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Research Article

Promoting Cassava as an Industrial Crop in Ghana: Effects on Soil Fertility and Farming System Sustainability

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Cassava is an important starchy staple crop in Ghana with per capita consumption of 152.9 kg/year. Besides being a staple food crop, cassava can be used as raw material for the production of industrial starch and ethanol. The potential of cassava as an industrial commercial crop has not been exploited to a large extent because of perceptions that cassava depletes soils. Recent finding from field studies in the forest/savannah transitional agroecological zone of Ghana indicates that when integrated in the cropping system as a form of rotation, cassava contributes significantly to maintenance of soil fertility, and thus large scale production of cassava for industrial use can contribute to poverty reduction in an environmentally responsive way. This paper discusses the role of cassava cultivation in soil fertility management and its implication for farming system sustainability and industrialization.

1. Introduction

Cassava is an important starchy staple crop in Ghana with per capita consumption of 152.9 kg/year [1]. Besides being a staple food crop, cassava can be used as raw material for the production of industrial starch and ethanol. In Ghana, cassava is cultivated as a monocrop or intercropped with other food crops, either as the dominant or subsidiary crop. In terms of quantity produced, cassava is the most important root crop in Ghana followed by yams and cocoyams, but cassava ranks second to maize in terms of area planted. The production of cassava in Ghana ranged from 10,217,929 MT to 12,260,330 MT in the period 2007–2009 covering an area of 800,531 ha to 885,800 ha [1]. Ghana currently produces about 12,260,000 MT of cassava annually. Out of this, 8,561,700 MT is available for human consumption while national consumption is estimated at only 3,672,700 MT resulting in surplus of about 4,889,000 MT which can be exploited for the production of industrial starch or ethanol.

Despite its importance, the potential of cassava as an industrial crop has not been exploited to any appreciable extent in Ghana, with the perception that cassava depletes soils [2, 3]. However, recent studies in the forest/savannah transitional agroecological zone as well as the semideciduous forest zone of Ghana have demonstrated that, when integrated in the cropping system as a form of rotation, cassava has the potential of maintaining soil fertility.

In most parts of Africa, cassava is planted just before the land is left to fallow [4, 5]. In the forest/savannah transitional agroecological zone of Ghana, farmers often rotate maize with cowpea and when they observe decline in productivity, the land is cropped to cassava for a period ranging between 12 to 18 months after which the maize/cowpea rotation is resumed [6]. Farmers in Benin also use cassava as a "strategy for regenerating soil fertility" [7], and the term used for cassava cultivation in Benin "jachère manioc" literally means "cassava fallow". According to [8], cassava is frequently grown on marginal soils. This is attributed to increasing population densities which often result in land pressure and successively shorter fallow periods thereby compelling farmers to allocate more of their land to cassava production [9]. Cassava is also frequently grown on marginal soils because of its efficiency in nutrient capture and removal [10]. In the forest/savannah transitional agroecological zone of Ghana where cassava is widely grown and used as soil fertility regenerating crop, cassava cultivation is intertwined with several factors such as ethnicity, access to resources (including labour, cash, and land), gender, and wealth.

This paper discusses the role of cassava cultivation in soil fertility management and its implication for farming system sustainability and industrialization.

2. Material and Methods

The research study on which this paper is largely based was part of a larger research program called "Convergence of Sciences—inclusive technology development for a better integrated crop and soil management" (CoS), which was implemented by University of Ghana for Ghana and Universite d'Abomey Calavi for Republic of Benin with technical backstopping from Wageningen University and Research Centre, Netherlands.

2.1. The Study Area and Population. The study was conducted in the Wenchi Municipal (7°27 and 8°30 N, 1° and 2°36 W) in the forest/savanna transitional agroecological zone of Ghana. The relief of Wenchi is gently undulating to flat. The soils, which are mainly Lixisols, are fragile with shallow top soils underlain with compact concretions and impermeable iron pans [11]. Temperatures are relatively high with a monthly mean of about 30°C. Rainfall is bimodal and starts in April and ends in November with a dry spell in August. The rainy season is followed by a long dry season from November to March. The annual rainfall is about 1300 mm with about 107 rainy days. Wenchi Municipal, which has a total population of 97,058 (2000 census), is ethnically diverse with about 20% of the population being migrants from the three northern regions of Ghana and the neighbouring Burkina Faso.

2.2. Research Approach and Methods. Wenchi was selected after an initial exploratory study carried out according to the ideas and principles of "technography" [12], which revealed the existence of local soil fertility management strategies, some of which seemed to contradict with dominant scientific beliefs. Among these was the inclusion of late maturing cassava varieties in rotational sequences in the cropping systems in the area as a soil fertility management strategy [13]. This study was thus conducted to explore the efficacy of the farmers' soil fertility management strategies and their relevant social context.

In order to ground the research in the needs of the farming communities, a diagnostic study was carried out in the study area between July 2002 and July 2003 using Participatory Rural Appraisal tools such as drawing of a community territory map (to identify the differences in soil fertility patterns), a transect walk (to reveal the diversity of the landscape), and analysis of soil fertility management strategies and group discussions. Group discussions (10–40) were held in the village centre and/or on farmers' fields.

In addition, two sets of individual interviews with farmers were conducted to collect qualitative and quantitative data. In the first interview, which involved 40 farmers, the selection of farmers was done through stratified sampling. A list of farmers in the community was obtained from the village committee secretary and every tenth name from the list was selected for individual interviewing. The second interview which involved 38 farmers was conducted later to look at the farming characteristics of the various subcommunities in the village using a wealth ranking exercise. For this interview, 6–10 persons were selected from each wealth category within each subcommunity. The individual interviews were semistructured in nature and served both to get more quantitative data on farm size, household composition and the farming system, and to obtain a better qualitative understanding of the soil fertility management strategies and their underlying rationale.

The diagnostic study was followed by farmer participatory on-farm experimentations with three (3) farmer research groups established soon after the diagnostic study to evaluate the agronomic efficacy of the soil fertility management practices being used by the farmers. Six cropping sequences: cassava cropping; pigeonpea cropping; mucuna/maize/mucuna rotation; cowpea/maize/cowpea rotation; maize/maize/maize; and *Imperata cylindrica* fallow were evaluated on both farmer-managed and researcher-managed plots for their effects on soil fertility and yield of subsequent maize test crop. To deepen our understanding of soil fertility management, we carried out further exploration of diversity among the farmers according to gender, ethnicity, and wealth. Farmers were selected from three communities in Wenchi according to ethnicity and gender for interview using semistructured questionnaires. We conducted two sets of interviews. For the first interview, the native households were categorised into male-headed and female-headed households. Subsequently, a stratified sample was selected consisting of 20 males from male-headed households, 20 females from male-headed households, and 20 females from female-headed households. In the case of the migrants, every farmer in the community was interviewed because of the small size of their population. As migrant women do not have their own farming enterprises, only males were interviewed. In the second interview, the farmers were selected through a wealth ranking exercise. Fifteen farmers were selected from each of three wealth categories for interviewing. In addition focus group discussions were held with chiefs, community leaders, family heads, and opinion leaders about land tenure systems in Wenchi.

3. Results and Discussion

3.1. Land Tenure and Cropping Systems in Wenchi. Four main types of holders of land were identified in Wenchi. These were as follows.

(1) The chief's holding known as the stool land or the traditional land. This is the land the chief holds in trust for the stool. These lands are managed by the "Abusahenes" (literally meaning share cropping chiefs) who are responsible

for managing the chief's natural resources, especially land in the traditional area.

(2) Family lands. This refers to the lands that belong to individual extended families or lineages. The family land is usually put under an Abusuapanyin (the head in the line of the inherited siblings) who administers the family land and distributes it among the other siblings with rights in the land.

(3) Individual lands. These are the lands that the first native individual was able to acquire and cultivate. Individual lands are also acquired as gifts from parents.

(4) Government lands. These refer to lands under reafforestation by the Forestry Services Division of the Forestry Commission of Ghana. These lands are given out to prospective farmers to grow their food crops while planting and maintaining trees for the commission. This form of arrangement whereby tenant farmers are given land to plant their food crops by the forestry commission while planting and tending trees for the commission is known as *taungya*.

Access to land for farming in Wenchi involves a spectrum ranging from rights acquired through renting to right of use of a piece of land temporarily. Traditionally, ownership of land is based on kinship, but vested in the traditional authority. Among the Akans in Wenchi, a system of family land exists in which having brought a virgin forest land under cultivation yields rights of usufruct "ownership" as long as the land is kept within a long duration of cultivation. Thus rights could be passed on to the next generation, where it now becomes a family land. Members of the matrilineal family who cleared the land have the right to farm the land. Both men and women in the family have usufruct right in the land. One can also gain access to patrilineal family land. Since migrants who settle permanently cannot own land in the community, the current land tenure arrangement implies that migrants can only access land for farming through renting, sharecropping, or *taungya*.

Land renting is by far the dominant form of contractual arrangement by which migrants gain access to land in Wenchi. Land can be rented from a family, an individual or stool. For family and individual lands, the land is usually rented for a period of 1-2 years and occasionally 3–5 years, depending on the financial needs of the landowner. When an immediate cash need arises, especially for unexpected emergencies such as funerals, marriages, medical bills, court cases, and construction works, land is usually rented out beyond 2 years. Rent is paid in advance before the tenant is allowed to cultivate the land. Advance payment is partly due to the fact that landowners prefer to receive the agreed upon rent as soon as possible before it loses its value. Lands are rented out for short periods because of fear of overexploitation of the land by migrants.

Farmers produce about six to eight different types of crops in Wenchi (Figure 1). The most important food crops in terms of area cultivated were maize, cassava, and yams while cowpea and groundnut were the major grain legumes in the cropping system. Tree crops were restricted to cocoa and cashew. In terms of plot size, maize is the most important crop in Wenchi with both the natives and migrant farmers, having plot size of about 1.3 and 2.2 ha, respectively (Table 1). Natives and migrants differ mainly with respect to

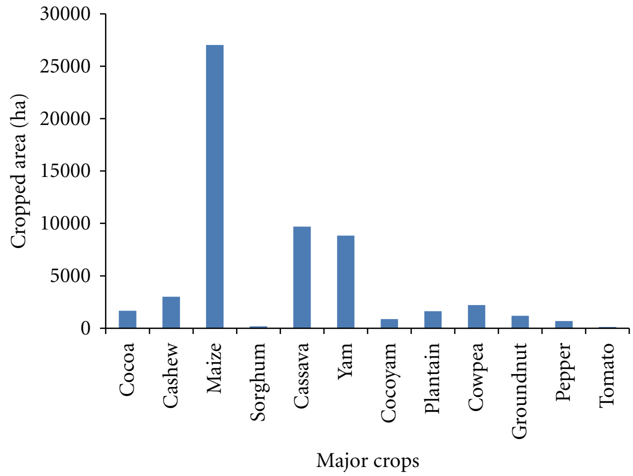

Figure 1: Area cropped (ha) to major crops in Wenchi (Source: MoFA, Wenchi).

the cultivation of tree crops as well as long duration crops such as pigeon pea and cassava. For cassava, the average acreage for natives is about 0.75 ha while it is only 0.3 ha for migrants. This is closely related to social dynamics around land tenure (both security and duration of tenure).

3.2. Indigenous Soil Fertility Management Strategies and Their Use. Farmers in Wenchi use the following cropping practices for maintaining the productivity of their farmlands: rotations involving cassava; rotations involving legumes such as cowpea, groundnut, and pigeon-pea; and mounding or ridging.

3.2.1. Crop Rotation in General. Farmers believe that different crops feed from different depths and on different nutrients in the soil. Hence they tend to rotate or intercrop different crops on the same piece of land when they observe yield decline of a particular crop.

3.2.2. Rotation Involving Pigeon Pea. Pigeon pea is usually grown as intercrop with other food crops such as maize, yam, and cassava in a form of relay. Pigeonpea is usually the last crop that is cultivated in this system. After harvesting the yam, maize, and the pigeon pea, the pigeonpea is cut back to allow the cassava to grow to maturity. When the cassava is harvested, the land is allowed to fallow under the pigeon pea for another one or two years, after which it is cut down, burnt and the land replanted to yam, maize, cassava, and pigeonpea again. From the point of view of the farmers, pigeonpea canopy protects the soil from the direct action of the sun and therefore prevents the soil from becoming hardened. According to the farmers, pigeonpea forms canopy after one year and shades out obnoxious weeds by suppressing their growth. The farmers also explained that leaf litter covers the soil, reduces soil erosion, improves infiltration, prevents heating of the soil, and enhances earthworm activity. Crops grown after pigeonpea, especially maize, are perceived by farmers to look greener, grow faster, and yield more.

Table 1: Mean acreage (ha) for selected crops in three communities in Wenchi District.

Community	N	Root and tubers		Cereals		Legumes		Tree crops	
		Cassava	Yams	Maize	Sorghum	Cowpea	Pigeonpea	Cocoa	Cashew
Asuoano	37	0.76	0.68	1.70	0	0.28	0.10	0.40	0.10
Beposo	37	0.65	0.56	1.80	0	0.16	0.12	0.20	0.22
Konkomba*	30	0.20	0.44	1.60	0.1	0.20	0	0	0.03
Residential status									
Native	58	0.75	0.60	1.3	0	0.21	0.10	0.33	0.2
Migrants	46	0.30	0.50	2.2	0.01	0.20	0	0	0.10

* Predominantly migrant community. Source: Adjei-Nsiah (Unpublished).

3.2.3. Bush Fallows. In this case, when farmers observe a decline in fertility of their soils after cropping for three to four successive years, they allow the land to lie fallow for 2-3 years before they go back and crop the land again. According to the farmers, fallowing the land for 2-3 years allows the land to regenerate its fertility. They mentioned that as the land is allowed to fallow, young trees begin to grow and shade the soil so that the land is not exposed to the direct action of the sun thereby keeping the soil moist all the time. They also reason that during the fallow period the litter of the vegetation on the land fertilises the soil as it decomposes.

3.2.4. Rotation with Cowpea. Farmers rotate maize with cowpea, which has a growing period of about 60–70 days, because of its food value and marketability and to maintain the fertility of their farmlands. According to the farmers, maize grown after cowpea grows faster and yields higher even if inorganic fertilizer is not applied to the maize. They mentioned that the nodules formed on the roots contain "energy" which is released for the growth of the maize when they decompose. Farmers also attribute the yield increase in maize after cowpea, to an increase in fertility of the soil as a result of the decomposition of the cowpea foliage that is left on the land after harvest. However, they remarked that if the land is not immediately used for cropping after harvesting the cowpea the fertility of the land is lost since cowpea foliage decomposes rapidly.

3.2.5. Construction of Ridges and Mounds. Farmers construct ridges or mounds on less fertile plots on fallowed land. On grasslands, farmers either plough the land and/or construct mounds or ridges. Farmers construct mounds or ridges or plough their land for two reasons: firstly, to control problematic weeds that invade the land as a result of decline in fertility, and, secondly, to improve the productivity of the soil. As they construct the ridges or mounds, the weeds and leaves on the land mix with the soil and fertilize the soil as they decompose. Farmers reason that the decomposed weeds and leaves when mixed with the soil improve the fertility of the soil and increase the yield of maize planted. According to the farmers, the construction of the mounds and ridges also loosens the soil, which becomes compact after continuous cropping. This allows water to percolate into the soil when it rains.

Table 2: Percentage of native and migrant farmers at Asuoano in 2002 practising various soil fertility management strategies.

Strategy (%)	Native farmers $N = 22$	Migrant farmers $N = 16$
Cassava cropping	82	44
Bush fallow	77	19
Pigeonpea	59	6
Rotation with cowpea/groundnut	18	50
Mounding/ridging	14	100

Source: [6].

3.2.6. Rotation Involving Cassava. Farmers often crop a piece of land for a period ranging from three to four years to maize and cowpea and when they observe decline in the fertility of the soil, they crop the land to cassava for 18–24 months after which they resume their maize/cowpea rotation. The farmers attribute the role of cassava in soil fertility regeneration to its ability to protect the soil from soil erosion through its canopy and its high leaf litter production, which also shades off the soil from the direct action of the sun and thus increases the activities of soil micro- and macroorganisms. The farmers attribute these beneficial roles of cassava to the fact that the varieties of cassava that the farmers grow are the spreading types that form a closed canopy and completely shade off the soil within few months after planting. The use of cassava for soil fertility regeneration is not only peculiar to Wenchi. Reference [7] also reported on the extensive use of cassava for soil fertility regeneration in some parts of Benin.

While the natives widely apply bush fallowing, and rotation involving long duration crops such as cassava and pigeonpea for maintaining the fertility of their farmlands, migrants who do not own land in the communities but depend largely on sharecropping and land renting for gaining access to land for farming use short-term rotational strategies such as rotations involving short duration crops such as cowpea and groundnuts (Table 2).

3.3. Farmers' Agronomic and Social Evaluation of Soil Fertility Management Strategies. Table 3 shows the effect of cropping sequence and N rate on maize grain yield and weed biomass associated with the maize crop 8 weeks after planting

Table 3: Effect of crop sequence and N rate on (a) maize grain and (b) weed biomass associated with the maize crop at 8 weeks after planting on researcher-managed plots.

Crop sequence	N rate (Kg ha^{-1}) O	N rate (Kg ha^{-1}) 60	Mean
(a)			
Speargrass fallow	1050	2848	1949
Cassava	3002	2738	2870
Pigeonpea	2422	2328	2697
Cowpea-maize-cowpea	1670	2128	1999
Mucuna-maize-*Mucuna*	2970	4195	3582
Maize-maize-maize	1380	2972	1754
Mean	2082	2868	
SED: crop sequence (CS) = 318.4; N Rate (NR) = 115.3; CS × NR = 375.8P < F : CS = 0.001; NR = 0.001; CS × NR = 0.01			
(b)			
Speargrass fallow	585	790	686
Cassava	270	300	285
Pigeonpea	390	500	445
Cowpea-maize-cowpea	325	395	360
Mucuna-maize-*mucuna*	300	345	323
Maize-maize-maize	240	430	335
Mean	351	460	
SED: Crop sequence (CS) = 65.9; N Rate (NR) = 52.4; CS ×NR = 112.1P < F : CS = 0.001; NR = 0.05; CS × NR = NS			

Source: [14].

[14]. According to these data, yields of maize ranged from 1.0 t ha^{-1} with spear grass fallow to 3.0 t ha^{-1} with plots previously under cassava when mineral fertilizer was not applied to the maize and on the fertilized plots yields ranged from 2.1 t ha^{-1} with the continuous maize plot to 4.2 t ha^{-1} with plots previously under *mucuna*/maize rotation. The cropping sequences did not have significant effects on soil chemical properties. Lower weed biomass was also associated with the maize crop grown on plots previously under cassava cropping. Weed biomass after cassava in the unfertilized plots was roughly half that found after the speargrass fallow and further reduced to a third of that found after speargrass fallow when cassava was followed by maize with fertilizer.

The beneficial effects of cassava on maize grain yield were mainly due to the relatively high amount of recycled N returned to the soil through the leaf litter and green leafy biomass of cassava which was ploughed back into the soil just before the maize test crop was planted. According to criteria set by [15], cassava litterfall is an important source of easily mineralisable N due to its high N (2.5%) and low lignin content, resulting in high decomposition rates [16]. While it is true that the major beneficial effect of cassava on subsequent maize crop was due to the high N cycling properties of cassava litter and the green leafy biomass which was returned into the soil just before the maize test crop was planted, we cannot exclude the potential role of mycorrizal associations as suggested by the very large initial effect of cassava on maize dry matter yield at 3 weeks after planting [14]. Beneficial effects of higher mycorrizal inoculums at the start of the crop season have repeatedly been reported for maize [17]. Unfortunately, mycorrizal associations were not studied. Other possible effects may include reduction in weed incidence as a result of the suppression of weeds by the cassava canopy. In agricultural systems, shade suppresses weeds growing on the site and interrupts continuous reseeding of the field [18] Cassava/maize rotation resulted in the highest return on investment both when N fertilizer was applied to the maize crop or not for the 2-year period (Table 4). This was due to low input use and labour requirement of cassava as well as the high cassava root yield obtained in this study which was around 31 t ha^{-1} which was far above the current national average of 14 t ha^{-1} [1].

While both native male and female farmers prefer cassava/maize rotation, migrant farmers prefer rotation involving cowpea (Table 5). Migrant farmers cite market and tenure insecurity as reasons for preferring cowpea/maize to cassava/maize rotation and this is reflected in the total farmland allocated to cassava by migrant farmers compared to native farmers (Table 1). Among the migrants, ethnicity, history, and context of migration as well as quality of relationships with the native community also played a major role in soil fertility management [19]. Migrants who had stayed in Wenchi for a longer period and considered their stay in Wenchi as permanent had managed to build long-standing relationship with the natives and had relatively secured and long-duration access to land and tended to use rotation involving cassava for maintaining soil fertility. There was one group of migrants who tended to look at their stay in Wenchi as temporal which had implication for soil fertility management. This group of migrants, although did not own land, tended to have large farms and seemed to succeed in accumulating wealth on the basis of soil mining. Native farmers, particularly women, on the other hand prefer cassava/maize rotation to cowpea/maize rotation due to the flexibility in the labour requirement and minimal use of external input in the cultivation of cassava as well as the role of cassava in food security [9, 19].

3.4. Implication of Large Scale Cassava Cultivation for System Sustainability. In farming systems with minimal application of external inputs, management of organic resources plays a major role in maintaining both nutrient availability and soil organic matter [15]. In a cereal-based farming system as that found in the forest/savanna transitional agroecological zone of Ghana, where external input use is minimal, most recycling of N and P occurs through cassava litterfall and green leafy biomass of cassava incorporated into the soil after cassava harvest [16, 20]. Cassava litterfall and green leafy biomass of cassava are important sources of easily mineralizable N due to their high nitrogen (2.5 and 3.5% for litterfall and green leafy biomass resp.) leading to high decomposition rates [14]. Maize roots may also benefit from cassava association with mycorrizal [17]. Thus, rotation involving cassava, within smallholder agriculture, has the

Table 4: Estimated costs of production, gross revenue and returns on investment of (a) various crop sequences (b) maize grown after the sequences with N application to the maize and (c) maize grown after the sequences without N application to the maize.

Crop sequence	Economic yield (kg ha^{-1})	Total revenue (US$)	Cost of production (US$)			Total cost	Net revenue	Return on investment
			Land	Input	Labour			
(a) Crops in the sequence								
[1]Cassava	31,000	2545.1	41.7	41.7	635.0	718.4	1826.7	254
[2]Pigeonpea	1,870	623.3	41.7	8.3	221.5	271.5	351.8	130
[3]*Mucuna*-maize-*mucuna*	2,016	365.1	41.7	41.7	247.4	330.8	34.3	10
[4]Cowpea-maize-cowpea	2,536 *(1,230)	1079.0	41.7	106,1	475.1	622.9	456.1	73
[5]Maize-maize-maize	3,287	595.2	41.7	36.1	386.1	463.8	456.1	28
[6]Speargrass fallow	0	0	41.7	0	0	41.7	−41.7	−100
(b) Maize after crop sequence with N application								
CS 1	2,738	495.9	13.9	104.2	190.2	308.3	187.6	61
CS 2	2,974	538.5	13.9	104.2	196.5	314.6	223.9	71
CS 3	4,194	759.4	13.9	104.2	245.9	364.0	395.4	108
CS 4	2,331	422.1	13.9	104.2	177.0	295.1	127.0	43
CS 5	2,126	385.0	13.9	104.2	175.4	293.5	91.4	31
CS 6	2,848	515.7	13.9	104.2	224.4	342.5	173.3	51
(c) Maize after crop sequence without N application								
CS 1	3,000	543.2	13.9	13.9	175.6	203.4	339.8	167
CS 2	2,423	438.8	13.9	13.9	165.5	193.3	245.5	127
CS 3	2,961	537.7	13.9	13.9	209.7	237.5	300.2	126
CS 4	1,772	302.8	13.9	13.9	155.2	183.0	119.8	66
CS 5	1,380	249.9	13.9	13.9	153.0	180.7	69.1	38
CS 6	1,048	189.8	13.9	13.9	173.7	200.9	−11.1	−6

[1]US$ 82.1 t^{-1}.
[2]US$ 333.3 t^{-1}.
[3]US$ 337.5 t^{-1} for cowpea and US$181.1 t^{-1} for maize.
*Yield of maize.
CS 1: cassava; CS 2: pigeonpea; CS 3: *Mucuna*-maize-*Mucuna*; CS 4: cowpea-maize-cowpea; CS 5: maize-maize-maize; CS 6: speargrass fallow (source: [14]).

potential of maintaining a reasonable supply of N and P to cereal crops, particularly maize considering the minimal use of external inputs in a maize-based farming system.

Although nutrient recycling is expected to be improved through incorporation of litterfall and harvested crop residues into the soil, it is likely that promoting cassava as an industrial crop may accelerate the depletion of nutrient stocks, particularly potassium through root harvest. Thus on the long term, K may become the most limiting nutrient especially on soils with K values as low as 0.2 cmol K kg^{-1} as those found in Wenchi [10, 14]. Increasing K input through mineral fertilizer application is difficult as potassium fertilizers are not readily available in rural markets, and smallholder farmers hardly apply fertilizers to cassava. Long-term K balances are therefore needed to address this issue. However, K removal may be reduced by half if the cassava stems are not removed from the field for planting [21].

In a place like Wenchi, where the population of the farming community is very heterogeneous, if we want to contribute to better conditions for farming system sustainability through large scale integration of cassava in the farming system, efforts must be oriented to design a range of social arrangements that will meet the specific needs and circumstances of different categories of people. One of such social arrangements is to invest in negotiation of and experimentation with new kinds of contractual and/or land tenure arrangements, involving also supporting control and sanctioning systems. There is also the need to work towards new institutional arrangements that may contribute to reduction of uncertainties and conflicts around land tenure. Possibility in this respect may include (a) contractual provisions for renting that create a link between the level of rent and the level of revenue obtained, (b) clear and agreed-upon rules as to who can contract out what land and who should be involved as witness, (c) increased involvement of local authorities in validating contracts, and (d) strengthening customary institutions to manage land-related conflicts at the local level.

4. Conclusion

The study shows the importance of cassava in the predominantly maize-based farming system of Wenchi, Ghana. Our

Table 5: Preferential ranking of different soil fertility management practices by native and migrant farmers in Wenchi.

Management practice	Ranking order							
	Natives				Migrants			
	Asuoano[a] $N = 10$	Beposo[b] $N = 5$	Droboso[c] $N = 7$	Average	Asuoano[d] $N = 6$	Beposo[d] $N = 6$	Droboso[e] $N = 5$	Average
(a) Ranking by natives and migrants								
Cassava	1	1	1	1	2	2	1	1.7
Pigeonpea	2	5	2	3	4	4	4	4
Mucuna/maize/*Mucuna*	7	6	4	5.7	5	6	6	5.6
Groundnut/maize/groundnut	4	3	3	3.3	3	3	3	3
Cowpea/maize/cowpea	3	2	5	3.3	1	1	2	1.3
Maize/maize/maize	8	7	6	7	7	7	7	7
Cowpea/cowpea/cowpea	5	4	7	5.3	6	5	5	5.3
Bush fallow	6	8	8	7.3	8	8	8	8
(b) Ranking by female and male Bonos	Females $N = 13$	Males $N = 10$						
Cassava	1	1						
Pigeonpea	2	3						
Mucuna/maize/*Mucuna*	5	7						
Groundnut/maize/groundnut	3	4						
Cowpea/maize/cowpea	4	2						
Maize/maize/maize	8	8						
Cowpea/cowpea/cowpea	7	5						
Bush fallow	6	6						

[a]Consisted of 6 males and 4 females; [b]Consisted of 4 males and 1 female; [c]Consisted of 6 females and 1 male; [d]Dagarbas; [e]Walas (source: [14]).

study has shown that cassava plays an important role in the predominantly maize-based farming system in Wenchi partly due to its nutrient recycling properties and also partly due to its role in food security as well as its flexibility in external input use and labour requirement. Even when there is no strong market demand for cassava, farmers still integrate cassava in their rotational system. As more farmers are resorting to putting their land under cassava than fallowing in the farming system, cassava cultivation could therefore serve as an entry point for farming system sustainability. There is however the need to (i) study the long term K balances to address the issue of K losses through removal of storage roots; (ii) evaluate the nutrient recycling capacities of different cassava genotypes; (iii) develop crop rotation/sequencing and soil management options that can improve and/or sustain the productivity of cassava through integrated soil fertility management (ISFM); (iv) design a range of social arrangements that will encourage investment in soil fertility through integration of cassava in the farming system by various categories of farmers in Wenchi. With the rising pressure on land as a result of population increase, the use of external nutrient inputs seems inevitable in the near future.

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