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Yams for Livelihoods

Yam: A Cash Crop in West Africa

Djana B. Mignouna, Adebayo A. Akinola,
Issahaq Suleman, Felix Nweke, and Tahirou Abdoulaye

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The YIIFSWA baseline study is part of the YIIFSWA project which is funded by the Bill & Melinda Gates Foundation.

Preface

The YIIFSWA (Yam Improvement for Income and Food Security in West Africa) project is an R4D project of IITA. The project is funded by the Bill & Melinda Gates Foundation and executed in Nigeria and Ghana by IITA in partnership with a consortium of national and international R4D agencies and in collaboration with service provider organizations, the private sector, farmers, and yam traders.

The YIIFSWA project has the following broad objectives:

1. Strengthen small-scale farmer and trader market linkages, particularly in less accessible producing areas, to realize benefits from improved ware yam productivity and market demand.
2. Strengthen capacities and empower small-holder farmers in the yam value chain.
3. Establish sustainable availability of high quality seed yam on a commercially viable and price competitive bases in targeted areas.
4. Reduce postharvest losses and improve product quality.
5. Develop technologies for high ratio propagation of high quality breeder and foundation seed yam.
6. Evaluate and scale out yam production technologies with improved and local popular varieties.
7. Identify more effective prevention and management tools and strategies for pests and diseases.

Each objective is addressed by a team of researchers supported by other researchers working on two cross-cutting components, namely impact monitoring, evaluation and learning; and communication and information dissemination.

The YIIFSWA Working Paper Series is published informally by YIIFSWA to disseminate its intermediate outputs. Publications in the series include methodologies for, as well as preliminary results of the various objective teams of the YIIFSWA project. The series is aimed at scientists and researchers working with national agricultural research systems in West Africa, the international research community, policy makers, donors, and members of international development agencies that are interested in yam. As these papers are not in their final form, comments are welcome. Such comments should be addressed to the respective authors or to the YIIFSWA Project Manager.

Individuals and institutions may obtain copies by writing to:

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International Institute of Tropical Agriculture
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Ibadan, Nigeria

1. Introduction

Yam and the African crises of poverty, hunger, and diseases[1]

African countries are experiencing high population growth rates and the total population in some countries is already too high relative to available resources including fragile environments. Among the continents of the world, Africa remains the epicenter of the challenges of poverty, hunger, and deadly diseases such as HIV/AIDs, malaria, and blindness. A high percentage of the population of most African countries is dependent on arable crop agriculture. Globally, Africa's contribution to supplies of grains is modest: maize, about 5%; rice, 3%; and wheat, 3% in the late 2000s (FAOSTAT 2013). But Africa is the lead player in the supplies of cassava with 50% of world production and yam with 95%. Africa's two predominantly world food crops, yam and cassava, are produced at a high cost because of low technologies (Nweke et al. 1991; Odoemenem and Otanwa 2011).

Investments in food crop Research and Development (R&D) by national governments, regional organizations, donors, and NGOs in Africa are focused on cereals and grains such as wheat, rice, and maize. Within the past 20 years, cassava has received R&D attention following the diffusion of IITA's (International Institute of Tropical Agriculture) high-yielding mosaic resistant TMS (Tropical Manioc Selection) cassava varieties and following the COSCA (Collaborative Study of Cassava in Africa) studies, which unveiled the crop's potential as a powerful poverty fighter in the continent.

Yam continues to be sidelined in national food policy programs in West Africa and ignored by African regional development agencies such as the African Development Bank. For example, Nigeria's current Minister of Agriculture, Dr Akin Adesina introduced an Agricultural Transformation Agenda for the purpose of promoting nine commodities including all major staples in Nigeria except yam (FMARD 2012). The African Development Bank, Africa's premier development institution, provides loans and grants for R&D covering staples like rice, maize, cassava, and wheat except yam and some other crops in 54 member countries[2].

In West Africa, yam can be a formidable force in the war against poverty, hunger, and deadly diseases if R&D measures are implemented to develop and disseminate technologies that can bring the crop into central focus in national food policies. The technological innovations will enable yam to benefit from policy programs that can drive down production costs. Yam is a preferred food in the region; some varieties, especially yellow varieties are sources of betacarotene and it is increasingly becoming a major source of foreign exchange in the region as an export crop (Nweke forthcoming).

Economic importance of yam in West Africa[3]

In West Africa yam (*Dioscorea* spp.) is a food and cash crop; it plays an important role in food security and in the livelihoods of 60 million people in the region. The crop is cultivated mostly in the derived, humid, and southern Guinea savanna agroecologies. About 48 million tons of yam (95% of global supply) are produced on 4 million hectares annually in the region, mainly in five countries: Benin, Côte d'Ivoire, Ghana, Nigeria, and Togo; Nigeria alone accounts for 70% of global yam supply.

[1]This subsection is borrowed from Nweke forthcoming.
[2]Dr Jonas Chianu, personal communication, IITA, Ibadan, 26 October 2013.
[3]This subsection is borrowed from Maroya 2014.

Yam ranks as one of the most important sources of calories in Benin, Côte d'Ivoire, and Ghana. The crop also makes a substantial contribution to protein in the diet, ranking as the third most important source of supply after maize and rice. Additionally, yam plays a significant role in social rites of passage, thanksgiving, etc. giving it prominence over other food crops in the region. Demand for the commodity is increasing; as incomes increase consumers shift from substitutes to yam especially when the price of yam relative to prices of its substitutes declines (Maroya 2014).

Objective and Justification for this working paper

This working paper aims to demonstrate that in West Africa yam is produced more for sale than for home consumption. The working paper is based on information collected from the baseline survey component of the YIIFSWA (Yam Improvement for Income and Food Security in West Africa) project. To achieve the working paper objective, levels and determinants of yam production with purchased inputs and yam harvest designated for sale by the farmers in Nigeria and Ghana are assessed.

Farm level information on yam of the nature and magnitude presented in this working paper is uncommon. The information presented here has wide geographical coverage and is deep in terms of the nature of data collected and reported here and in subsequent reports to be prepared from the YIIFSWA Complementary Baseline Survey data. The information is collected from 76 yam fields, 75 households, 45 villages, three agroecologies, and two countries. The information collected includes oral interview questions and responses and direct field area and yield measurements as well as physical observations at field, household, and village levels. "Production costs in the yam-based cropping systems of southeastern Nigeria" by Nweke and others comes close to the one reported in this working paper in terms of depth of information but not in terms of geographical coverage. Besides, the Nweke study which was conducted in the mid-1980s and reported in 1991 is no longer current (Nweke et al. 1991). Therefore, this working paper is an overdue update of the Nweke study on a wider scale.

Yam production constraints and the YIIFSWA project

which affect the yam food sector impede national policy program efforts aimed at promoting yam as a priority crop in the various countries in West Africa. High production costs arise from the high incidence of destructive yam pests and diseases such as nematodes, viruses, fungi, scale insects, beetles, etc. at both pre-harvest and postharvest stages; the high labor input associated with land preparation, planting, staking, weeding, and harvesting; and the increasing shortage of virgin land suitable for production of the crop. These problems are rooted in low production and post-production technologies in the yam food sector (Maroya 2014). These constraints have therefore formed the basis for YIIFSWA project's interventions. The Project aims at doubling the productivity of yams that would stimulate a sustainable increase in incomes for smallholder yam producers and contribute to their food security and economic development.

YIIFSWA is a five-year research-for-development project of IITA which took off in September 2011. The project is funded by the Bill & Melinda Gates Foundation and executed in Nigeria and Ghana by IITA in partnership with a consortium of national and international R&D agencies, namely the Nigerian NRCRI (National Root Crops Research Institute), the Ghanaian CRI (Crops Research Institute), NRI (Natural Resources Institute) of the UK, AGRA (Alliance for a Green Revolution in

Africa), CRS (Catholic Relief Services), and DDS (Diocesan Development Services) in collaboration with service provider organizations, the private sector, farmers, and yam traders (Maroya 2014).

The project addresses the following broad constraints:

- The high cost and unavailability of disease free seed yams.
- On-farm postharvest losses.
- Low soil fertility.
- Unexploited potential of yam markets by smallholder farmers.
- Unavailability of adapted varieties to stress environments of the savanna agroecologies.
- Yam diseases and pests.
- Limited opportunities for smallholder farmers, mainly rural women, in yam production and marketing.

YIIFSWA Complementary Baseline Survey methodology

Sample design. This working paper is based on a sample survey of yam producing areas of Nigeria and Ghana; the two countries account for 80% of West Africa's yam supply. In either country all yam agroecologies, namely humid forest, derived savanna, and southern Guinea savanna were covered. In each agroecology communities were randomly selected: three in Nigeria and two in Ghana making a total of 25 communities, 15 in Nigeria and 10 in Ghana (Fig. 1). The sample size was determined by the time resource available for the survey which was November and December 2013. In each community a stratified random sample of three households was selected. Members of the community were assembled and requested to group themselves into three by size of their

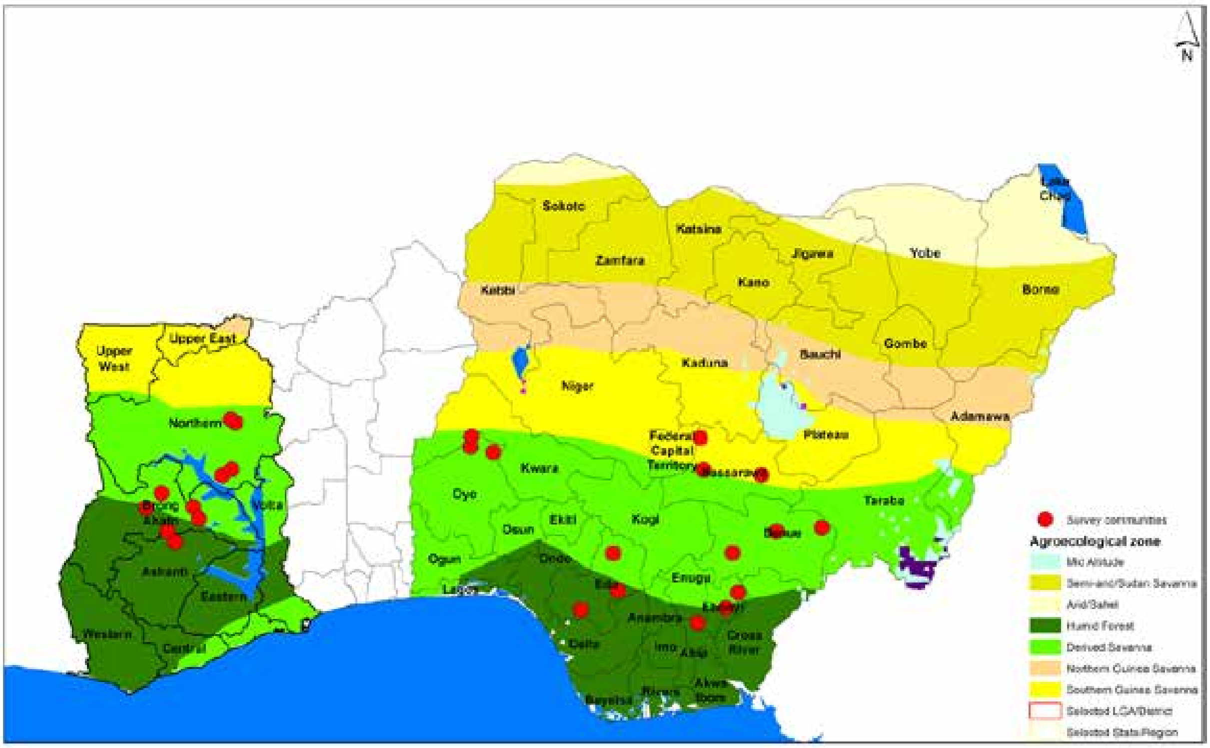

Figure 1. Map of survey areas in Ghana and Nigeria where field measurements were taken, 2013.

yam production operations—large, medium, and small; in each group one farm household was selected randomly. The household yam farm size categories were unique to each community and varied across communities. In each selected household, all yam fields planted in the 2013 season were surveyed.

The time period when the survey was conducted was also an element of sampling. Yam planting dates vary depending on agroecology and in some cases on the yam variety, such as early or late maturing varieties. Each variety has a growing period at the end of which the variety must be harvested to avoid crop losses to damage. This means that the harvesting time for different varieties with differing growing periods and planting times was spread over several months in the year which could not be accommodated by the limited time frame and other resources available for the study. For this reason, the peak season of November and December when most mature yam was still in the field was purposely selected; most early maturing varieties had already been harvested and could not be represented in the yield sample taken.

Data collection

Data were collected through oral interviews of the selected farmers and through direct measurements in the yam fields. Oral interviews were conducted with structured questionnaires which were designed and pretested. There were three structured questionnaires, one administered at the community level, one at the household level, and the last at field level. Respondents to the community level interviews were all yam producers, men and women in the community who were interviewed as a group. Information collected at this level was such as would not vary with farm household, such as availability of market and other rural infrastructure. The community level interview was conducted in the village square and in some occasions in the community hall depending on the wish of the community leaders.

The head of the household and spouse, where applicable, were interviewed at the household level in their home for information that would vary across households such as characteristics of the household, available resources, yam production objectives, etc. At the field level, the field owner responded to the oral interview for information such as production methods, yam varieties grown, plans for sale and for home consumption of yams to be harvested, etc. The field level interviews were conducted in the various yam fields.

Yam yield and field area were measured with guidance from the owner of the field. Field area measurement was done with Global Positioning System (GPS). Yield measurement was based on a sample plot of about 50 square meters harvested close to the center of the field, weight and numbers of stands and tubers were counted. The yam was purchased from the farmer at the market rate; the initial plan was to leave the yam for the farmer after he was paid but extension guides and survey labor scrambled for it. Measurement was done regardless of yam variety and fields that had been milked for seed yam production were skipped in yield measurement.

Local farmers were used as labor for harvesting, they and the survey farmers were paid the wage rate obtained in the community. Enumerators who conducted the interviews and took the field area and yield measurements were in all cases experienced scientists from IITA and the national R&D institutions in the survey countries.

Data management and analyses

A few days after the field work for data collection which lasted 30 days between November and December 2013, (10 days in Ghana and 20 in Nigeria), the questionnaires were reviewed by the YIIFSWA scientists who led in the field data collection. The data were transcribed by data entry clerks who were university graduates. After the transcription, the YIIFSWA scientists went through the data in a verification exercise before analyses began. The verification was a continuous process because in spite of cross checking the questionnaire before transcription and the transcribed data, errors kept showing in the process of analyses. But none of the problems observed at the various stages of checking called for a revisit to survey sites. Credit should be given to the scientists who served as enumerators.

Descriptive analyses are carried out and reported in Section II; the aim is to provide background information for more rigorous analyses. The bulk of the data analyses were based on economic models, including Ordinary Least Square (OLS), Logit, Probit, and Tobit models.

Plan of this working paper

This working paper is presented in six sections; Section I is the introduction. Section II is a discussion of the yam production contexts in Nigeria and Ghana by descriptive presentation of the survey data as a background for statistical analyses in the subsequent sections. Readers who may not wish to be bothered with rigorous econometric tests may be satisfied with the information in Section II. Section III demonstrates that yam is widely produced with a range of purchased inputs such as hired labor, seed yam, farm chemicals, etc. and identifies the determinants of the use of the various purchased inputs. Section IV shows that yam responds positively in terms of land area and yield to the application of the various purchased inputs. Section V estimates how much of the yam harvest the farmers designate for sale and identifies determinants of the levels of the yam designated for sale. The working paper is synthesized in Section VI.

2. Yam Production Contexts in Nigeria and Ghana

Yam-producing villages

Following the stratified random sampling, weighted by a priori knowledge of levels of yam production, and the procedure adopted in the YIIFSWA Complementary Baseline Survey methodology, the yam producing villages in Nigeria and Ghana are as follows: 70% in the derived savanna, 20% in the humid forest, and 10% in the southern Guinea savanna. Village level information collected in the survey shows that in Nigeria, there are periodic markets in 20% of the villages and in Ghana 10%. Availability of village markets is a proxy for level of commercialization; it is also presumed that villages with periodic markets are not as remote from urban centers as others without the markets.

The YIIFSWA baseline researchers investigated availabilities of health and farm input supply facilities in the survey villages. The result of this investigation turned out to be appalling; some of these facilities were found in only one or two of the villages in Nigeria and Ghana, respectively. In

Ghana in particular, many of the villages drew drinking, cooking, and washing water from puddles and rivulets which become stagnant in the dry season. This dismal scenario points to the high level of deprivation under which yam is produced in West Africa.

Yam is produced more for sale than for home consumption; in both Nigeria and Ghana 60% of harvest, after discounting for seed, is sold and only 40% is consumed in the farmers' households. The crop attracts a high price in the urban markets because it is patronized by high-income consumers. Producers work hard to produce so much yam, yet they live in penury; why? Nweke's hypothesis is that there is a problem at the level of outlet for yam from the farm to urban markets (Nweke forthcoming).

In Ghana, a yam producer faces three options when disposing of his crop: one, the producer takes a loan from a trader at planting time to pay high production costs, at harvest the trader arrives at the farm with a truck and carries the yam away at his price; two, a trader also arrives at a farm of a producer who did not receive a loan and makes an offer, if the price is not acceptable to the producer the trader goes to another farm with his empty truck; and three, the farmer takes a truckload of his yam direct to the urban market and stops at the entrance (the league of middlemen prohibits farmers from entering the wholesale market with yam), a middleman takes the truck load and negotiates the price with wholesalers behind the farmer and takes his agreed and unagreed commission before handing the proceeds over to the farmer who does not know what the wholesaler paid. To take the truckload of yam back to the farm is an expensive option for the farmer.

Obviously, the context in which yam producers sell their crop has a high potential to impoverish them; policy interventions are needed to change the unfair situation. The first step is to empirically assess the marketing situation to determine if the yam traders are enriched by the context which impoverishes the farmers. The empirical assessment will identify measures which if implemented will enable all participants in the yam value chain, the producers as well as the traders, to be equitably compensated for their efforts.

Yam farm households

Women are underrepresented as heads of yam producing households; the ratio of women to men as heads of households is 1:25 in the randomly selected sample of 75 yam-producing households in Nigeria and Ghana. This leaves a low degree of freedom that does not permit objective assessment of yam production performance by men and women. For this reason, further discussion of gender production activities in this working paper is limited.

Concern is often expressed that the population of farmers is aging (Omotayo 2002; Amos 2009); the YIIFSWA Complementary Baseline Survey data confirm this concern because the age distribution reveals some over working age heads of households. But the distribution includes a larger number of younger household heads with a modal age range of 40 to 49 years (Fig. 2). If the over age heads of households that are due for retirement are discounted, mean age of the household heads will be within the working age range in other occupations.

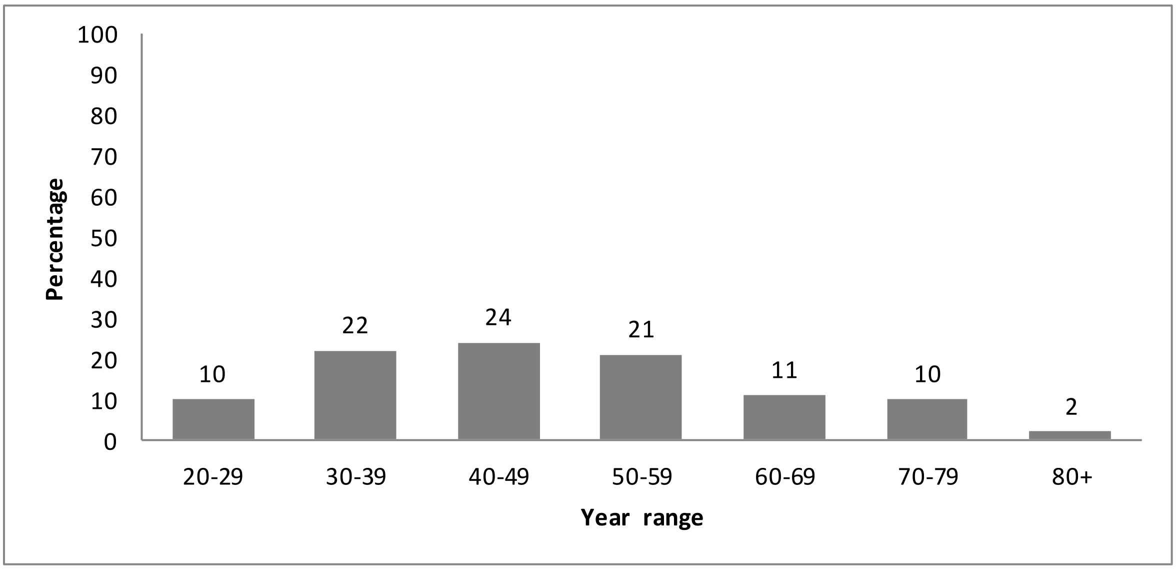

Figure 2. Nigeria and Ghana: Age distribution of yam producing household heads, 2013.
Source: YIIFSWA Complementary Baseline Survey.

The young heads of households are concentrated in remote areas; such young people stay in farming for a number of reasons. They are not as much aware of urban employment opportunities, because of lack of exposure, as their age mates in peri-urban areas. In addition, in several cases, young men in remote areas are obligated by tradition to stay back on the farm and take charge of the family legacy after the death of their fathers, which is often early because of the short life expectancy among the yam farming communities. The relatively large number of under thirty-year-old heads of households observed in the survey were heads of extended families; some of them were in their early 20s and unmarried but heading their late fathers' households.

Furthermore, the headship of households should be understood in the proper context of the surveyed areas. Often by tradition, in most parts of Nigeria and Ghana the oldest male member of a household is its head, even if he is an old man past working age in a household with economically active men and women or even if he is an underage boy in a household with economically active women members. This knowledge, if not accounted for, could lead to biased assessment of impact of age of household head on yam production.

The level of formal education of the heads of the yam farm households, in terms of number of years spent in formal education institutions is low. In Nigeria, more than 40% had no formal education, 60%, five years or less; about 10% of the heads of yam producing households in Nigeria had 10 or more years (Fig. 3). The situation is more dismal in Ghana where more than 70% of the heads of the yam farm households had zero years of formal education; more than 85%, 5 years or less; and only 5% had 10 or more years. Yam producers interviewed in the YIIFSWA Complementary Baseline Survey that had 10 or more years of formal education in both Nigeria and Ghana are people who retired to farming from urban wage employments and are part-time yam farmers. The context of close to zero formal education among main line yam producers should be of primary concern in R&D efforts aimed at promoting yam production in West Africa as a business in the 21st century.

Yam production practices in both Nigeria and Ghana include superstition and ritualism. Issahaq Suleman, a government extension officer in Ejura district in Ghana reported that ritual materials prepared in clay or calabash pots were sprinkled on seed yam before planting and after planting the pots were left hidden in the field to protect the yield of the crop from enemies because of the belief that through ritualism a farmer could transfer a good crop of yam in another's field to his own. In fact, during the YIIFSWA Complementary Baseline Survey field work, pots filled with uncertain materials were observed in yam fields visited in Brong Ahafo and Ashanti regions[4]. In Nigeria, Dr C.C. Okonkwo, the former international yam trials manager at IITA, reported that one reason a farmer would not sell his seed yam was that selling seed yam was interpreted as selling one's luck; equally buying seed yam could translate into buying bad luck[5].

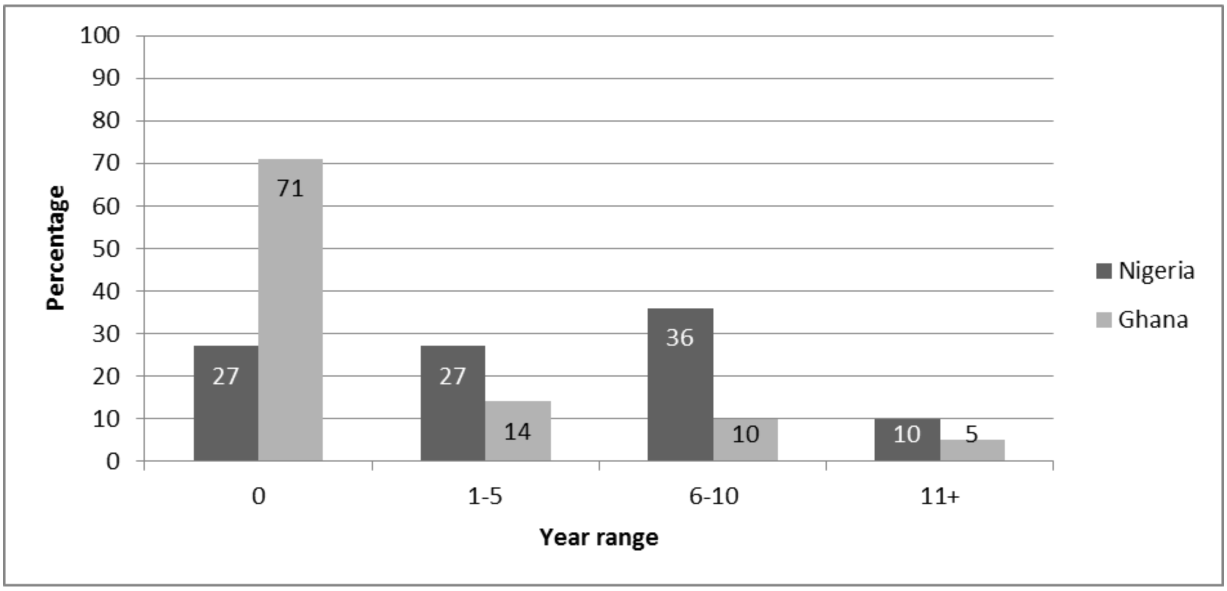

Figure 3. Nigeria and Ghana: Percentage distribution of level of formal education (years) of heads of yam producing households, 2013.
Source: YIIFSWA Complementary Baseline Survey.

The problem of superstitious and ritual practices in yam production which enhanced formal education can help address has implications for the management of yam production as a business. The ritual materials entail expenditure of resources including cash. More importantly, crop failures are blamed on the enemy next door; solutions to pest and diseases problems are sought in ritualism. Farmers who engage in superstitious and ritual practices are unlikely to be open to new technologies which they would view with suspicion.

One reason for limited R&D attention to labor-saving technologies in African agriculture is the wrong assumption in R&D circles that relative to other inputs such as fertilizers farmers have labor because of the large farm household sizes[6]. The implication of the observed large yam farm households, average of about 12 persons and ranging from 1 to 35, in both Nigeria and Ghana, is that on farm labor availability depends on the composition of the households (Table 1). Many of the large households are composed of aged women in polygamous families and many school age or younger children whose contributions to farm work are minimal. This means that household size could be a misleading proxy for labor availability in yam production.

[4]Personal communication, February 2014.
[5]Personal communication, February 2014.
[6]Patrick Ngody, 2010. Personal communication.

Table 1. Nigeria and Ghana: Household size (no./household), 2013.

Source: YIIFSWA Complementary Baseline Survey.

Statistics	Nigeria	Ghana
No. of observations	41	21
	no./household	
Mean	11.54	11.95
Min.	1	3
Max.	35	25
Std. Dev.	8.31	6.06

Table 2. Nigeria and Ghana: Yam field size (ha/farmer) by country, 2013.

Source: YIIFSWA Complementary Baseline Survey.

Statistics	Nigeria	Ghana
No. of observations	39	21
	ha/households	
Mean	1.82	1.60
Min.	0.22	0.11
Max.	12.32	6.74
Std Dev.	2.25	1.74

The yam fields

Most of the yam farm households had one yam field each; less than 5% of them had more than one in both Nigeria and Ghana. Average yam field size was 1.82 ha per household in Nigeria and 1.60 ha in Ghana (Table 2). In Ghana the yam fields surveyed are situated at distances of up to 15 km from the village centers. Yam is produced under a shifting cultivation system; each season farmers move into new forest lands in search of suitable land for yam production--suitable in terms of high fertility soil, low incidence of yam pests and diseases, and the availability of yam stake trees, without ever returning to land that has already been used for yam production.

Some yam fields are located far from farmers' homes along forest tracks with thick bushes of such sharp grasses as imperata and across rivulets, some of which are knee deep. On-farm transportation is by bicycle or motorbike for men; virtually all women travel on foot, leaving home early in the mornings and returning late in the evenings with headloads of firewood in the planting seasons and firewood and crop in the harvesting seasons.

In Nigeria, the context is dismal but less so than in Ghana because in Nigeria yam is produced under long fallow rather than under shifting cultivation as in Ghana. Nigerian yam farmers return to grow yam on land previously planted with yam every three to five years; in between, other crops could be grown on the land. Distances between home and yam fields are not as long as in Ghana and they are not increasing. Farm roads are foot tracks that are in most cases motorable by bush taxis. Women commute mostly on foot. In spite of these differences between Nigeria and Ghana, yield was not higher in Ghana than in Nigeria. In both countries there was no significance difference in yields (Table 3).

Table 3. Nigeria and Ghana: Yam yield (t/ha) by country, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Statistics	Nigeria	Ghana	t-value
No. of observations	40	20	
		no./household	
Mean	19.45	18.22	0.23
Min	2.93	4.34	
Max	45.00	35.93	
Std Dev	11.02	8.68	

In some agroecologies in the two countries yam is staked, sometimes elaborately. In Ghana, yam producers use preexisting small trees in the field as stakes for yam. During land clearing for yam cultivation, farmers collect and burn the residue around small trees which die and the yam vines are guided to twine on them. Nigerian yam producers carry stakes, usually split bamboo or suitable branches of other plants to yam fields in agroecologies such as the humid forest and derived savanna where the environment calls for elaborate staking of yam. In the southern Guinea savanna where there is more sunshine staking of yam is less elaborate; yam vines are directed to twine on stalks of corn and guinea corn intercropped with the yam.

In both Nigeria and Ghana, sole cropping was not common. Most of the farmers practiced intercropping and relay cropping. Farmers aim at maximizing yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop through intercropping and relay cropping. Cassava is the most common crop intercropped or relayed with yam in both countries. Rice is particularly more common in Ghana than Nigeria. Other crops include sorghum, melon, and beans. In virtually all cases, yam is gown in mounds in both Nigeria and Ghana; the exception, as observed in the YIIFSWA Complementary Baseline Survey, is a relatively small niche area along the banks of River Niger with light and deep alluvial soil. In Ghana, the mounds are almost of uniform size but in Nigeria the size varies depending on soil depth. The near uniform size of yam mounds in all the surveyed villages in Ghana has a negative effect on the yam tuber shape in areas where the soil is too shallow for the standard mound size.

Yam mound making is not only laborious, it is backbreaking; in later sections of this working paper it will be shown that cost of labor for mound making is one of three biggest constraints to yam production expansion, other major constraints are yam pests and diseases and the high cost, scarcity, and low quality of seed yam. But apart from mound making all yam production operations are labor intensive because all of them are performed with the hand hoe, machete, and digging sticks without any form of a labor-saving technology.

Problems of yam pests and diseases, especially nematodes and viruses are ubiquitous in both countries. In Ghana, the yam beetle is causing considerable damage to yam tubers and it is a serious cause of distress to yam producers in that country; that problem is no longer of serious concern in Nigeria. The potential for improvement in yam production through information exchange between Nigeria and Ghana is high. Such information could be generated through comparative analyses of differences in yam production practices between the two countries.

In yam production, the seed is the tuber, i.e., the crop. In Nigeria and Ghana yam producers purchase part and produce part of the seed yam they plant. Yam is widely produced with purchased inputs, especially the seed yam and hired labor; chemical fertilizer, herbicide and pesticides are used but not commonly. As much as 60% of yam harvested after discounting for seed yam is sold and 40% is consumed at home both in Nigeria and Ghana. These observations constitute indisputable evidence that yam is produced as a cash crop in West Africa.

The study reveals that yam is mostly produced in villages that are remote from urban centers especially in Ghana with limited health, sanitation, educational, farm input, etc. facilities. Some of the heads of most yam producing households are aged; the young ones are among them because of family traditional obligations or lack of exposure to urban employment opportunities. The mainline yam farmers have zero or little formal education. All these have negative implications for progress toward improvement of the yam food sector.

Yam is produced with low technologies for labor saving, seed production, and the yam pest and disease control. But among the most critical constraint is yam production under shifting cultivation in Ghana which exposes the farmers to unproductive and tortious commutation between home and yam fields. Although some men are able to accomplish on-farm transportation through forest tracks by bicycles and motor bicycles, women commute on foot on a daily basis with head loads of firewood and crops over the long-distant bush tracks. The practice of shifting cultivation which is rooted in the farmers' continuous search for fertile land, low yam pest and disease incidence, and stake trees have negative implications for environmental degradation.

In both Nigeria and Ghana, yam is grown on mound seedbeds which vary in size in Nigeria depending on soil depth. The near uniform size of yam mounds in all the surveyed villages in Ghana results in poor yam tuber shape in some areas where the soil is not deep enough. Making yam mounds is laborious and backbreaking. The difficulty of finding sufficient seasonal migrant hired labor for yam mound making is one of the biggest constraints to yam production expansion in both Nigeria and Ghana; other critical constraints are the yam pest and disease problem and the high cost, scarcity, and low quality of seed yam.

Yam is widely produced with purchased inputs, especially seed yam and hired labor; chemical fertilizer, herbicide, and pesticides are used but not commonly. As much as 60% of yam harvested after discounting for seed yam is sold and 40% is consumed at home, both in Nigeria and Ghana. These observations constitute indisputable evidence that yam is produced as a cash crop in West Africa.

Women are underrepresented as heads of yam producing households; the ratio of women to men as heads of households is 1:25 in the randomly selected sample of 75 yam-producing households in Nigeria and Ghana. This leaves a low degree of freedom that does not permit objective assessment of yam production performance by men and women. For this reason, further discussion of gender in yam production activities in this working paper is limited.

Numerous differences in yam production practices between Nigeria and Ghana suggest that the potential for improvement in yam production through information exchange between the two countries is high. Such information could be generated through comparative analyses of differences in yam production practices between the two countries..

3. Yam Production with Purchased Inputs

Introduction

Yam production demand for labor, seed, and other materials such as stakes is high; if these inputs are not provided as required or provided but not in a timely manner, suboptimal crop performance results. For this reason, inputs available in the household are frequently supplemented by purchase from external sources, especially when the crop is produced for sale, which is more often than not the case. This section assesses levels of use of various purchased inputs in yam production in Nigeria and Ghana and tries to establish the circumstances under which the inputs are purchased with the aim of suggesting measures that if implemented can motivate farmers to expand the level of use of the purchased inputs where such can help improve resource-use efficiency in yam production.

Purchased inputs

Inputs used in yam production which may be secured from sources external to the household include seed yam, labor, farmland, chemical fertilizer and herbicides, and mechanical and mechanized vehicles for use in field-to-home transportation. In both Nigeria and Ghana only one or two yam fields in the survey were cleared mechanically and in Ghana, where environmental conditions and other considerations such as access to machinery permitted, an uncommon situation, land was plowed before yam mounds were made. Therefore, the use of machinery in yam production was uncommon.

Yam fields surveyed were on plots of farmland acquired by inheritance, plots allocated by the village central authority, or plots purchased or rented from neighbors for a fee in cash or kind. Farmland was considered a purchased input if it was purchased or rented for a cash or kind payment. Hired labor, i.e., labor paid for in cash or kind, was used in various combinations with family labor for land clearing, seedbed preparation, sowing, weeding, and harvesting operations. For each operation hired labor was considered used if the operation was executed mostly or in full with hired labor.

Farm transportation is here referred to as field-to-home transportation because in areas where yam is not stored in the field it is stored at home, often for security reasons. Mechanical field-to-home transportation was by bicycle and hand-pushed carts or wheel barrows; mechanized transportation was by motorized vehicles such as motorcycles, tractors, and other four-wheeled motor vehicles. Bicycles, hand-pushed carts or wheel barrows, and motorcycles were usually owned by some of the smallholders. Four-wheeled motorized vehicles such as taxis and tractors were available locally for hire on a custom basis. Farmers with large quantities of yam output often rented tractors or taxis for transporting yam on an individual basis where farm road conditions permitted. On-farm transportation equipment is considered a purchased input if it is mechanical such as bicycles, carts or wheel barrows or motorized vehicles such as motorcycles, tractors, or other vehicles even if owned by the farmer since the equipment is purchased and is maintained with running expenses incurred in cash.

Frequencies of use of purchased inputs

Farmland. In Nigeria, 14% of the yam fields surveyed were acquired by purchase, 14%by renting, 70% by inheritance, and 2% by allocation from community leaders. In Ghana, 3% of the yam fields surveyed were acquired by purchase, 41% by renting, 34% by inheritance, and 22% by allocation from community leaders. Therefore, use of farmland as a purchased input in yam production was more common in Ghana than in Nigeria.

Seed yam. Frequently, a yam field is planted partly with purchased and partly with farmer's own produced seed yam. Farmers interviewed were asked to state, for each field, how many out of 10 seed yams planted were purchased and how many were own produced; this information was converted to a percentage. Approximately 40% of seed yams used by the surveyed farmers in both Nigeria and Ghana were purchased and 60% own produced. In both countries there were fields planted with only purchased seed yams and in Ghana there were fields planted with only farmer's own produced seed yams (Fig. 4).

Hired labor. Usage of hired labor in yam production is wide spread but more so in Nigeria than in Ghana. For example, hired labor was used for at least one of the five farm operations, namely land clearing, seedbed preparation (mounding), planting, weeding, or harvesting in about 95% of the fields in Nigeria and in about 80% in Ghana (Table 4). The wide spread use of hired labor can be explained by the high labor requirement in yam production. The hired labor was more commonly used in land clearing, seedbed preparation, and weeding than in sowing and harvesting. More detailed analyses of the survey data presented elsewhere reveal that mounding and weeding require more man days of work than land clearing, planting, and harvesting.

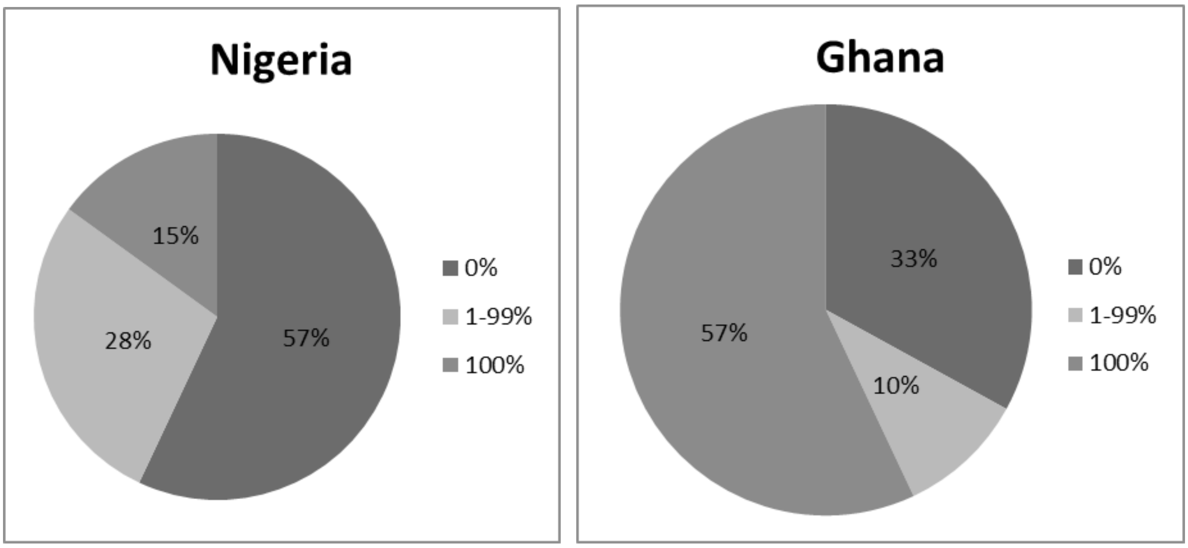

Figure 4. Nigeria and Ghana: Distribution of yam fields by percentage of seed yam planted that was purchased by country, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Table 4. Nigeria and Ghana: percentage frequency of yam fields by operation by source of labor by country, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Operation	Source	Nigeria	Ghana	Both countries
No. of observations		40	21	61
		Percentage		
Land clearing	Hired	90	81	87
	Family	10	19	13
	Total	100	100	100
Seedbed prep	Hired	80	81	80
	Family	20	19	20
	Total	100	100	100
Sowing	Hired	68	48	61
	Family	32	52	39
	Total	100	100	100
Weeding	Hired	88	67	80
	Family	12	33	20
	Total	100	100	100
Harvesting	Hired	70	33	57
	Family	30	67	43
	Total	100	100	100

Inorganic fertilizers. Inorganic fertilizers were used in 25% of yam fields surveyed in Nigeria but in none in Ghana. Limited farmer access to chemical fertilizer could be a factor in non-use of the purchased input in yam production in Ghana but more important, Issahaq Suleman reported that Ghanaian farmers are uncertain about the value of fertilizer in yam production[7]. Farmers are concerned that fertilizer may have negative effects on food quality and storability of yam produced. However studies on the relationship between fertilizer application and incidence of certain pests and diseases on yam inspired on-farm farmer participatory fertilizer experiments by government researchers in Ejura showed that chemical fertilizers carefully applied to yam results in yield increase with no adverse effects on yam pest and disease attacks, yam storage, and food quality (Yahaya 2011). Therefore, there is need to convince farmers of the positive effects of fertilizer use in yam production.

Herbicide. Herbicide was used either for land clearing, weeding, or both. For land clearing, herbicide was more widely used in Ghana; 46% of the surveyed yam fields compared with 17% in Nigeria. In Ghana, yam is planted in new forest land each year while in Nigeria yam is planted in fields with relatively short fallow. On the other hand, the chemical was more widely used for weeding in Nigeria; 52% of the surveyed yam fields and 38% in Ghana.

[7]Issahaq Suleman, personal communication, January 2014.

Mechanized field-to-home transportation. Field-to-home transportation of yam was widely mechanized, especially in Nigeria where yam was transported by head load from only 5% of the fields surveyed to home, from 20% by non-motorized vehicles, and from as much as 75% of the fields by motorized vehicles. In Ghana, the crop was transported from 17% of the fields surveyed to home by head load, from 20% by non-motorized vehicles, and from 63% by motorized vehicles. In Ghana, yam cultivation in new forest lands each year makes use of certain motorized vehicles for field-to-home transportation of yam difficult because of the inadequacy of farm roads.

Synthesis. The analyses above provide convincing evidence that yam is widely produced with a range of purchased inputs depending on the farmer's need to supplement family supplies, on farmer's access to the inputs, and on the farmer's assessment of the value of the purchased input in yam production. For example, among inputs purchased by yam producers, the frequency of use of purchased or rented farmland is the lowest; the reason is that farmers' need to supplement family supplies is low because, compared with other inputs, farmland is widely available from family sources.

The frequency of use of farm chemicals, namely chemical fertilizers and herbicides, which are usually purchased, is low especially in Ghana. In Ghana farmers are uncertain about the positive value of chemical fertilizer in yam production and all the farm chemicals which are imported and distributed mostly by government agencies are often expensive and not easily accessible to the farmers in both Nigeria and Ghana. Seed yam is an important input whose value in yam production depends on its quality; farmers are aware of this but most of them use less purchased than own produced because purchased seed yam is not necessarily superior in quality than own produced ones; in addition, seed yam is not always available in the market in sufficient quantities.

On the other hand, field-to-home transportation and labor are the most frequently used purchased inputs in yam production; the reasons are insufficiency or inadequacy of alternative family supplies and relative ease of farmer access. Under the condition of increasing home-to-field distances caused by farmers moving deeper into forests in search of virgin land for yam production, head loading is a non-viable alternative to motorized and non-motorized vehicles for field-to-home transportation of the crop, even under smallholder production. The transportation vehicles, once purchased, remain available locally because they are maintained by local artisans and some, especially motorized vehicles, are available for hire within the farmers' communities.

Hired labor is the most frequently used purchased input in yam production among the farmers surveyed because family supplies are too low compared with need. In addition, hired labor, though expensive, is available locally; the survey reveals that 45% of hired labor in the surveyed villages came from within their areas and 55% from outside their areas. But even the hired labor that comes from outside the community is also accessible locally because it comes as seasonal migrants and they reside in the area during the crop season.

The extensive use of purchased inputs which are in short supply from family sources and which are accessible to the farmers is convincing evidence that yam is produced as a cash crop in West Africa. This conclusion is based on the fact that farmers invest cash in the production of commodities which are expected to yield cash in return.

Determinants of use of the purchased inputs

An attempt is made in this section to identify the factors which motivate a smallholder to invest cash in the purchase of farmland, seed yam, hired labor, chemical fertilizer, and herbicide and in mechanical or mechanized field-to-home transportation of yam, i.e., to adopt these purchased inputs in yam production.

Theoretical model

The two most popular functional forms used in explaining farmers' adoption decisions are the Probit (the standard cumulative distribution function) and the Logit (the logistic distribution) models (Polson and Spencer 1991). The Probit model is:

$$T_i = F(W_i) = \int_{-\infty}^{W_i} \frac{1}{\sqrt{2\pi}} \exp(-S^2/2)ds \qquad \text{..... Eqn. III-I}$$

For $-\infty < w_i < \infty; w_i = X_i'\beta$

where:

Ti is the probability that the *ith* farmer chooses to use purchased input, zero otherwise.
X is the *n* by *k* matrix of the explanatory variables and *β* is a k by 1 vector of parameters to be estimated.

The logistic distribution function is closely associated with the standard normal cumulative function of the Probit model. For equation III-1, the change in the probability that the farmer uses a purchased input given change in anyone of the explanatory variables can be computed as:

$$\frac{\partial T_i}{\partial x_i} = \left(\frac{\partial_F}{\partial w_i}\right)\left(\frac{\partial w_i}{\partial x_i}\right) = F(w_i)\beta \qquad \text{..... Eqn. III-2}$$

where:

F(wi) is the standard normal density (logistic density) function for the Probit (Logit) model.

Empirical model

Studies of smallholder technology adoption in parts of Africa are widely reported in literature (Polson and Spencer 1991; Adesina and Zinnah 1993; Nweke et al. 1988). Most of these studies are analyses of adoption processes for new technologies and are based on information collected from a relatively narrow area within a country. Here, analysis of adoption of purchased inputs in yam production is that of existing practices. The analysis is based on information at the field, household, and village levels collected in 25 villages in two countries; Nigeria and Ghana. The unit of analysis is the individual field; a farmer could apply a purchased input in one and not in another of his yam fields.

Hired labor was used in performing land clearing, seedbed preparation, sowing, weeding, and harvesting operations in the surveyed fields. In yam production, seedbed preparation (mounding) and weeding are the two most labor intensive farm operations (Tshiunza 1998). The survey data for this report show that virtually all fields prepared with hired labor were also weeded with hired labor and vice versa. For example, labor was employed for mounding in 80.33% of the fields surveyed and for weeding also in 80.33; these were virtually the same fields. Analyses of use of hired labor in seedbed preparation or in weeding provide sufficient insight into the determinants of use of hired labor in yam production. Use of hired labor in yam seedbed preparation is defined as a binary variable, one if the farm operation is performed mostly or fully with hire and zero otherwise.

Field size and production objective (for sale or for home consumption) are possible field level determinants of the probabilities of use of hired labor for seedbed preparation or for weeding in yam production. The percentage of yam harvest from the field designated for sale by the field owner is specified as proxy for production objective. In practice, the decision before planting for sale is a better determinant of adoption of purchased inputs than the percentage ultimately sold because once a farmer decides to plant for sale he or she makes investment in purchased inputs, irrespective of how much he or she ultimately sells. After harvest, te amount ultimately sold is determined by crop performance, home consumption needs, and current market conditions. But farmers surveyed were unable to provide information on how much they planned to sell before planting.

Seed yam as a purchased input is a continuous variable which varied from zero to 100 and is defined as the percentage of total seed yam planted in the field that was purchased. As in the case of hired labor, field size and percentage of yam harvested in the field designated for sale are possible field level determinants of the probabilities of use of purchased seed yam.

Field-to-home transportation of yam as a purchased input is a binary variable defined as one if the yam is transported by a mechanical or mechanized means as defined above or zero if by head load. Location of the field in terms of whether the field is situated in a residential area or in distant fields could have been a likely determinant of the probability that field-to-home transportation is mechanized but yam fields are virtually all situated far from home, particularly in Ghana.

Despite the fact that a few farmers used fertilizer in Nigeria, usage of chemical fertilizer, herbicide, and mechanization of farm land clearing are uncommon in both Nigeria and Ghana and therefore analyses of determinants of their use are unproductive.

The household variables specified as determinants of the probability that any of the purchased inputs was used were household size and the age of the household head. Formal education of the head of the household is a possible determinant but it has low variability as the farmers usually did not have more than a few years of primary education. The few farmers who are better educated soon reason like the majority with whom they interact on a daily basis or if they show better ideas they are quickly copied by the rest. As a result, level of formal education does not make much difference to the adoption of farm technologies and practices in a village setting (Nweke 1996).

Population density and level of commercialization are some of the village-level factors which can influence the probability of use of purchased inputs in yam production. Periodic village market meetings and distance to nearest urban centers are used as proxies for population density and level of commercialization of the village community. The frequency of village markets, and the distance to the nearest urban center are specified as discrete variables.

Country dummies are specified as a binary variable, one if Nigeria and zero if Ghana. Similarly, agroecologies, namely the humid forest, derived savanna, and southern Guinea savanna zones are also specified as binary variables. The country and agroecology dummies are specified to remove their effects. The variables are defined in Table 5.

Table 5. Definition of variables specified in the regression functions of use of purchased inputs in yam production, 2013.
Source: YIIFSWA Complementary Baseline Survey

Variable	Unit or Type	Explanation
Dependent variable		
PLABOR	Binary	1 if hired labor was used for seedbed preparation, else 0.
PSEED	Percentage	Percentage of seed yam purchased.
FMTRAN	Binary	1 if mechanized or mechanical, else 0.
PLAND		1 if rented or purchased, else 0.
Field variables		
FSIZE	Ha	Field size in ha.
PSALE	Percentage	Percentage of yam harvest designated for sale.
Household variables		
HHSIZE	Discrete	Household size in number.
AGEHH	years	Age in years.
Village variables		
VILMKT	Binary	1 if periodic market is in village, or else 0.
DISTURB	Kilometer	Distance to center.
Country dummies		
NIGERIA	Binary	1 if Nigeria, else 0.
GHANA	Binary	1 if Ghana, else 0.
Agroecology dummies		
HFREST	Binary	1 if humid forest, else 0.
DSAVA	Binary	1 if derived savanna, else 0.
SGSAVA	Binary	1 if southern Guinea savanna, else 0.

Four variations of the Probit model were estimated for each of the four purchased inputs: (1) field variables, (2) household variables, (3) village variables, and (4) a combination of all the variables. Empirical results

Use of hired labor in seedbed preparation. Along with country and agroecology zone dummies, specified field variables explained 24% (Pseudo R^2 = 0.2366) of the variability in the probabilities of adoption of hired labor for seedbed preparation; household variables, 11% (Pseudo R^2 = 0.1110); and village variables, also 11% (Pseudo R^2 = 0.1105); combined variables 56% (Pseudo R^2 = 0.5640) (Table 6). The percentage of yam harvest designated for sale is significantly correlated with the probability of use of hired labor for seedbed preparation in the combined equation. Field size is significantly related to the probability of use of hired labor for seedbed preparation in yam production in both field and combined variables equations. In the combined variables equation, the two specified household variables, namely age of household head and household size show a significant relationship with the probability of use of hired labor for seedbed preparation. The relationship between field size and the probability of use of hired labor for seedbed preparation is positive in both the field and combined variables equations. The relationship between distance to urban market and the probability of use of hired labor in seedbed preparation is also positive in the village and combined variables equations.

Table 6. Nigeria and Ghana: Estimates of parameters of explanatory variables of probability of use of hired labor for seedbed preparation in yam production, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Variable name	Variable level			
	Field	Household	Village	Combined
Intercept	0.2909	–	–	18.9009
	(–1.50)			(1.93)**
FSIZE	1.3660	–	–	2.1673
	(1.87)*			(2.21)**
PSALE	–0.0495	–	–	–0.2099
	(–1.50)			(-2.12)**
HHSIZE	–	–0.0193	–	–0.2309
		(–0.45)		(–1.81)*
AGEHH	–	–0.0375	–	–0.1600
		(–1.53)		(–1.86)
DISTURB	–	–	0.0989	0.1137
			(1.17)	(0.77)
NIGERIA	–0.1017	0.3496	0.7079	–2.1314
	(–0.12)	(0.46)	(0.52)	(–0.87)
HFREST	3.5239	2.6200	2.2814	7.2564
	(1.92)**	(1.87)*	(1.57)	(2.06)**
DSAVA	1.7557	1.2823	1.2878	0.2157
	(1.59)	(1.26)	(1.31)	(0.12)
Statistics				
No. of observations	60	61	43	43
Chi²	14.21	6.71	4.88	24.88
Prob>Ch²	0.0144	0.2429	0.3001	0.0016
Pseudo R²	0.2366	0.1110	0.1105	0.5640

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models. ***denotes $P \leq 0.01$, ***denotes $0.01 \leq P \leq 0.05$, and * denotes $0.05 \leq P \leq 0.10$.

Purchased seed yam. In combination with country and agroecology zone dummies, specified field variables explained 14% (Adjusted R^2 = 0.1449) of the variability in the probabilities of use of purchased seed yam; household variables, 7% (Adjusted R^2 = 0.0708); village variables, 17% (Adjusted R^2 = 0.1696); and all the variables combined, 48% (Adjusted R^2 = 0.4792) (Table 7).

The percentage of yam harvested which is designated for sale has a significant relationship with the probability of use of purchased seed yam in the field and combined variables equations. Age of household head is significant in the combined variables equation. The relationship between household size in the household equation and field size and distance to urban market in the combined variables equation, respectively, and the probability of use of purchased seed yam in yam production is positive

Table 7. Nigeria and Ghana: Estimates of parameters of explanatory variables of probability of use of purchased seed yam in yam production, 2013.
Source: YIIFSWA Complementary Baseline Survey.

	Variable level			
Variable name	Field	Household	Village	Combined
Intercept	114.6887	77.1965	99.3006	238.5976
	(4.10)***	(2.53)***	(3.89)***	(6.18)***
FSIZE	–1.3414	–	–	0.7673
	(–0.51)			(0.32)
PSALE	–1.0536	–	–	–2.0915
	(–2.21)**			(–5.05)***
HHSIZE	–	0.2693	–	–0.0020
		(0.36)		(0.00)
AGEHH	–	–0.1800	–	–0.8683
		(–0.45)		(–2.13)**
DISTURB	–	–	–0.5223	0.3868
			(–0.49)	(–0.35)
NIGERIA	–33.6840	–35.8575	–62.6033	–71.4172
	(–2.90)**	(–2.97)**	(3.89)***	(–4.62)***
HFREST	–2.8819	–7.3258	–11.0606	–5.8731
	(–0.51)	(0.33)	(–0.52)	(–0.35)
DSAVA	–13.4084	–13.4370	–10.4288	–26.6384
	(–0.72)	(–0.68)	(–0.58)	(–1.78)*
Statistics				
No. of observations	60	61	43	43
Chi^2	3.00	1.91	3.14	5.83
Prob.>Ch^2	0.0184	0.1066	0.0250	0.0001
Adj. R^2	0.1449	0.0701	0.1696	0.4792

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models.
***denotes $P \leq 0.01$, **denotes $0.01 \leq P \leq 0.05$, and *denotes $0.05 \leq P \leq 0.10$.

Mechanized field-to-home transportation. Together with country and agroecology zone dummies, specified field variables explained 12% (Pseudo R^2 = 0.1185) of the variability in the probabilities of use of mechanical or mechanized vehicle in field-to-home transportation of yam; household variables, 16% (Pseudo R^2 = 0.1650); village variables, 15% (Pseudo R^2 = 0.1521); and all the variables combined, 31% (Pseudo R^2 = 0.3117) (Table 8). None of the specified variables in all equations is significantly related to the probability of use of mechanical or mechanized vehicle in field-to-home transportation of yam. Field size is positively related with the probability of use of mechanical or mechanized vehicles for field-to-home transportation of yam in both the field and combined variables equations. Distance to urban market is positively correlated with the probability in the combined variables equation.

Table 8. Nigeria and Ghana: Estimates of parameters of explanatory variables of probability of use of mechanical or mechanized means for field to home transportation in yam production, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Variable name	Variable level			
	Field	Household	Village	Combined
Intercept	17.8589	17.4959	15.1000	24.4626
	(7.11)***	(0.01)	(0.01)	(0.00)***
FSIZE	0.0153	–	–	–0.4010
	(0.05)			(–0.86)
PSALE	–0.0156	–	–	–0.0177
	(–0.35)			(–0.20)
HHSIZE	–	–0.0796	–	–0.0361
		(–1.17)		(0.33)
AGEHH	–	–0.0184	–	–0.1191
		(–0.49)		(–0.62)
DISTURB	–	–	0.0749	0.3278
			(0.50)	(0.74)
NIGERIA	1.6410	2.0566	1.8913	3.6118
	(1.36)	(1.50)	(1.10)	(1.27)
HFREST	–15.9421	–14.2392	–14.3142	–16.2665
	(–)	(–0.01)	(–0.01)	(0.00)
DSAVA	–15.4612	–13.7992	–13.8462	–17.4380
	(–10.78)***	(–0.01)	(–0.01)	(–0.00)
Statistics				
No. of observations	58	59	43	43
Chi²	3.45	4.83	12.03	5.04
Prob>Ch²	0.4855	0.4374	0.0171	0.7530
Pseudo R²	0.1185	0.1650	0.2580	0.3117

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models. ***denotes $P \leq 0.01$, ***denotes $0.01 \leq P \leq 0.05$, and * denotes $0.05 \leq P \leq 0.10$.

Rented or purchased farmland. Jointly with country and agroecology zone dummies, specified field variables explained 21% (Pseudo R^2 = 0.2116) of the variability in the probability of use of renting or purchasing farmland; household variables, also 15% (Pseudo R^2 = 0.1510); village variables, 26% (Pseudo R^2 = 0.2580); and all the variables combined, 44% (Pseudo R^2 = 0.4403) (Table 9).

Field size and distance to urban market are both significantly correlated with the probability of renting or purchasing farmland for yam production only in the combined variables equation. But the relationship of the probability of renting or purchasing farmland for yam production with field size in field and combined variables equations is positive. The relationship of the probability of renting or purchasing farmland with age of household head in household and combined variables equations is also positive.

Table 9. Nigeria and Ghana: Estimates of parameters of explanatory variables of probability of renting or purchasing farm land for planting yam, 2013.
Source: YIIFSWA Complementary Baseline Survey.

	Variable level			
Variable name	Field	Household	Village	Combined
Intercept	0.6945 (0.38)	–0.8772 (0.55)	0.7806 (0.48)	2.9828 (0.78)
FSIZE	0.4739 (1.58)	–	–	1.8503 (1.84)*
PSALE	–0.0581 (–1.56)	–	–	–0.1316 (–1.54)
HHSIZE	–	–0.0317 (–0.80)	–	–0.0995 (1.26)
AGEHH	–	0.0097 (0.45)	–	0.0308 (0.66)
DISTURB	–	–	–0.1615 (–1.58)	–0.2326 (–2.03)**
NIGERIA	1.7883 (2.39)**	1.4643 (2.12)**	0.4629 (0.39)	1.4840 (0.92)
HFREST	–0.8347 (–0.70)	–1.0217 (0.92)	–0.7062 (–1.58)	–1.6354 (-0.96)
DSAVA	1.1019 (1.02)	1.2143 (1.15)	2.7318 (1.84)*	3.3643 (1.790)*
Statistics				
No. of observations	60	61	43	43
Chi^2	15.86	11.66	12.03	20.54
Prob> Chi^2	0.0073	0.0398	0.0171	0.0086
Pseudo R^2	0.2116	0.1510	0.2580	0.4403

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models. ***denotes $P \leq 0.01$, ***denotes $0.01 \leq P \leq 0.05$, and * denotes $0.05 \leq P \leq 0.10$.

Discussion

Clearly, the strong positive correlation between field size and the probability of use of hired labor in yam seedbed preparation is convincing evidence that availability of hired labor for seedbed preparation and weeding is essential for yam production expansion under the present hand tool technology (Table 10).

This situation presents a gloomy picture for yam production expansion. Supply of farm labor for hire is inelastic; often when a farmer is willing to pay a high and increasing farm wage, labor for hire is difficult to find. Yam mound making is a backbreaking activity while opportunities for off-farm employment with better cash returns such as hawking manufactured goods in urban streets, motorcycle taxi operation, etc. are expanding in urban centers.

Table 10. Nigeria and Ghana: Yam field area (ha/farmer) by labor source by operation, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Operation	Source	No. of observations	Mean	Min.	Max.	Std. Dev.
Land clearing	Hired	52	1.79	0.15	12.32	2.0768
	Family	8	1.40	0.11	6.74	2.1812
Seedbed prep.	Hired	48	1.98	0.15	12.32	2.2532
	Family	12	0.79	0.11	1.94	0.4477
Sowing	Hired	36	1.65	0.15	7.73	1.5651
	Family	24	1.88	0.11	12.32	2.7001
Weeding	Hired	48	1.71	0.15	7.73	1.6672
	Family	12	1.85	0.11	12.32	3.3508
Harvesting	Hired	34	1.92	0.15	7.73	1.8692
	Family	26	1.51	0.11	12.32	2.3375

Table 11. Nigeria and Ghana: Household size (no. of households) by source of labor by operation, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Operation	Source	No. of observations	No. of persons/household			
			Mean	Min	Max	Std dev
Land clearing	Hired	53	11.75	1	35	7.1250
	Family	8	11.88	3	35	10.8685
Seedbed prep.	Hired	49	11.41	1	35	6.5349
	Family	12	13.25	3	35	11.2179
Sowing	Hired	37	11.08	1	35	6.4952
	Family	24	12.83	3	35	12.8333
Weeding	Hired	49	11.47	1	35	7.0063
	Family	12	13.00	3	35	9.9453
Harvesting	Hired	35	11.46	4	35	7.0517
	Family	23	12.19	1	35	8.4096

Hired labor was used for land preparation more frequently in smaller households and family labor more frequently in larger households as would be expected (Table 11).

But the hired labor for seedbed preparation was used more frequently in households headed by younger people than in others headed by older people (Table 12) because households headed by younger people cultivate larger yam fields than households headed by older people.

The statistically weak and negative relationship between percentage of yam harvest designated for sale and the probability of use of hired labor in seedbed preparation is unexpected because hired labor is paid with cash proceeds from yam production activity. The positive though statistically weak correlation between distance to urban markets and the probability of use of hired labor in seedbed preparation implies that hired labor for seedbed preparation is more frequently used in remote than in peri-urban areas (Table 13).

Table 12. Nigeria and Ghana: Age of household head (years) by source of hired labor by operation, 2013. Source: YIIFSWA Complementary Baseline Survey.

Operation	Source	No. of observations	Years			
			Mean	Min	Max	Std. Dev.
Land clearing	Hired	53	46.62	20	74	15.1775
	Family	8	49.63	22	80	17.7041
Seedbed prep.	Hired	49	45.57	20	74	15.6870
	Family	12	52.92	32	80	13.1523
Sowing	Hired	37	45.11	20	74	14.5407
	Family	24	49.96	20	80	16.5253
Weeding	Hired	49	46.88	20	74	15.1845
	Family	12	47.58	20	80	16.9569
Harvesting	Hired	35	47.14	20	74	15.5491
	Family	26	46.85	20	80	15.5092

Table 13. Nigeria and Ghana: Percentage of frequencies of labor source by availability of village market in survey villages, 2013. Source: YIIFSWA Complementary Baseline Survey.

Operation	Source	No. of obs.	Percentage		
			Available	Not available	Total
Land clearing:	Hired	53	21	79	100
	Family	8	0	100	100
Seedbed prep.	Hired	49	20	80	100
	Family	12	8	92	100
Sowing	Hired	37	22	78	100
	Family	24	12	88	100
Weeding	Hired	49	20	80	100
	Family	12	8	92	100
Harvesting	Hired	35	23	77	100
	Family	26	12	88	100

Distance to urban market is a proxy for level of commercialization of the village community and use of hired labor should be higher in commercial than non-commercial areas.

What is the implication of the above observed correlations? The statistically strong and positive correlation between field size and the probability of use of hired labor in seedbed preparation and the unexpected correlations between the probability and market factors suggest that an increase in market value of yam without improved labor-saving technology is unlikely to result in expanded production.

The statistically strong negative correlation between percentage of yam harvest designated for sale and the probability of use of purchased seed yam is determined by the informal nature of the yam seed system. The observed statistically strong and negative relationship suggests that the more a farmer plants yam for sale the less he or she depends on purchased seed yam. The informal yam seed system, which though market driven does not deliver quality seed yam in sufficient quantities, compels commercial yam producers to depend on own produced rather than on purchased seed in their production enterprises.

The analysis of the probability of use of mechanical or mechanized field-to-home transportation of yam failed to yield a statistically significant correlation with any of the specified variables in all the specified equations. Field-to-home transportation of yam and indeed all travel between residence and yam fields is one of the toughest tasks in the yam production activities; farm roads in general have received little if any attention in national food policy programs in both Nigeria and Ghana but more so in Ghana.

Due to the statistically strong relationship of the probability of renting or purchasing farmland for yam production which is positive with field size and negative with distance to urban market, a proxy for population pressure and commercialization is expected; large-scale farmers who are more common in remote areas rent farmland more frequently than smaller farmers who are more common in peri-urban areas (Table 14). The relationships which suggest that large-scale farmers have needed to rent or purchase farmland to supplement family land suggest that limited availability of suitable farmland is becoming an increasing impediment for yam production expansion. The situation is exemplified in Ghana where farmers are pushing deeper into forest lands in search of suitable land for yam cultivation and in Nigeria where farmers are cultivating yam under short fallow in spite of the high pest and disease implications of yam production under intensive practices.

To summarize, analyses of determinants of use of purchased inputs in yam production reveals three serious impediments to yam production expansion, namely, the increasing shortage and high cost of hired labor, a shortage of suitable land for yam production and poor farm roads. These impediments call for development and diffusion of labor-saving and pest and disease control technologies in yam production; the constraints also call for improvement in farm roads. Under the present expansion of employment opportunities for unskilled labor in urban centers yam production expansion will be hard to achieve without labor-saving technologies for at least some of the yam production tasks including seedbed preparation and weeding and without improvement in farm roads. Effective yam pest and diseases control technologies will permit yam production under intensive methods and reduce farmers' need to search for virgin land for cultivation of the crop.

Table 14. Nigeria and Ghana: Yam field area (ha/farmer) by source of farmland, 2013.
Source: YIIFSWA baseline survey.

Statistics	Farmers who rented or purchased some farmland	Farmers who relied on only family land
No of obs.	41	19
	ha/farmer	
Mean	2.03	1.13
Min.	0.22	0.11
Max.	12.32	4.01
Std. Dev.	2.36	1.06

4. Yam Production Response to Use of Purchased Inputs

Yam production response to use of purchased inputs could be with respect to change in land area cultivated, or yield per unit land area, or both. Availability of labor for hire would have positive effects on both land area and yield per unit area, especially if the labor is hired for relevant operations such as seedbed preparation for land area expansion and weeding for increasing yield per unit area. Farmers could supplement family labor with hired labor to expand yam land area. Hired labor may also be used to ensure timeliness in carrying out critical farm operations such as weeding. Similarly, availability of seed yam for purchase will have a positive effect on yam land area expansion because farmers could supplement own produced with purchased seed yam. The effect of purchased seed yam on yield increase depends on the quality of purchased relative to own-produced seed yam.

Availability of farm land for renting or for purchase would affect field area expansion positively as farmers would be able to acquire additional land for yam production. Its effect on yield per unit area would depend on whether or not farmers apply other purchased inputs on rented farmland. As a labor-saving practice, field-to-home transportation of yam by mechanical or mechanized vehicles would have a positive effect on yam farm land area expansion; its effect on yield per unit area would be indirect. Use of chemical fertilizers may not have a direct effect on land area expansion; it has been shown, however, that yield would respond to some chemical fertilizers, especially under poor soil conditions and when the fertilizer application is appropriate in terms of dosage and nutrient content.

Relationship between field area expansion and use of purchased inputs

The farmer groups interviewed in the survey villages were asked what had been the trend (increasing, no change, or decreasing) in yam production. Yam production was reported to be decreasing in 22 of the 25 villages surveyed; because of the low variation in this information analysis of yam land area response to use of purchased inputs is based on field level data generated from 76 yam fields cultivated in the 2013 season by 75 farm households in 25 villages across the three agroecologies surveyed.

Empirical model

The relationships between land area expansion and uses of the relevant purchased inputs are determined through econometric analysis with the OLS model across the 76 fields. The yam field area in ha is the dependent variable; there are three groups of independent variables namely purchased inputs, household, and market factors. Relevant purchased inputs are hired labor for seedbed preparation, purchased seed yam, mechanical or mechanized transportation, and rented or purchased farmland. Household variables are age, gender of the household head, and household size; and market factors are percentage of yam harvested designated for sale, distance of the village to nearest urban center, and frequency of village market. Distance to nearest urban center and frequencies of village market are proxies for population pressure and commercialization. These explanatory variables are fitted in separate equations and combined in one equation. Agroecology and country dummies are specified in each equation to remove their effects. The variables are defined in Table 15.

Table 15. Definition of variables specified in the regression function of yam production response to use of purchased inputs in terms of field size and yield, 2013.
Source: YIIFSWA Complementary Baseline Survey

Variable	Unit or Type	Explanation
Dependent variables		
FSIZE	Ha	Field size in ha.
YLDHA	Ton	Yam yield in t/ha.
Purchased input variables		
HLABOR	Binary	1 if hired labor was used for seedbed preparation, else 0.
PSEED	Percentage	Percentage of seed yam purchased.
PLAND	Binary	1 if land was rented or purchased, else 0.
FERT	Binary	1 if chemical fertilizer was applied, else 0.
FMTRAN	Binary	1 if mechanical or mechanized, else 0.
Market variables		
DISTURB	Kilometer	Distance to urban center.
VILMKT	Binary	1 if periodic market is in the village, else 0.
Field variables		
FSIZE	Ha	Field size in ha.
PSALE	Percentage	Percentage of yam harvest designated for sale.
STDHA	Discrete	Number of yam stands per ha.
INTCRP	Binary	1 if intercropped, else 0.
FERT	Binary	1 if fertilizer was applied, else 0.
STAKE	Binary	1 if staked, else 0.
Household variables		
HHSIZE	Discrete	Household size in number.
AGEHH	Years	Age of head of household.
Country dummies		
NIGERIA	Binary	1 if Nigeria, else 0.
GHANA	Binary	1 if Ghana, else 0.
Agro-ecology dummies		
HFREST	Binary	1 if humid forest, else 0.
DSAVA	Binary	1 if derived savanna, else 0.
SGSAVA	Binary	1 if southern Guinea savanna, else 0.

Empirical results

The purchased input specification explained less than 2% of variation in field area (Adjusted R^2 = 0.0168); household specification, less than 10% (Adjusted R^2 = 0.0731); market specification, less than 5% (Adjusted R^2 = 0.0325); and combined variables specification, about 10% (Adjusted R^2 = 0.1102) (Table 16).

Table 16. Nigeria and Ghana: Estimates of parameters of explanatory variables of yam field size in ha, 2013.
Source: YIIFSWA Complementary Baseline Survey.

	Variable level			
Variable name	Purchased input	Household	Market	Combined
Intercept	1.0175 (0.64)	0.6955 (0.35)	1.2056 (–0.64)	–6.6964 (1.46)
HLABOR	1.3264 (1.79)*	–	–	1.6808 (1.63)
PSEED	–0.0055 (0.79)	–	–	0.0045 (0.36)
PLAND	0.8027 (1.17)	–	–	1.1006 (1.04)
FMTRAN	–	–0.2924 (–0.25)	–	–2.1855 (–1.23)
HHSIZE	–	0.0341 (0.91)	–	0.0618 (1.34)
AGEHH	–	0.0102 (0.50)	–	0.0364 (1.2)
PSALE	–	–	0.0234 (0.81)	0.0602 (1.48)
DISTURB	–	–	0.1366 (2.21)**	0.1461 (2.14)**
VILMKT	–	–	0.1366 (0.78)	0.0609 (0.31)
NIGERIA	–0.1628 (–0.23)	0.3215 (0.52)	1.3646 (1.30)	1.4400 (1.03)
HFREST	–0.5684 (–0.48)	–0.1044 (–0.09)	–0.4756 (–0.34)	–0.8451 (–0.55)
DSAVA	–0.2936 (–0.29)	0.5510 (0.56)	–0.1786 (–0.18)	–0.4062 (–0.37)
Statistics				
No of Obs.	58	60	43	43
Chi^2	0.87	0.33	1.23	1.40
$Prob>Ch^2$	0.5403	0.9182	0.3117	0.2182
Adj R^2	0.0168	0.0731	0.0325	0.1102

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models.
***denotes $P \leq 0.01$, **denotes $0.01 \leq P \leq 0.05$, and *denotes $0.05 \leq P \leq 0.10$.

Hired labor was significantly correlated with field area at 0.08% probability level in the purchased input equation and at 0.11% in the combined equation; the correlation coefficient is positive in both specifications. All other specified purchased input variables are statistically significant at more than 20% probability levels in both the purchased input and combined variables equations. The correlation coefficient of rented or purchased farmland is positive in both the purchased input and combined variables equations. Purchased seed yam is negatively correlated with field area in the purchased input equation and positively correlated with it in the combined variables equation. Mechanical or mechanized field-to-home transportation is negatively correlated to the field area in both the purchased input and combined variables equation.

Discussion

The low explanatory powers of the specified variables in each of the four equations underscore the position of the 22 out of 25 farmer groups surveyed who maintained that yam production was decreasing in their villages. Analysis of FAO data which reveals that from 1961 to 2006 the trend of per capita yam area harvested was flat in both Nigeria and Ghana confirms the position of the 22 farmer groups (Fig. 5). The flat trend of the area harvested helps explain the difficulty of finding explanations for low statistical significance of most of the specified explanatory variables.

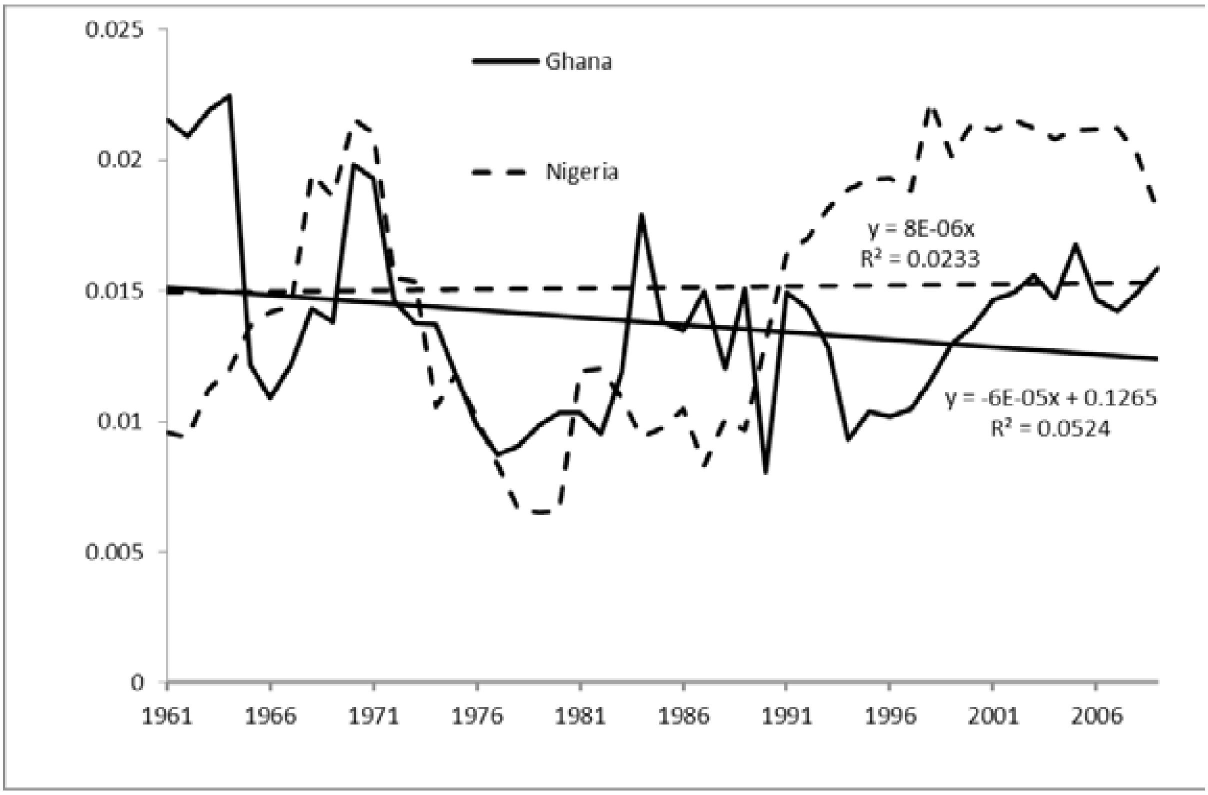

Figure 5. Ghana and Nigeria: Per capita yam land area (ha), 1961 to 2006.
Source: FAOSTAT, 2009.

However, yam field size is clearly positively responsive to use of hired labor, especially for farmland clearing, seedbed preparation, and harvesting. Since no other purchased input is significantly correlated with field size, hired labor is the most important purchased input which enables farmers to expand their yam production operations. The high cost and scarcity of hired labor are an effective bottleneck in yam production which neutralizes the positive effects of other purchased inputs in yam field area expansion. The implication is that an alternative to hired labor is needed to expand the production of the crop.

Relationship between yam yield and use of purchased inputs

Among the purchased inputs used in yam production in Nigeria and Ghana which can influence yield are hired labor for specific field operations especially weeding, purchased seed yam, rented or purchased farmland, fertilizer, herbicides and pesticides. Fertilizer was applied in some surveyed fields in Nigeria but in none in Ghana while the frequencies of application of herbicides and pesticides were low or zero in both countries.

Empirical model

The relationships between yam yield and uses of the relevant purchased inputs are determined through econometric analysis with the OLS model across the surveyed fields. Yield in tons per ha is the dependent variable; there are three groups of independent variables namely purchased inputs, agronomic practices, and market factors. Relevant purchased inputs are hired labor for weeding, purchased seed yam, fertilizer, and rented or purchased farmland. Agronomic practices are field size, yam plant population, staking, and intercropping; and market factors are the percentage of yam harvest designated for sale and distance of the village to nearest urban center. Distance to nearest urban center is a proxy for population pressure and commercialization. These explanatory variables are fitted in separate equations and combined in one equation. Agroecology and country dummies are specified in each equation to remove their effects. Because fertilizer was used in Nigeria but not in Ghana, a separate set of equations were estimated with Nigerian data alone with fertilizer specified in the purchased input and combined variables equations.

Empirical results

In joint Nigeria and Ghana estimates, the purchased input variables specified explained less than 10% of variation in yield (Adjusted R^2 = 0.0720); agronomic practices, nearly 60% (Adjusted R^2 = 0.5819); market variables, less than 5% (Adjusted R^2 = 0.02066); and combined variables, close to 70% (Adjusted R^2 = 0.6855) (Table 17).

In separate Nigeria estimates, the purchased input variables explained less than 10% of variation in yield (Adjusted R^2 = 0.0682); agronomic practices, about 50% (Adjusted R^2 = 0.5194); market variables, about 5% (Adjusted R^2=0.0650); and combined variables, more than 60% (Adjusted R^2 = 0.6203) (Table 18).

Table 17. Nigeria and Ghana: Estimates of parameters of explanatory variables of yam yield in tons/ha, 2013.
Source: YIIFSWA Complementary Baseline Survey.

	Variable level			
Variable name	Purchased input	Field	Market	Combined
Intercept	39,428.9300 (3.91)***	15,007.6000 (2.22)**	32484 (2.21)**	–5995.5170 (–.38)
HLABOR	–3014.5470 (–0.51)	–	–	9656.2060 (1.57)
PSEED	1.4356 (0.03)	–	–	–10.8773 (–0.19)
PLAND	256.4768 (0.05)	–	–	–1519.5960 (–0.19)
FERT	–	–	–	–
FSIZE	–	175.3407 (0.24)	–	618.9192 (0.68)
STDHA	–	2.2094 (6.91)***	–	2.4172 (6.75)***
INTCRP	–	384.4754 (0.24)	–	2446.3040 (1.22)
STAKE	–	–10508 (–2.17)**	–	–11,597.0400 (2.50)**
PSALE	–	–	579.9313 (2.06)**	460.4953 (2.14)**
DISTURBA	–	–	–743.4254 (–1.54)	–347.5064 (–1.01)
NIGERIA	–2948.7130 (–0.53)	–996.9260 (–0.27)	–20,042.8300 (–2.27)**	–8884.1200 (–1.20)
HFREST	4316.4660 (0.49)	14,235.6800 (2.08)**	1815.4150 (0.20)	8786.1590 (1.27)
DSAVA	–13,702.3900 (–1.80)*	–9255.7140 (–1.81)*	–10,191.2400 (–1.30)	–6270.1580 (–1.19)
Statistics				
No of obs.	60	59	42	42
Chi²	1.76	12.53	3.14	8.45
Prob.>Ch²	0.1248	0.0000	0.0189	0.0000
Adj. R^2	0.0720	0.5819	0.02066	0.6855

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models.
***denotes $P \leq 0.01$, **denotes $0.01 \leq P \leq 0.05$, and *denotes $0.05 \leq P \leq 0.10$.

Table 18. Nigeria: Estimates of parameters of explanatory variables of yam yield in ts/ha, 2013.
Source: YIIFSWA Complementary Baseline Survey.

	Variable level			
Variable	Purchased input	Field	Market	Combined
Intercept	34,001.0200 (3.25)***	14,269.61 (2.10)**	13747.1400 (0.99)	–4692.6650 (–0.32)
HLABOR	3077.9630 (0.36)	–	–	12345 (1.79)*
PSEED	–71.8414 (–0.99)	–	–	–32.6476 (–0.51)
PLAND	–8857.7220 (–1.21)	–	–	–5389.5880 (–0.86)
FERT	12,085.8700 (1.92)*	–	–	–3928.7200 (–0.71)
FSIZE	–	110.8972 (0.12)	–	533.3318 (0.57)
STDHA	–	2.1878 (5.88)***	–	2.6958 (5.76)***
INTCRP	–	–571.1802 (–0.26)	–	13148 (0.62)
STAKE	–	–5426.7420 (–0.95)	–	–7382.2640 (1.38)
PSALE	–	–	540.3416 (1.77)*	221.5140 (0.77)
DISTURB	–	–	–63.5556 (–1.15)	–214.5125 (0.51)
HFREST	–2034.4410 (–0.21)	5846.5330 (0.71)	–3029.3290 (–0.31)	–636.3702 (-0.07)
DSAVA	–7857.7300 (–0.98)	–8081.5490 (–1.45)	–9483.0260 (–1.20)	5984.298 (–1.10)
Statistics				
No of obs.	40	39	37	37
Chi²	1.48	7.85	1.63	5.90
Prob.>Ch²	0.2168	0.0000	0.1919	0.0001
Adj. R²	0.0682	0.5194	0.0650	0.6203

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models. ***denotes $P \leq 0.01$, ***denotes $0.01 \leq P \leq 0.05$, and * denotes $0.05 \leq P \leq 0.10$.

In the joint Nigeria and Ghana estimates, none of the purchased inputs specified is significantly correlated with yield either in the purchased input or in the combined variables equation at 10% probability level. The yam stand density (yam plant population) and staking are significantly correlated with the yield at high probability levels in both the agronomic and combined variables equations, the coefficient of yam stand density is positive but that of staking is negative also in both equations (Fig. 6).

Among market variables, only percentage of yam harvest designated for sale is significantly correlated with yield but that is only in the market equation; the correlation coefficient is positive (Fig. 7).

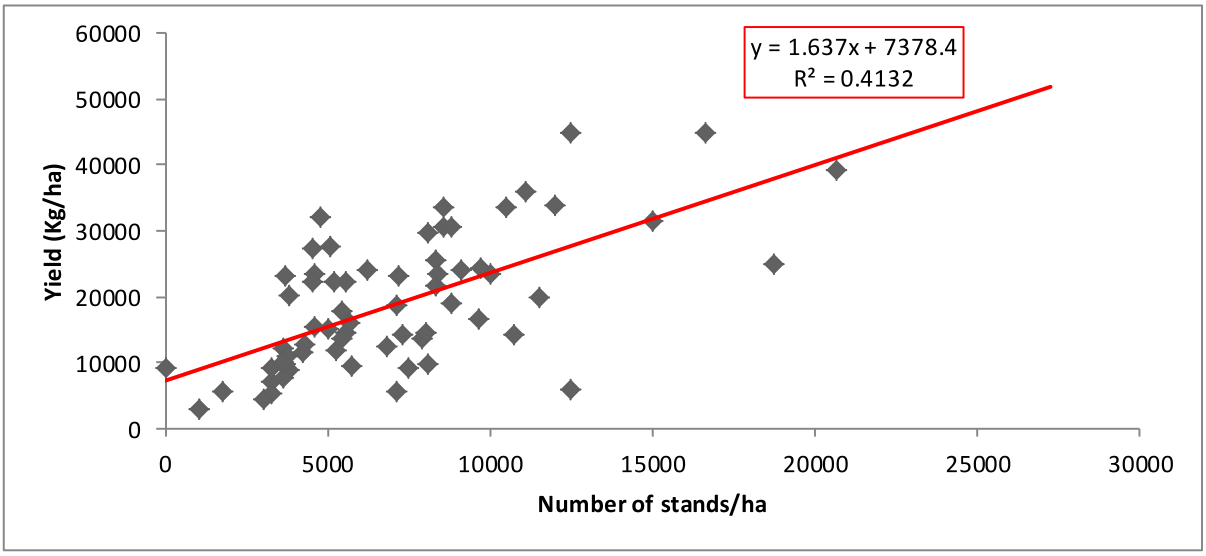

Figure 6. Nigeria and Ghana: Relationship between yam yield (tons/ha) and yam stand density (stands/ha), 2013.
Source: YIIFSWA Complementary Baseline Survey.

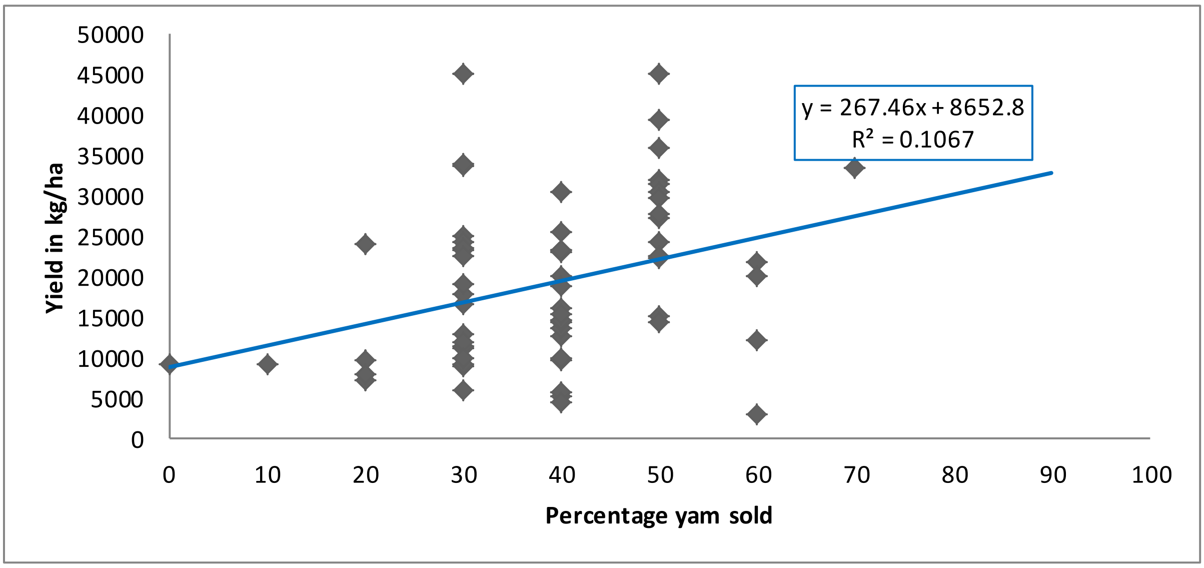

Figure 7. Nigeria and Ghana: Relationship between yam yield (t/ha) and percentage of yam harvested designated for sale, 2013.
Source: YIIFSWA Complementary Baseline Survey.

In separate Nigeria estimates, fertilizer use is significantly correlated with yield at about 5% probability level in the purchased input equation, the coefficient is positive. Yam stand density is significantly correlated with the yield at a high probability level in the agronomic practices and combined variables equations, the coefficients are positive in both equations. The coefficient of percentage of yam harvest designated for sale is significant at less than 10% in the market equation, the coefficient is positive.

Discussion

The statistics estimates for yam stand density, staking, and fertilizer application in the various equations highlight the strong positive effect improved agronomic practices could produce on yam yield. The negative sign of the coefficient of staking is environmentally determined; staking is less elaborate in derived savanna where yield is higher than in the southern Guinea savanna. Other important agronomic practices in terms of effect on yield include size of seed yam planted which is not specified because the survey was conducted at harvest and soil fertility level which was not assessed because of the limited objective of the survey. The survey was conducted to provide baseline information for impact assessment of ongoing R&D measures being implemented by IITA in collaboration with national and other international R&D agencies in West Africa. In future the impact of the R&D measures will be assessed by repeating the survey in the same soil environments.

The unexpected statistics estimated for some key market variables such as hired weeding labor and rented or purchased farmland reflect a number of real data situations, especially low variability in the data. The situation is that either the input was used in a disproportionately large number of the fields as is the case with hired weeding labor or the input was used in equally disproportionately low percentage of the fields as is the case with rented or purchased farmland. The unexpected estimates for purchased seed yam are for a different reason, namely purchased seed yam is not necessarily superior to own-produced ones because as already explained, the informal seed yam system in West Africa though market driven does not deliver quality or sufficient seed yam in the market. But percentage of yam harvest designated for sale reveals proper and expected statistics to show that production for market indeed has positive effect on yam yield.

Summary

Within the limits of data available, clearly yam production responds, in terms of yield and area expansion, to market factors including use of purchased inputs and hired labor in particular. For this reason, improvement in farmer access to the inputs which they purchase will help expand yam production. Most importantly, development and diffusion of labor-saving technologies, especially for seedbed preparation and weeding, is called for because of the increasing scarcity and wages of hired labor. But agronomic practices such as the yam stand density and staking where appropriate are more powerful determinants of the yield than market factors. This conclusion underlines the need for development of improved yam agronomic practices including changing the universal yam seedbed type, namely mounds to perhaps ridges in order to accommodate higher yam stand density. However, measures to accomplish this change should be preceded by agronomic studies aimed at understanding farmers' rationale for planting yam in mounds.

5. Yam Production for Sale

Proportion of yam production designated for sale

The yam sales information is based on farmer estimates of how they planned to use yam in the field when harvested. To facilitate the estimation process, the information was solicited on a field-by-field basis. Each farmer was asked how many out of 10 portions of total yam in the field he or she planned to sell for each of his or her yam fields. This represents the yam planted purposely for sale and not surplus over consumption needs.

The result shows that about 60% of yam harvested after discounting for seed was designated for sale, average for both Nigeria and Ghana. The farmers' estimates of the number of portions of yam they planned to sale varied from a minimum of about 30% in Nigeria to a maximum of 90% which was in Ghana. The mean was about equal in Nigeria, 58% and Ghana, 60% (Table 19). There was no field in the survey where a percentage of yam harvest was not designated for sale.

Table 19. Nigeria and Ghana: Percentage of yam harvest designated for sale (tons/ha) by country, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Statistics	Nigeria	Ghana
No. of observations	40	21
	Percentage	
Mean	58.2	59.9
Min.	28.3	42.9
Max.	80.0	90.0
Std. Dev.	12.36	12.25

Determinants of percentage of yam harvest designated for sale

The determinants of the proportion of yam harvest designated for sale is identified in a regression analysis, the procedure is as follows:

Theoretical models

The proportion of the yam per field planted for sale has an upper and lower limit of 100% and zero, respectively. The distribution of this variable shows that a substantial number of the fields (25%) assumed the lower limit of zero while a small number (4%) assumed the upper limit of 100. The Tobit model is an appropriate framework for identifying, in a regression analysis, the determinants of a variable so distributed (Akinola 1987; Greene 2003). The Tobit model (Tobin 1958) has been widely used in analyses of farmer technology adoption decisions (Akinola and Young 1985; Kothari 2004; Greene 2003).

The theoretical framework of the Tobit model can be explained by the threshold concept. The decision to sell may be characterized as a dichotomous choice between two mutually exclusive alternatives. This implies that there is a "break point" in the dimension of the explanatory variables below which a stimulus elicits no observable response. Only when the strength of the stimulus exceeds the threshold level does a reaction occur and the second decision on the proportion to sell is taken.

Let Y denote a decision variable which is the dependent variable and X a vector of explanatory variables. Y takes on two values, $Y = y^*$ if the decision results in a sale, and $Y = 0$ if it results in home use. At values of X greater than the break point there is a probability of I for sale; the proportion sold, represented by y*, is continuous. At values of X below or equal to the break point, the probability of sale is zero and proportion sold is zero.

The stochastic model of the analysis is as follows:

$$Y_i = Y_i^* = X_i'\beta + \varepsilon_i \text{ if } X_i'\beta + \varepsilon_i > T \qquad \text{...... Eqn. V-1}$$

$$= 0 \text{ if } X_i'\beta + \varepsilon_i < T$$

i = 1, 2, …, N

Where:

N is the number of fields, Y_i is the proportion sold variable, X_i is a vector of explanatory variables, β_i is a vector of' unknown coefficients, T is the threshold point, and β_i is an independently distributed error term assumed to be distributed N (0, σ^2).

To interpret the dependent variable as the probability of making a choice, some notion of probability is used as the basis of the transformation. The process translates the values of the X_i into a probability which ranges in value from 0 to 1. For the transformation to maintain the property, increases in X_i are associated with increases (or decreases) in the dependent variable for all values of X_i, the standard cumulative normal distribution of $X'\beta$ is used. It is given by:

$$F(X'\beta) = \int_{-\infty}^{X_i'\beta} \frac{1}{\sqrt{2\pi}} e^{\frac{-s^2}{2}} ds \qquad \text{.... Eqn V-2}$$

Where:

s is a random variable which is normally distributed with mean zero and unit variance.
To estimate the parameter, β a maximum likelihood method is applied.

To estimate the parameter "β" a maximum likelihood method is applied. In order to judge the appropriateness of the above specification, two alternative models are posited: the discrete choice (Probit) model and the continuous (OLS) model described earlier. For the discrete model, the proportion sold is assigned a value of one for all values above the break point..

Empirical model

The unit of analyses is the individual field; a smallholder household which grows a staple crop in multiple fields is unlikely to sell the crop from all its fields in equal proportions. The proportion of the crop from a field sold may depend on whether the field is owned by a male or a female household member; women are more often responsible for food expenditure in the households (IFPRI 2008). The proportion of the crop from a field sold could also depend on the use of purchased inputs in the field. Higher proportions would be sold from fields cultivated with purchased inputs than from fields cultivated with inputs generated internally from the household.

At the household level, the household size may influence the proportion of a crop sold. The characteristics of the household head such as level of formal education, age, and gender may influence the level of commercialization of a crop. In a village where marketing facilities such as link roads to urban market centers are easily accessible, farmers will be more commercially oriented in crop production than farmers in villages with poor access to urban market centers. These variables are as defined in Table 20.

Four variations of the empirical model are estimated: field, household, and village levels and an estimate based on a combination of all the variables. Labor is hired for all field operations at varying frequencies in yam production; it is more frequently hired for seedbed preparation and weeding than any other operation. For this reason, hired labor for the two operations is specified. Further, because of the overlap of use of hired labor for the two operations among the fields explained above, use of hired labor is specified in two separate field and combined variables equations, respectively, one for seedbed preparation and the other for weeding operation. The analyses are conducted with Nigeria data; Ghana data have a low degree of freedom and do not improve estimates when combined with Nigeria data.

Table 20. Definition of variables specified in the regression function of percentage of yam harvest designated for sale, 2013.
Source: YIIFSWA Complementary Baseline Survey

Variable	Unit or type	Explanation
Dependent variable		
PSALE	Percentage	Percentage of yam harvest designated for sale.
Field/purchased input variables		
FSIZE	Ha	Field size.
PLABOR	Binary	1 if hired labor was used for seedbed preparation, else 0.
WLABOR	Binary	1 if hired labor was used for weeding, else 0.
PSEED	Percentage	Percentage of seed planted was purchased.
PLAND	Binary	1 if land was rented or purchased, else 0.
YIELD	t/ha	Yam yield.
MMALE	Binary	1 if field is owned by men, else 0.
FMALE	Binary	1 if field is owned by women, else 0.
FAMILY	Binary	1 if field is jointly owned, else 0.
Household variables		
HHSIZE	Discrete	Number of household members.
AGEHH	Year	Age of head of the household.
EDUC	Discrete	Number of years of formal education of household head.
GENDA	Binary	1 if household head is male, else 0.
Market variables		
DISTURB	km	Distance to urban center.
VILMKT	Binary	1 if periodic market is in the village, else 0.
HFREST	Binary	1 if humid forest, else 0
DSAVA	Binary	1 if derived savanna, else 0

Empirical results

Field variables including the purchased input variables specified explained 6% in the seedbed preparation hired labor (Pseudo R^2 = 0.0584) and 7% in the weeding hired labor equations (Pseudo R^2 = 0.0681) of the probability of sale of yam. Household variables explained just 1% (Pseudo R^2 = 0.0134) and village market variables, 2% (Pseudo R^2 = 0.0235) of the probability of sale. The combined variables equation explained 13% (Pseudo R^2 = 0.1300) of the probability of sale in seedbed preparation hired labor and 15% (Pseudo R^2 = 0.1461) in the weeding hired labor equation (Table 21).

Table 21. Nigeria: Estimates of parameters of explanatory variables of percentage of yam harvest designated for sale, 2013.
Source: YIIFSWA Complementary Baseline Survey.

	Variable level			
Variable name	Field	Household	Market	Combined
Intercept	42.2201 (8.39)***	44.4947 (4.45)***	37.4311 (16.11)***	54.2094 (5.40)***
FSIZE	1.1052 (1.91)*	–	–	0.7809 (1.43)
WLABOR	8.8839 (2.01)**	–	–	9.2293 (2.20)**
PSEED	–0.1133 (–3.38)**	–	–	–0.1459 (–5.03)***
PLAND	–8.7654 (2.76)**	–	–	–8.6409 (2.77)***
YIELD	0.0001 (0.77)	–	–	0.0002 (2.19)**
MMALE	–4.1621 (–1.21)	–	–	–4.3974 (–1.52)
FAMILY	–3.1449 (0.53)	–	–	–7.8109 (–1.54)
HHSIZE	–	–0.0897 (–0.84)	–	–0.1835 (–2.27)**
EDUC	–	–0.6526 (–1.52)	–	–5214 (1.37)
GENDA	–	5.6635 (0.59)	–	4.0662 (0.61)
DISTURD	–	–	0.6388 (2.43)**	0.0034 (0.01)
VILMKT	–	–	–0.4738 (–0.71)	–0.5181 (–1.01)
Statistics				
No. of obs.	39	40	37	37
Chi^2	19.62	3.95	6.45	40.08
Prob.>Chi^2	0.0065	0.4128	0.0397	0.0002
Pseudo R^2	0.0681	0.0134	0.0235	0.1461

Notes: Figures in parentheses are t-ratios in the case of Linear and z-ratios in the cases of Logit models. ***denotes $P \leq 0.01$, ***denotes 0.01 ≤$P \leq 0.05$, and * denotes 0.05 ≤ $P \leq 0.10$.

The coefficients of purchased inputs specified in the field variable equation are significant at high probability levels, especially in the weeding hired labor equation; probability levels vary from 0 to 5%. No coefficient of the variables specified in the household equation is significant at less than 10% probability level. In the village level market equation, the coefficient of distance to urban markets is significant at 2% probability level.

The coefficients of hired seedbed preparation and weeding labor are positive in their respective field level equations; the coefficients of percentage of seed yam purchased and rented or purchased farmland are negative in both the seedbed preparation and weeding hire labor equations. The coefficient of the ownership of yam in the field by male household members is negative in relation to joint, family-owned fields in both the seedbed preparation and weeding hired labor equations but the coefficient of female-owned fields is positive in relation to female-owned yam fields in the seedbed preparation equation but negative in the weeding hired labor equation. In both equations, the coefficient of female-owned yam fields is larger than that of male-owned fields. The coefficients of field size and yam yield per hectare are positive in both the seedbed preparation and weeding hired labor equations.

In the household variables equation, the coefficient of male head of household is positive in relation to that of female household head. In the village level market equation, the coefficient of distance to urban market centers is positive while that of frequency of village market is negative.

In the combined variables equations coefficients of more variables become significant at less than 10% probability levels, some are highly significant, especially in the weeding hired labor equation. For example, in the weeding hired labor equation, the coefficients of all the purchased inputs, namely weeding hired labor, percentage of seed yam purchased, rented or purchased farmland and fertilizer are significant at less than 10% probability levels. In addition, the coefficients of field size, yam yield per hectare, and age of household head are also significant at less than 10% probability levels. The coefficient of distance to urban market centers and frequency of village markets are not significant at 10% probability level.

In the combined variables weeding hired labor equation, weeding hired labor is positively correlated with the probability of sale of yam while percentage of seed yam purchased, rented or purchased farmland and fertilizer are negatively correlated with the probability of the sale (Table 21). The coefficient of the field ownership by a male household member is higher than that of ownership by a female household member. The coefficients of field size and yield are positively correlated with the probability of sale of yam. The coefficient of distance to urban market centers is positive and that of frequency of village market is negative.

Discussion

The above statistical analyses provide clear evidence of a strong positive relationship between yam production for sale and production with purchased inputs; farmers who produce for sale purchase production inputs and obtain higher yields than farmers who produce more for home consumption (Fig. 8).

This suggests that the more commercial yam producers are more efficient in terms of yield achieved, than non-commercial producers. Larger scale farmers produce proportionately more for sale than smaller farmers (Fig. 9).

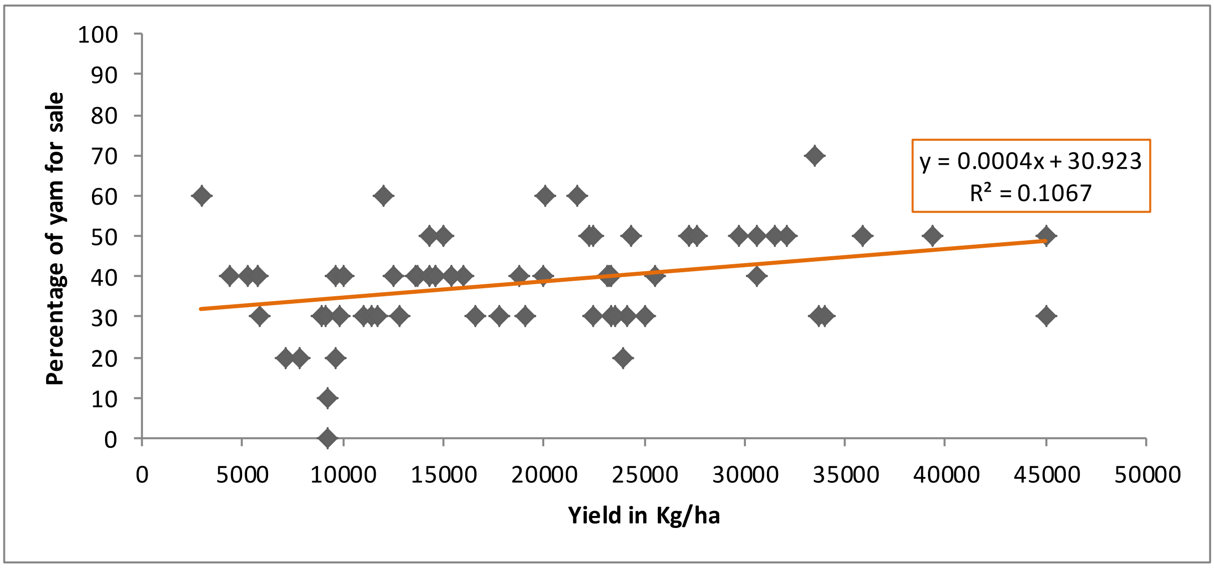

Figure 8. Nigeria and Ghana: Relationship between percentage of yam harvest designated for sale and yield (kg/ha), 2013.
Source: YIIFSWA Complementary Baseline Survey.

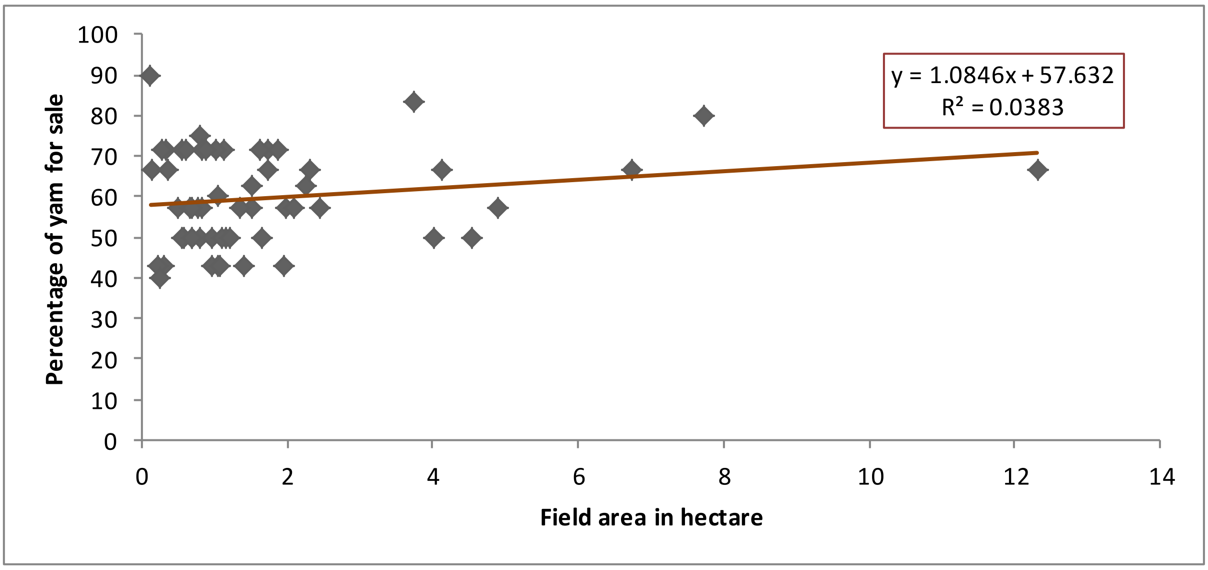

Figure 9. Nigeria and Ghana: Relationship between percentage of yam harvest designated for sale and field size, 2013.
Source: YIIFSWA Complementary Baseline Survey.

Men produce proportionately more for sale than women and male-headed households produce proportionately more for sale than female-headed households. Farmers in villages further from urban market centers or in less populated zones produce proportionately more for sale than farmers in villages closer to urban market centers or those in more populated areas, although the difference is not statistically significant. Because of the requirement for virgin land, yam production is concentrated in areas remote from urban centers and in less densely populated zones.

Summary

In both Nigeria and Ghana yam is produced more for sale than for home consumption. Production for sale is more common in areas remote from urban market centers and in less populated zones than in areas close to urban market centers and in more populated zones because of the yam's production requirement for virgin land. Men and male-headed households produce proportionately more for sale than women and female-headed households. Farmers who produce with various purchased inputs such as seed yam, rented or purchased farmland, chemical fertilizer and herbicides, and mechanical and mechanized vehicles for field-to-home transportation, and especially hired labor for seedbed preparation and weeding sell proportionately more yam than farmers who rely mostly on family supplies of those production inputs. Farmers surveyed reported that they stored yam for sale during the planting season to pay for hired labor for seedbed preparation and weeding. Farm management study is needed to assess how much of the cash proceed from sales of yam is left after paying hired labor. A casual observation during the survey suggests that farmers work hard but their level of living is low.

6. Synthesis

Overview of this working paper

This working paper is presented in six sections; Section I is the introduction. Section II is a discussion of the contexts in which yam is produced in Nigeria and Ghana. Section III demonstrates that yam is widely produced with a range of purchased inputs such as hired labor, seed yam, and farm chemicals. Section IV shows that yam responds positively in terms of land area and yield to the application of the various purchased inputs. Section V estimates how much of the yam harvest the farmer designates for sale.

Yam production contexts in Nigeria and Ghana

Most yam is produced in villages remote from urban centers especially in Ghana with limited health, sanitation, educational, farm input, etc. facilities. Young men are among heads of yam producing households because of family traditional obligations or lack of exposure to urban employment opportunities. The mainline yam farmers have zero or little formal education. All these have negative implications for progress toward improvement of the yam food sector.

Yam is produced with low technologies for labor saving, seed production, and yam pest and disease control. But among the most critical constraint to yam production in Ghana is shifting cultivation which exposes the farmers to unproductive and tortuous commutation between home and yam fields. Although some men are able to accomplish on-farm transportation through forest tracks by bicycles and motor bicycles, women commute on foot on daily bases with head loads of firewood and crops over the long-distant bush tracks. The practice of shifting cultivation which is rooted in the farmers' continuous search for fertile land, low yam pest and diseases incidence, and stake trees have negative implications for environmental degradation.

In both Nigeria and Ghana, yam is grown on mound seedbeds which vary in size in Nigeria depending on soil depth. The near uniform size of yam mounds in all the surveyed villages in Ghana results in poor yam tuber shape in some areas where the soil is not deep enough. Making of the yam mounds is laborious and backbreaking. The difficulty of finding sufficient seasonal migrant hired labor for yam mound making is one of the biggest constraints to yam production expansion in both Nigeria and Ghana. Other critical constraints are the yam pest and diseases problems and high cost, scarcity, and low quality of seed yam.

Yam is widely produced with purchased inputs, especially seed yam and hired labor; chemical fertilizer, herbicide, and pesticides are used but not commonly. As much as 60% of yam harvested after discounting for seed yam is sold and 40% is consumed at home. These observations constitute indisputable evidence that yam is produced as a cash crop in West Africa.

Numerous differences in yam production practices between Nigeria and Ghana suggest that the potential for improvement in yam production through information exchange between the two countries is high. Such information could be generated through comparative analyses of differences in yam production practices between the two countries and disseminated through farmer-to-farmer extension methods by exchange visits by yam producers between the two countries.

Yam production with purchased inputs

Yam is widely produced with a range of purchased inputs depending on need of the farmer to supplement family supplies, on farmer access to the inputs, and on the farmer's assessment of the value of the purchased input in yam production. Among inputs purchased by the yam producers, the frequency of use of purchased or rented farmland is the lowest; the reason is that farmers' need to supplement family supplies is low because, compared with other inputs farmland is widely available from family sources. Most of the farmers use less purchased than own-produced seed yam because purchased seed yam is not necessarily superior in quality than own-produced ones and seed yam is not always available in the market in sufficient quantities.

Hired labor is the most frequently used purchased input in yam production among the farmers surveyed because family supplies are too low compared with need. In addition, hired labor, though expensive, is available locally; the survey reveals that the hired labor of the surveyed villages was 45% from within their areas and 55% from outside their areas. But even the hired labor that come from outside the community are also accessible locally because they come as seasonal migrants and reside in the area through the crop season.

The extensive use of purchased inputs which are in short supply from family sources and which are accessible to the farmers is convincing evidence that yam is produced as a cash crop in West Africa. This conclusion is based on the fact that farmers invest cash in the production of commodities which are expected to yield cash in return.

Analyses of determinants of use of purchased inputs in yam production reveals three serious impediments to yam production expansion, namely, the increasing shortage and high cost of hired labor, shortage of suitable land for yam production, and poor farm roads. These impediments call for development and diffusion of labor-saving and pest and diseases control technologies in yam production; the impediments also call for improvement in farm roads. Under the present expansion of employment opportunities for unskilled labor in urban centers yam production expansion will be hard to achieve without labor-saving technologies for at least some of the yam production tasks including seedbed preparation and weeding, and without improvement in farm roads. Effective yam pest and diseases control technologies will permit yam production under intensive methods and reduce farmers' need to search for virgin lands for cultivation of the crop.

Yam response to production with purchased inputs

Clearly yam production responds, in terms of yield and area expansion, to market factors including use of purchased inputs. For this reason, improvement in farmer access to the inputs which they purchase will help expand yam production. Most importantly, development and diffusion of labor-saving technologies, especially for seedbed preparation and weeding, is called for because of the increasing scarcity and wages of hired labor. Agronomic practices such as the yam stand density are as powerful determinants of yam yields as market factors. This conclusion underlines the need for development of improved yam agronomic practices including changing the universal yam seedbed type, namely mounds to perhaps ridges in order to accommodate higher yam stand density. Measures to accomplish this change should be preceded by agronomic studies aimed at understanding farmers' rationale for planting yam in mounds.

Yam production for sale

In both Nigeria and Ghana yam is produced more for sale than for home consumption. Production for sale is more common in areas remote from urban market centers and in less populated zones than in areas close to urban market centers and in more populated zones because of the yam's production requirement for virgin land. Farmers who produce with various purchased inputs especially hired labor sell proportionately more yam than farmers who rely mostly on family supplies of those production inputs. Farmers surveyed reported that they stored yam to sell during planting season to pay for hired labor for seedbed preparation and weeding. Farm management study is needed to assess how much of the cash proceed from sales of yam is left after paying hired labor. Casual observation during the survey suggests that farmers work hard but their level of living is low.

Key takeaways

What are the key takeaways from this working paper? Current yam production does not use technologies in terms of pest and disease control, and labor-saving and agronomic practices especially the mound seedbed type.

Yam is produced more for sale than for home consumption; in both Nigeria and Ghana 60% of harvest, after discounting for seed, is sold and only 40% is consumed in the farmers' households. The crop attracts a high price in the urban markets because it is patronized by high-income consumers. Producers work hard to produce so much yam, yet they live in penury. There is problem at the level of outlet for yam from the farm to urban markets. Policy interventions are needed to change the unfair situation; the first step is to empirically assess the marketing situation to determine if the yam traders are enriched by the context which impoverishes the farmers and to identify measures which if implemented will enable all participants in the yam value chain, the producers as well as the traders, to be equitably compensated for their efforts.

Yam is widely produced with purchased inputs, especially hired labor. But high and increasing farm wages and scarcity of hired labor constitute a critical impediment for yam production expansion. Farmers surveyed reported that they stored yam to sell during planting season to pay high for hired labor for seedbed preparation and weeding. A farm management study is needed to assess how much of the cash proceed from sales of yam is left after paying hired labor. The hired labor situation calls for investment in measures to develop mechanical labor-saving technologies and to change certain labor-intensive agronomic practices such as the mound seedbed type.

Yam responds positively to the application of purchased inputs in terms of yield and land area expansion, which shows that the potential for improvement is high if R and D measures are implemented to improve production technologies. It shows that farmers will readily adopt new yam production technologies which can solve felt needs and drive down production costs.

The potential for improvement in yam production through information exchange between Nigeria and Ghana is high. Such information could be generated through comparative analyses of differences in yam production practices between the two countries and disseminated through exchange visits between yam producers of the two countries in the form of farmer-to-famer extension methods. .

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