunch), they go down to Ush.250 per bunch, during the season when large quantities are harvested, i.e. May to August. Price fluctuations only slightly differ across sites. At the first site, additional price deductions up to 25 % during the rainy seasons according to poor accessibility are reported. Dessert bananas, e.g., *bogoya*, showed lower seasonal price variability.

Coffee had only one main harvesting season in the region, so that a seasonality of the banana-kind cannot be observed. Yet through the harvesting season, also two price fluctuations were reported. While at site 2, prices at the beginning of the season were lower (at about Ush.200 kg^{-1}), and rose towards the end of the season to about Ush.300 kg^{-1}, at site 3, prices fell during the season from Ush.300 kg^{-1} to Ush.150 kg^{-1}.

Post harvest and processing activities were considerably low at all sites. Coffee was partly dried, partly sold fresh. There seemed to be not many problems in storing coffee, especially when dried. Banana was processed to beer in case of the *embire* variety, which seemed to be a quite profitable business especially at site 3. Future requirements mentioned by the farmers were mainly for processing *matooke* to improve storage capability and reduce post harvest losses,

so that adding value or storing until the higher price season can overcome low price seasons

Diagnostic Survey

Plot management and yield

Banana monocrop plots formed 47 % of the surveyed farms, banana-coffee intercrop (at almost equal ratios) were 32 % and banana-coffee side by side with overlapping interface and sparse intercrop was 21 %. The diagnostic survey observations showed that most (80%) of the plantations were on moderately fertile soils on medium slopes. Farms on poor and good soil were 10 % each. Distribution of banana monocrop and banana-coffee intercrop on poor and good soil was not different. However, majority of banana monocrop farms received higher soil fertility management attention, especially mulch, application than banana coffee-intercrop. Among banana monocrop plots, 50 % were mulched with coffee husk, 25 % received grass mulch and 25 % depended on self-generated mulch (banana residues) only while mulch use in banana-coffee intercrop was; coffee husk (31%), grass mulch (13%) and banana residues only (56 %). Level of crop sanitation was generally low and was not significantly different among the cropping systems in place, i.e. <20% of the of the surveyed farms had moderate level of sanitation (Table 9). No farm was observed with high level of sanitation. Coffee monocrop plots did not receive any attention other than harvesting.

Banana plants under monocrop were generally more vigorous (bigger girth) than those under coffee intercrop as shown in (Table 9). Bunch weights (used as yield indicators) were not significantly different although bunches from monocrop recorded higher weight (17.2kg) compared to those from banana-coffee intercrop (15.1 kg) (Table 9). Farms which received coffee husk had significantly heavier bunches (25 kg) compared to those which relied on grass mulch (16 kg) and banana residues only (13 kg) (Table 9).

Pests and diseases observed in the DS

Banana

Banana weevil and nematodes were the key pests noted on almost all the surveyed farms. Banana weevil was observed on 95 % of moncrop and 100 % of intercrop plots (Table 10). A mean of 85 % of monocrop and 81 % intercrop banana mats sampled were infected with the weevil. Level of banana rhizome damage from the weevil ranged from 1 % to 16 %. Average rhizome damage in the monocrop and intercropping systems were not significantly different (Table 9). However, plots in which coffee husk was consistently applied had significantly lower level of rhizome damage than those that relied on self-mulch (banana residue) or grass mulch (Table 11). Nematodes were observed on all the surveyed plots (Table 10). However damage levels were generally low (mean of 8 % root necrosis) (Table 9). Neither cropping systems nor soil fertility management methods showed significant differences in root necrosis levels. Toppling of bananas, possibly due to nematodes and or banana weevil, was observed on 50 % of the monocrop plots compared to 81 % of the intercrop plots, but mean (%) mats which toppled per plot were low in the intercrop (8 %) compared to monocrop (14 %) (Table10).

Key banana diseases were, (a) matooke wilt on East African Highland varieties, observed on 75 % and 81 % of the monocrop and intercrop plots respectively. However, only a mean of 7 % mats per plot were infected in the banana-coffee intercrop compared to 32 % per plot in the monocrop; (b) Fusarium wilt was observed on 60 % of monocrop plots and 94 % of the intercrop plots. Mean (%) mats affected per plot were low in intercrop (17 %) compared to 30 % in the monocrop. Other minor diseases observed were banana streak virus (BSV) on 5 % of the monocrop plots and a bacterial rot on 6 % of the intercrop plots.

Coffee

Coffee berry borer was the key pest observed on 45 % of the coffee monocrop plots compared to 94 % of the banana-coffee intercrop plots. However, affected plants were lower (14 %) in intercrop than in monocrop plots (23 %). Defoliators and sceletonizers were generally higher in the intercrop than in the monocrop. Other pests were mealy bugs and scales.

Coffee wilt and leaf rust were the key diseases observed on coffee. Number of plots with coffee wilt was higher in intercrop (100 %) compared to monocrop (45 %). However, infected plants per farm were similar (19 % and 18 % respectively for intercrop and monocrop) (Table 10). Leaf rust was higher in intercrop than in monocrop. All the sampled plots in the intercrop had leaf rust. Mean plants affected were 42 %. In monocrop, 50 % of the sampled plots had leaf rust and a mean of 14 % of the plants per plot were affected. Lichens and moss on the stems were also observed.

Discussion

The study shows that farming systems at the surveyed sites are complex and diverse. Complexity of the system has partly arisen from shortage of land and lack of liquidity. Intercropping of several crops on one plot was justified by the need to maximise on space and labour. Labour is available at all the surveyed sites but farmers are unable to make use of it to improve management of the farms. The PRA results from sites one and two provides further indirect evidence that production system is declining since farmers reported that they sometimes intercrop banana with coffee to replace an old banana plantation on a poor land. Usually such degraded land never receives further attention once banana has died out. Sustainability of coffee therefore seems to be tied to banana because the limited resources (labour and other inputs) are directed to banana.

The prevalent intercropping system adopted in the region is farmers' innovation and scientific data is lacking to prove the biological interactive benefits reported by farmers.

Table 1. Ranking of cash and food crops at the survey sites in Mbarara district, Uganda

Site	Cash crops	Food crops
Site 1	1. Bananas 2. Beans 3. Coffee 4. Livestock (milk)	1. Bananas 2. Cassava 3. Millet 4. Horticulture
Site 2	1. Bananas 2. Coffee 3. Tomatoes 4. Pineapples 5. Passion fruits	1. Bananas 2. Millet 3. Beans 4. Sweet potatoes 5. Cassava, 6. Irish potatoes
Site 3	1. Beans 2. Coffee 3. Bananas 4. Groundnuts 5. Maize	1. Bananas 2. Finger millet 3. Beans 4. Cassava 5. Sweet potatoes 6. Maize

Table 2. Percentage banana types grown at the study sites in Mbarara district

Type	Site 1	Site 2	Site 3
Matooke (Cooking)	75	80	50
Embiire(brewing)	10	5	25
Bogoya (dessert)	10	10	15
Ndizi (dessert)	5	5	10

Table 3. Management/agronomic practices applied in old banana plantations at the survey sites in Mabarara district, Uganda

Management/Agronomic Practice	% farmers observing the practice		
	Site 1	Site 2	Site 3
Desuckering (keeping 3-6 suckers per mat)	100	100	100
Weeding	100	100	100
Mulching using:			
Banana residues	80		
Banana residues + beans residue		85	80
Grass	10	<5	10
Manure			
Farm yard manure/compost	<10	10	20
Coffee husk		10	
Sanitation	15	30	20
Deleafing	100	100	100

Table 4. Coffee varieties grown at the survey sites in Mbarara district

Variety/type	% farmers growing coffee		
	Site 1	Site 2	Site 3
Traditional Robusta variety	60	100	80
Improved clonal robusta	5	30	10
Arabica			25

Table 5. Agronomic practices used in coffee plantations at the survey sites in Mbarara district

Agronomic practice	% farmers applying the practice		
	Site 1	Site 2	Site 3
New Plantations			
Use of elite seedlings	25	70	30
Use of manure at planting	Nil	Nil	30
Prunning	Nil	Nil	Nil
Training	Nil	Nil	Nil
Old plantations			
Weeding	Nil	100	100
Manuring	Nil	Nil	30
Pruning	Nil	Nil	25
Training	Nil	Nil	Nil
Stumping/ Changing crop cycle	<30	50	<40

Table 6. Ranking of general production constraints at the survey sites in Mbarara district

Rank of Constraint	Sites		
	1	2	3
1	Market	Market	Market
2	**Pests and diseases**	Pests and diseases	Pests and diseases
3	Poor soil fertility	Poor soil fertility	Poor management
4	Lack of inputs	Lack of inputs	Poor soil fertility
5	Drought		Drought
6			Hail stones

Table 7: Pests and diseases of bananas and coffee reported by farmers at survey sites in Mabarara district

Rank of pest/disease	Sites		
	1	2	3
Bananas			
1	Banana weevil	Banana weevil	Banana weevil
2	Fusarium wilt	Fusarium wilt	Fusarium wilt
3	Toppling (nematodes)	Matooke wilt	Toppling (nematodes)
4		Toppling (nematodes)	
Coffee			
1	Scales & mealy bugs	Dieback	Coffee berry borer
2	Coffee wilt	Scales & mealy bugs	Scales
3	Coffee berry borer	Coffee wilt	Mealy bugs
3	Coffee stem borer		Leaf miners
4			Coffee wilt
5			Leaf rust (in Arabica coffee)
6			Defoliators

Table 8: Estimated financial returns from banana and coffee as reported by farmers at the survey sites in Mbarara district

Yields (USh. 000 per ha.)	Banana	Coffee
Cash	990-2,470	1,500-3,460
Food value	370-790	-
Total value	1,360-3,260	1,500-3,460

Table 9. Banana girth, bunch weights, weevil damage and nematode damage (%) [1]

Cropping system	Girth (cm)	Bunch weight (kg)	Rhizome damage (%) by weevils	Root necrosis (%) by nematodes
Banana monocrop	82.8±3.2a	17.2±2.5a	3.9±1.5a	8.2±2.0a
Banana-coffee intercrop (ratio 1:1)	77.8±2.5a	15.2±2.4a	3.2±1.4a	8.8±1.8a

Value in the table followed by same letters in a column are not significantly different (p>0.05)
Diagnostic survey, 2003

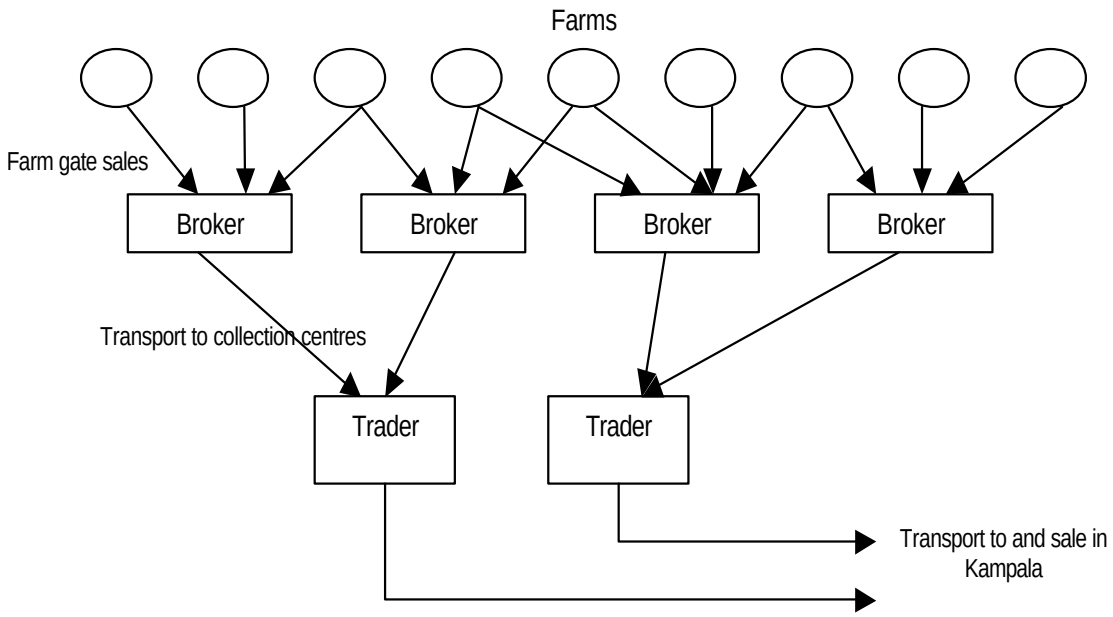

Figure. 1 The farm gate marketing system for bananas and coffee reported by farmers at the surveyed sites in Mbarara district

Table 10. Farms (%) and mean plants (%) affected by different banana and coffee pests and diseases in banana-coffee monocrop and intercrop at Ndaija, Mbarara district

Pest/Disease	Farms affected (%)			Mean plants affected (%) per farm		
	Monocrop	Intercrop	Difference	Monocrop	Intercrop	Difference
Bananas						
Pests						
Banana weevils	95	100	ns	85	81	ns
Nematodes	100	100	ns	69	79	ns
Toppling	50	81	*P<0.05	14	8	*P<0.05
Diseses						
Matooke wilt	75	81	ns	32	7	*P<0.05
Fusarium wilt	60	94	*P<0.05	30	17	*P<0.05
Banana streak virus (BSV)	5	0	ns	45	0	-
Banana bacterial disease	0	6	ns	0	10	-
Coffee						
Pests						
Coffee berry borer	45	94	*P<0.05	23	14	ns
Defoliators (pest not seen)	30	56	*P<0.05	13	62	*P<0.05
Leaf sceletonizer (pest not seen)	40	56	*P<0.05	12	41	*P<0.05
Mealy bugs	35	50	*P<0.05	6	10	ns
Scales	5	13	ns	15	16	ns
Red blisters	0	6	ns	0	50	-
Diseases						
Coffee wilt	45	100	*P<0.05	18	19	ns
Leaf rust	50	100	*P<0.05	14	42	*P<0.05
Lichens & moss	30	94	*P<0.05	50	87	*P<0.05

Source: Diagnostic survey, 2003.

Table 11. Mean banana corm damage (%) by weevils and bunch weight under different types of mulches at Ndaija, Ntungamo , Uganda (2003)

Type of mulch	Corm damage[1] (%±s.e)	Bunch weights (kg±s.e)
Banana trash	6.1±1.7a	13±a
Grass	5.2±1.7ab	16±a
Coffee husk	2.8±1.3b	25±b

[1] Data followed by same letters in a column are not significantly different (p>0.05)

source: Diagnostic survey, 2003

Allocation of poor soil to coffee is considered by the farmers as a way of exploiting the differences in the root systems of bananas and coffee. Coffee being deep-rooted crop exploits nutrients from the sub soil while banana exploits the surface soil. However, there is lack of information from this system on; (1) how much nutrients are being lost from the system so that adequate replenishment can be put in place. Currently banana monoculture receives external inputs but the intercrops depend on self-replenishment. Sustainability of the system on self-replenishment of the nutrients is doubtful. This is supported by the farmers report that longevity of banana in the banana-coffee intercrop system ranges from 3 years to over 15 years depending on the management and inputs, (2) Optimum land carrying capacity, best intercrop combinations and planting patterns to enhance crop co-existence has not been established. It was established that crop spacing was highly varied in the intercrop situation, suggesting that farmers lacked proper advice on how best to do it. The extension service also lacked information on the proper method of intercropping since farmers reported that the extension service discouraged intercropping.

Diagnostic survey (DS) at site 2 provides insight into serious biological constraints to be addressed and beneficial aspects for exploitation to improve the system productivity and sustainability. It was reported during the PRA and confirmed in the DS that banana bunches from banana-coffee intercrop usually tend to be smaller and less competitive in the market. This constraint can be addressed by developing optimum spacing and soil nutrient requirements to take care of the competition. The DS also confirmed farmers' reports that banana weevil, fusarium wilt and matooke wilt are the key pest constraints in bananas. However, the DS further shows that nematodes should also be addressed. The effects of intercrop on pests varied. Banana weevil incidence was not significantly different between banana monocrop and banana-coffee intercrop. This is at variance with observations by Kehe (1985 and 1988) that plantains mixed with older coffee plants in Cote d'Ivoire had low weevil incidence compared to other crop mixtures. There may is a need to investigate this aspect further by taking into account plant age and spacing.

Use of coffee husk in the plantations showed good potential for fighting poor soil fertility and banana weevil. Studies on use of coffee husk for soil fertility management in banana production have been done at Makerere University, Kabanyolo research station (Bwamiki et al., 1994). However, the authors did not look at relationships between coffee husk and banana weevil. On-farm data on the role of coffee husk is also still limited. Gold *et al*, 2001 reports that Sarah (1990) found that spreading coffee mulch at the base of banana mats had disappointing results with banana weevil. Quantity, method of application and consistency/frequency of use of coffee husk should be looked at on-farm level to verify these observations.

The number of banana mats affected by key banana diseases, fusarium wilt and matooke wilt were however, fewer in the banana-coffee intercrop although the number of banana-coffee intercrop plots with the diseases were more than those under monocrop. This is the first time such an observation has been made and hence detailed studies to confirm the observations are required. Matooke wilt is usually associated with very high soil fertility around the homestead (Kangire – personal communication). Banana monocrop plots received more attention with regard to soil fertility management than banana-coffee plots. This may have also contributed to the observed differences.

With regard to the economic aspects of the banana-coffee systems in Mbarara, district, the PRA results suggest that farmers at the surveyed sites are not only profit oriented; liquidity and food security play an important role in economic decision-making. The major constraints to production are land scarcity, poor marketing options and therefore lack of liquidity, which leads to poor crop management and poor exploitation of the economic potential of the region. Both the economic and agronomic potential, especially of intercropping systems is not yet fully exploited. Banana and coffee play a major economic role as cash crops and food crop (banana) at all the sites.

Marketing is a key area to be addressed to generate the necessary liquidity for reinvestment into the system. It was reported above that both banana and coffee prices fluctuate over the seasons and that there are differences among the sites with regard to coffee i.e. prices at site 2 are lower at the beginning of the season while at site 3 prices high at the beginning of the season. The explanation for this difference is due the liquidity pressure at the beginning of the season, which seems to be high at site 2. Farmers have no cash reserves and are thus forced to sell off at almost any price. Later in the season, liquidity pressure is not so high any more, and farmers are in a better negotiating position. On the other hand, at site 3, prices are higher at the beginning of the season, when small quantities of coffee are available, while during the season, quantities rise, and thus prices decline. Site three also depends on beans as a cash crop, which is usually available for sale at the beginning of the coffee season. It would be interesting to see why inter-regional trade does not balance these different price developments in adjacent regions.

Besides these seasonal price volatilities, one has to consider long-term price developments of both banana and coffee. Also here, perceptions differ across sites. While at the first site, both banana and coffee prices are considered to have declined through the last decade and thus negatively affected profitability of both crops, at sites two and three, banana, particularly *matooke*, is considered as getting higher prices as ten years ago. This is said to be due to better infrastructures and higher demand in the urban regions. During the same period coffee seems to have experienced a sharp decline of prices. It was mentioned that *matooke* prices have risen from Ush.500 to Ush.2,500 per bunch. Coffee prices were reported to have declined from Ush.800 kg^{-1} to the above-mentioned Ush.300 kg^{-1}.

Organizations and marketing boards that could counterbalance these negative developments, especially in coffee prices, and increase the market power in other products' trade are not present at all the three sites. Co-operatives disintegrated during the early nineties, mostly due to corruption and mismanagement. While at sites one and three farmers are about to revitalize the cooperative system, and hope for more market power and better prices, farmers at site two are reluctant from doing so. They argue that during high price seasons, there is no need for collective action, and during the low price seasons, collective action would be pointless due to the overall surplus and price depression throughout the region.

Conclusions

It is recommended that: (a) optimising banana-coffee intercropping management by developing proper spacing and adoption of improved technologies to improve soil fertility, and minimize pest problem will increase longevity of the plantations and result in higher yields of both banana and coffee under the current key constraint of land and labour shortage, (b) improved marketing organisation by replacing middlemen with farmers' organisations and provision of better market information will increase farmers' cash income through leaving higher shares of the market price with the farmer and increasing the negotiation power of farmers versus traders. Thus increase farm gate prices and remove the bottleneck of lack of cash and financial liquidity to add resources (labour and nutrient imports) to optimise management and input utilisation.

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