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Article

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*Corresponding author: Jonas Osei-Adu CSIR-Crops Research Institute (CRI), 3785, Ghana
E-mail: aduseiz@yahoo.co.uk

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Profitability of positive selection technique for seed yam production in Ghana and Nigeria

Jonas Osei-Adu^{1,2*}, Robert Aidoo, Simon Cudjoe Fialor, Stella Ama Ennin², Kingsley Osei² and Bright Owusu Asante

Abstract: Over the years, the traditional seed system has failed to deliver quality seed yam for propagation. This is due to the high incidence and severity of the yam mosaic virus leading to yield losses of 52.6%–65.4%. The Positive Selection (PS) technique has shown promise as a possible mitigation measure. This study was therefore aimed at evaluating the profitability of seed-yam production through the use of PS technique as a viral mitigation measure. Three hundred and sixty-eight (368) seed yam farmers across Ghana and Nigeria were sampled. Profitability was determined using Return on Investment (ROI) and Benefit Cost Ratio (BCR) analysis. Regression analysis was applied for the determinants. Result from this study indicates that seed yam production is more profitable when the effect of the yam mosaic virus is mitigated using PS technique with a net return of US\$ 3,417.98/ha compared to US\$ 1,795.58/ha for non-use. This implies the use of PS technique can increase seed yam profitability by 26.69%. Sex, farmer experience in yam production, education, migration status, extension contact, off-farm income and use of PS technique were significant determinants of profitability. It is therefore

ABOUT THE AUTHOR

Robert Read Reviewing editor Jonas Osei-Adu is a Senior Research Scientist (Agricultural Economist, Monitoring, Evaluation and Learning Consultant) with a PhD in Agricultural Economics. Dr. Osei-Adu has over 13 years experience as a research and development practitioner in the area of Agricultural Research, Project Management, Monitoring, Evaluation and Learning (MEL), Agribusiness Development and Agricultural Innovation Systems. Dr. Osei-Adu has 54 publications (16 refereed journal papers, 16 technical reports, 10 conference papers, 9 posters and 3 production guides) to his credit and currently the Coordinator for the USAID funded CORAF-PAIRED project, Agricultural Productivity Technology Centre (APTC), Dr. Osei-Adu was the Leader for Management M&E for the CAY -Seed project in Ghana and Nigeria, MEL Officer for the USAID funded Feed the Future projects at CSIR-CRI, African Development Bank (AfDB) funded Support for Agricultural Research for the Development of Strategic Crops (SARD_SC) in Africa project and AfDB funded Dissemination of New Agricultural Technologies in Africa (DONATA) project.

PUBLIC INTEREST STATEMENT

Positive Selection as viral mitigation measure is highly profitable in seed yam production with a net return of US\$ 3,417.98/ha when combined with planting on ridges, the use of minisetts and application of neem powder. This provides some level of evidence for the intense promotion of the technique for quality seed yam production to overcome the challenges of the traditional seed systems. The tradition seed system over the years have failed to deliver quality seed yam for propagation. This has been due to the high incidence and severity of the yam mosaic virus leading to yield losses of 52.6%–65.4% explain the high levels of poverty among smallholder yam farmers.

recommended that the PS technique be widely disseminated as a mitigation strategy for the control of the yam mosaic virus disease.

Subjects: Agriculture; Agricultural Development; Agricultural Economics

Keywords: Positive selection; Profitability; Returns; Investment and Seed Yam

1. Introduction

Yam is an important food and cash crop in West Africa and provides livelihood to over 60 million people in the region (Djana et al., 2014). About 95% of the global yam supply originates from Benin, Côte d'Ivoire, Ghana, Nigeria and Togo. Yam as a crop is traditionally propagated by seed or sett (tuber portion; Aighewi et al., 2015). According to Maroya et al. (2014), yam in the traditional system is propagated mainly from tubers, which has a number of challenges such as; high incidence of pest and disease and low propagation rate.

Three main seed systems exist for yam production in West Africa, namely, the traditional, formal and an integration of the traditional and formal systems. The traditional seed system relies heavily on the farmer-saved seed and is by far the most important source of seed in most farming systems of the world (Almekinders & Louwaars, 2002). The traditional seed system for yam involves selecting small whole tubers from a ware yam (double harvesting) and cutting ware tubers into setts (Aighewi et al., 2015). Maroya et al. (2014) found the production of seed yam to be an integral part of ware-yam production in the yam belts of Nigeria and Ghana. Tripp (2001) also reported that farmers were the major source of seed in most countries with weak formal seed systems.

Seed yam produced under the traditional system is normally affected by several pathogens, including viruses, nematodes and bacteria. According to Aihembhor et al. (2017), the build-up of diseases can cause up to 80% yield reduction in yam. They further indicated that the Yam Mosaic Virus (YMV) was the most economically important yam virus that reduced tuber yield and quality. These challenges create scarcity of quality seed yam, making it expensive as it accounts for about 50% of the production cost (Oguntade et al., 2011).

Farmers' continuous reliance on the traditional seed system for seed yam in Ghana and Nigeria has led to low productivity of ware yam as a result of the poor seed quality. In addition, seed multiplication rate is low under the traditional system, where one tuber produces only one ware tuber and at most three tubers, without accounting for losses. This situation is exacerbated by the long growth cycle of yam and the long dormancy period. Despite the numerous improved production technologies promoted by research institutions and extension agents, the poor-quality seeds used by yam farmers in West Africa make farmers vulnerable and financially insecure.

The Community Action in improving Farmer Saved Seed Yam (CAY-Seed) project, initiated in 2015, was therefore a direct response to the challenges of the traditional seed yam system to improve yield and the financial situation of yam farmers. The project was aimed at testing the effectiveness of the PS technique, together with other improved production practices for quality seed-yam production in Ghana and Nigeria.

PS technique is the process of consciously identifying and marking, by means of tagging or pegging, healthy yam plants to be harvested as seed. De Bokx and Van der Want (1987) described it as a technique used in formal seed-potato multiplication to select mother plants from the best plot of potatoes. Kinyua et al. (2001) noted that through PS technique, producers were able to identify healthy-looking plants in the field to be harvested later for seed for the next cropping season.

The practice of positive selection is an old age tradition but limited in terms of scale. Its use in potato became widespread through an action research by the International Potato Centre (CIP). Potato farmers in Kenya were faced with low yields due to the use of farmer saved potato seeds

which were of poor quality. Farmer saved seeds were often diseased causing significant yield reduction when used as mother plants. Through action research using an integrated-on farm trial approach, significant yield increases were achieved for ware potato production using mother plants from positive selection. According to Gilsemacher et al. (2012), PS technique plots gave an average yield of 14.2 t/ha which was significantly higher than the 11.8 t/ha for farmer saved seed. Its use in yam production however is limited by very few publications.

Aihebhor et al. (2017) published “The response of white yam (*Dioscorea rotundata* Poir) tuber portions to positive selection for quality seed yam” which was based on an Msc thesis at the University of Ibadan, Nigeria. Balogun et al. (2017) also published the “Relative efficiency of positive selection and tissue culture for generating pathogen-free planting materials of yam”. Both papers demonstrated the ability of the PS technique to reduce pest and disease incidence and severity for yield improvement. According to Aihebor et al. (2017), yields from positively selected plants were higher and statistically significant from non-positive selected plants. For the first cycle of planting, positively selected plants gave a yield of 6.03 t/ha compared to 4.99 t/ha for Non-PS plants. For the second cycle of planting, the PS plants gave a yield of 7.05 t/ha and the Non-PS with 5.25 t/ha. This confirms the findings of Gilsemacher et al. (2012), who noted that a continuous practice of positive selection can further improve yields. Yield improvements from positive selection are as result of its ability to reduce disease incidence and severity.

PS as a technique requires additional resources in the form of labor for identification, tagging and periodic monitoring of plants before tubers are eventually harvested. This has the tendency to increase production cost. Farmers as rational economic beings will only adopt this technique if the returns from using PS technique in the form of profit is higher than the extra cost. Unfortunately, empirical evidence on the profitability of PS in yam production is non-existence. The objective of this study was therefore to evaluate the profitability of seed-yam production under PS technique in Ghana and Nigeria using primary data from farmers’ fields.

2. Materials and methods

2.1. Study area and design

This study was conducted within selected communities in Ghana and Nigeria, where the CAY-seed project was implemented using the Randomized Control Trial (RCT) design. That is thirty (30) farmer-managed trials were established per community within 16 communities in Ghana and Nigeria leading to a total of 480 trials for both countries. Eight communities in Ghana and Nigeria were assigned *PS technique*, planting on ridges, use of minisett technique and neem powder application to constitute the treatment communities. Similarly, another set of eight communities in Ghana and Nigeria with similar characteristics like the treatment communities were assigned planting on ridges, use of minisett technique and neem powder application (Control) except PS technique that was the difference between the treatment and control communities. Therefore, any difference in yield between the treatment and control can be attributed to the use of PS technique since that was the only difference between the two groups.

Project communities in Nigeria, were within the Bwari and Kwali Local Area Councils in the Abuja Federal Capital Territory (FCT). Communities within Ghana, on the other hand, were within the Ejura Sekyeredumasi and Atebubu Amantin municipalities, where farmers were exposed to the PS technique and other agronomic practices.

The coordinates of the Ejura Sekyeredumasi municipality in Ghana are: longitude 1°5' W and 1°39' W and latitude 7°9' N and 7°36' N, with Ejura as the administrative capital; and those of Atebubu Amantin municipality, also in Ghana, are: longitude 0°30' W and 1°26' W, latitude 7°23' N and 8°22' N, with Atebubu as the capital. The coordinates of Bwari local area council in Nigeria are: latitude 9°26' N and longitude 7°44' W, whereas those of Kwali local area council are as

follows: 8° 11' latitude N and longitude 7° 08' W. **Figures 1 and 2** represent the maps of the study areas in Ghana and Nigeria, respectively.

2.2. Sampling

The 480 yam farmers within 16 communities in Ghana and Nigeria, who were exposed to the PS technique and other agronomic practices, formed the study population. The sample for the study was drawn from both PS and Non-PS (control) communities. Applying the sample size determination formulae given in Yamane (1967), the minimum required sample was 218 farmers, who were exposed to the PS and other agronomic practices. However, Salkind (1997) proposed oversampling by 40–60% to account for low response rate and uncooperative subjects. Taking this into account, 368 farmers (186 from PS technique and 182 Non-PS technique communities) were sampled. The response rate was 89.67%, which was higher than the 60% desirable response rate proposed by Baruch (1999).

The study sample was achieved using the multistage-sampling procedure. The 1st stage was the purposive selection of Ghana and Nigeria, where the CAY seed project had been implemented. The 2nd stage was a census of two project districts and FCTs in Ghana and Nigeria, respectively. The 3rd stage also was a census of 16 project communities across Ghana and Nigeria, with the final stage being the simple random sampling of 23 beneficiaries of the CAY seed project within project communities. The simple random sampling was undertaken using the Excel randomization function based on a project beneficiary list obtained from the CAY seed project.

2.3. Data, variables, and analyses

Data were collected through a formal survey conducted in Ghana and Nigeria using a standardized structured questionnaire. Profitability was determined such that

$$NRI = NFI/TC \quad (1)$$

where NRI = net return on investment, NFI (US \$) = net farm income from seed yam, and TC (US \$) = total cost of seed yam production. NFI and TC were determined via [Equations 2 and 3](#), respectively:

$$NFI = GM - TFC \quad (2)$$

Figure 1. Map of Ghana showing the study area.

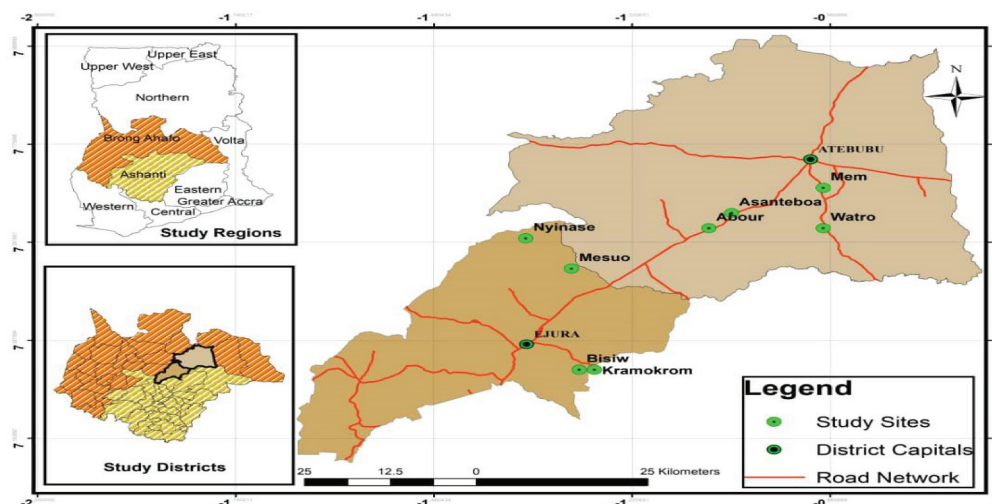
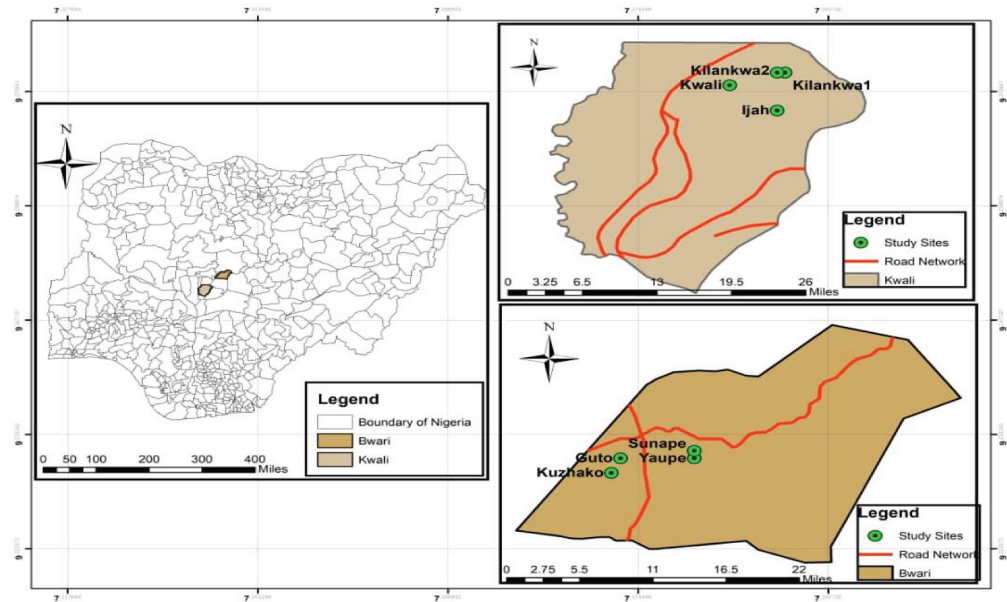


Figure 2. Map of Nigeria showing the study area.



$$TC = TVC + TFC \quad (3)$$

where GM (US \$) = the gross margin from seed-yam production, TFC (US \$) = total fixed cost of seed-yam production, and TVC (US \$) = total variable cost of seed-yam production. GM was determined via Eq. (4) given below:

$$GM = TR - TVC \quad (4)$$

where TR (US \$) = total revenue from seed yam (defined as the product of the quantity (t/ha) produced (Q) and the price (P) of seed yam (US \$) (see below)):

$$TR = Q \times P \quad (5)$$

Profitability determinants were estimated using linear regression analysis. A linear regression model was specified and estimated such that

$$NFI = \beta + Sex + Exp + Educ + Hlabor + Off - farm + PS + \varepsilon$$

where NFI (Net Farm Income) was the dependent variable measured as the difference between total revenue and total cost (which is the difference between gross margin and total fixed cost). The explanatory variables for the model were: Sex measured as a dummy variable (1 = Male, 0 = if otherwise); Exp = experience, measured as number of years in yam production; Educ = educational level of the farmer, measured as number of years in school; Hlabor = use of household labor, measured as the proportion of household size in youthful age bracket; off-farm = off-farm income, measured as a dummy variable (1 = if respondent is involved in off-farm income generating activities, 0 = if otherwise); the amount of income generated from off-farm activities; PS = positive selection, measured as a dummy variable (1 = if respondent was introduced to PS, 0 = if otherwise); and ε = residual.

Table 1. Frequency distribution of farmer characteristics												
Variable ²	Ghana					Nigeria					ALL	
	PS [†]		Non-PS ^{††}		PS	Non-PS		PS	Non-PS	PS	Non-PS	
	Freq	%	Freq	%		Freq	%		Freq		Freq	%
Sex												
Male	58	66.7	51	64.6	57	71.3	50	59.5	115	68.9	101	62
Female	29	33.3	28	35.4	23	28.8	34	40.5	52	31.1	62	38
Level of Education												
None	41	47.1	49	62	18	22.5	10	11.9	59	35.3	59	36.2
Basic	37	42.5	22	27.8	29	36.3	36	42.9	66	39.5	58	35.6
Quranic	0	0	0	0	1	1.3	1	1.2	1	0.6	1	0.6
Secondary	7	8	7	8.9	22	27.5	25	29.8	29	17.4	32	19.6
Tertiary	2	2.3	1	1.3	10	12.5	12	14.3	12	7.2	13	8
Primary Occupation												
Farmer	87	100	79	100	68	85	70	83.3	155	92.8	149	91.4
Traders	0	0	0	0	3	3.8	7	8.3	3	1.8	7	4.3
Civil Servants	0	0	0	0	4	5	3	3.6	4	2.4	3	1.8
Craft	0	0	0	0	5	6.3	4	4.8	5	3	4	2.5
Nativity												
Natives	46	52.9	57	72.2	67	83.8	75	89.3	113	67.7	132	81
Non-natives	41	47.1	22	27.8	13	16.3	9	10.7	54	32.3	31	19

Source: Field survey, 2018

To ensure effective comparison between Ghana and Nigeria, Cost and price data is normalized using the United States Dollars (USD). That is all cost and price data is converted into USD as a common currency factor. Socio demographic and farm level data is sample from the CAY-seed project were farmers at baseline had similar characteristics and were exposure to the same techniques. This therefore makes the samples (Ghana and Nigeria) comparable.

3. Results and discussion

3.1. Socio demographic and descriptive characteristics

Yam production in Nigeria and Ghana were male-dominated, such that 68.9% and 62% of the farmers in PS and Non-PS technique communities, respectively, were males (Table 1). Access to basic education was 39.5% and 35.6% for PS and Non-PS technique communities, respectively (Table 1). Yam production was the primary occupation for Ghana. However, Nigeria had 6.3% and 8.3% of farmers engaged in craft and petty trading as their primary occupation, respectively, and undertook yam production as a secondary occupation (Table 1). Farmers in Ghana would need to be encouraged and supported to explore secondary sources of income besides yam production. This should create income opportunities to acquire inputs for quality seed-yam production. Secondary sources of income should also serve as a mitigation strategy in times of crop failure and other disasters. Nigeria had more local community residents involved in the production process such that 83.8% and 89.3% of the PS and Non-PS technique communities, respectively, were resident in the locality (Table 1).

The primary source of farm income across communities was yam production, with 44.30% and 93.90% for PS and Non-PS technique communities, respectively (Table 1).

Household sizes within study communities were relatively large, such that Ghana on the average, had 8 persons/household and 9 persons/household for PS and Non-PS communities respectively (Table 2). Households provided labor for seed-yam production and that explains why households were relatively large. Yam-production experience was 18 and 19 years for Ghana and Nigeria, respectively. Farmers in Ghana and Nigeria had 7–8 extension visits per cropping season (Table 2). About 80.8% and 76.7% of farmers in PS and Non-PS technique communities, respectively, used their own seed for yam production.

Seed-yam output from PS-technique communities was significantly higher than that from Non-PS-technique communities (Table 3). Using PS technique, farmers could increase their output by 0.91 t/ha, which was statistically significant (Table 3). The same trend was observed within countries (Ghana and Nigeria), where output for PS-technique communities was higher than that for Non-PS-technique communities (Table 3). The country-level results also indicated that PS-technique communities in Nigeria had higher output (5.56 t/ha) than PS-technique communities in Ghana (5.12 t/ha). However, Non-PS-technique communities in Nigeria had a lower output (4.41 t/ha) relative to Non-PS-technique communities in Ghana (4.43 t/ha). This might be due to difference in socio economic and farm-level characteristics (Sex, experience, education, extension contact and migration status) of respondents.

The performance of PS-technique communities in both countries was attributable to the use of PS planting materials. These materials were relatively clean, reducing the viral load as compared with planting material from the open market. PS materials were treated with fungicides and insecticides before planting, which prevented attacks from pests and diseases. The soil was also treated with neem (*Azadirachta indica* A. Juss) leaf powder to overcome attack from nematodes. It is therefore clear from this study that combining PS technique with seed and soil treatments can prevent damage from pests and diseases in seed-yam production.

3.2. Production cost structure

Cost of seed, insecticides, fungicides, neem leaf powder and labor were the variable-cost items for seed-yam production in the study areas. TVC for PS-technique communities (US \$ 5,951.62/ha) was slightly higher than that for Non-PS-technique communities (US \$ 5,896.47/ha; Table 4). However,

Table 2. Descriptive statistics on farmer characteristics												
Variable ³	Ghana					Nigeria					ALL	
	PS ^t		Non-PS ^{tt}			PS		Non-PS			PS	
	Mean	SD ^{ae}	Mean	SD		Mean	SD	Mean	SD		Mean	SD
Education (years)	3	4.59	4	4.82		7	5.04	8	4.96		5	5.14
Household size (Number)	8	4.18	9	4.95		9	6.09	8	5.26		9	5.19
Experience (years)	18	12.54	19	13.28		19	11.99	19	11.36		19	12.27
Ware yam farm size (ha)	0.74	0.50	0.59	0.35		1.53	1.24	1.15	0.85		1.12	1.01
Extension contact (Number)	7	5.34	7	4.138		8	7.119	8	8.036		8	6.26

Source: Field survey, 2018

Table 3. Average output(t/ha) for treatment⁴

Location		N	Minimum	Maximum	Mean	SD ^{ae}
GHANA	PS [†]	87	2.88	7.27	5.12	0.98
	Non-PS ^{††}	79	1.33	7.11	4.43	1.04
NIGERIA	PS	80	3.76	7.50	5.56	0.99
	Non-PS	84	1.13	6.70	4.41	1.02
ALL	PS	167	2.88	7.50	5.33	1.01
	Non-PS	163	1.13	7.11	4.42	1.02

Source: Field Survey, 2018.

Table 4. Seed yam total variable costs (US\$/ha)

Cost Item ⁵	Ghana		Nigeria		ALL	
	PS [†]	Non-PS ^{††}	PS	Non-PS	PS	Non-PS
Seed	502.72	519.79	511.32	505.91	506.84	512.64
Insecticide	20.41	20.67	23.38	22.86	21.83	21.79
Fungicide	22.47	22.78	34.28	35.01	28.13	29.08
Neem powder	157.97	170.15	439.24	424.53	292.71	301.24
Labor	4945.99	5210.16	5271.90	4863.88	5102.11	5031.71
Total variable Costs (TVC)	5649.55^{NS}	5943.55	6280.11^{NS}	5852.18	5951.62^{NS}	5896.46

Source: Field Survey, 2018.

the difference was not statistically significant (Table 4). This was as a result of the insignificant effect of the extra labor required to undertake PS activities. Use of PS technique did not lead to an increase in production cost.

Cost of labor represented the largest component of TVC in both PS- and Non-PS-technique communities (Table 4). Cost of labor represented 85.73% and 85.33% in PS- and Non-PS-technique communities, respectively. The huge share of labor cost as part of TVC was as a result of the labor-intensive nature of the improved technologies introduced in both PS- and Non-PS-technique communities. All the communities sampled for the study were introduced to three main improved technologies, namely, planting on ridges, minisett technique and neem powder application. In addition, PS communities were introduced to the use of positive selection as a viral mitigation measure.

Construction of ridges was done manually, which added to labor requirement. The use of the minisett technique, which required manual cutting of setts into minisetts and the treatment of these minisetts, was also labor-intensive. Application of the neem-leaf powder involved the placing of 20 g of the neem leaf powder into holes for planting and covering of same to complete the planting process. Extra labor was required for farmers in PS-technique communities for virus identification, tagging and monitoring. The conduct of these activities contributed to the huge share of labor relative to TVC.

The cost of seed represented less than 9% of TVC (Table 5) which was lower than the 42% reported by Omojola (2014) and 50% reported by Oguntade et al. (2011). This low share of seed cost as part of TVC was attributable to the use of the minisett technique, where seed-yam setts were cut into 50 g each, contrary to the use of setts. According to Aighewi et al. (2015), at planting time, farmers in the traditional seed-yam system cut larger ware yams into tops, middle and bottom, weighing between 200 g and 500 g. However, for the 50-g-size minisetts, only 825 setts were required to produce 20,000

Table 5. Percentage distribution of TVCs

Variable Input ⁶	GHANA		NIGERIA		ALL	
	PS [†]	Non-PS ^{††}	PS	Non-PS	PS	Non-PS
Seed	8.90	8.75	8.14	8.64	8.52	8.69
Insecticide	0.36	0.35	0.37	0.39	0.37	0.37
Fungicide	0.40	0.38	0.55	0.60	0.47	0.49
Neem leaf	2.80	2.86	6.99	7.25	4.92	5.11
Labor	87.55	87.66	83.95	83.11	85.73	85.33
TVC	100		100	100	100	100

Source: Field Survey, 2018

Table 6. TFC⁷ (US \$) for seed yam production

Fixed Input	GHANA		NIGERIA		ALL	
	PS	Non-PS	PS	Non-PS	PS	Non-PS
Land	42.29	43.39	40.39	40.57	41.38	41.94
Cutlass	10.27	12.21	8.66	8.17	8.87	9.40
Hoe	7.63	8.82	24.42	23.75	15.68	16.51
TFC	60.18 ^{NS}	64.42	73.47 ^{NS}	72.48	65.93 ^{NS}	67.85

Source: Field Survey, 2018.

minisetts for planting a hectare. This means, by using minisetts, the farmer needed only 4.13% of the total seed requirement as compared with the traditional system.

Major fixed-cost items from the study areas were land, hoes and cutlasses, which were combined with variable cost items to produce seed yam. TFC was generally higher in Non-PS-technique communities than in PS-technique communities, but not significantly (Table 6). Country-level analysis showed a slightly higher TFC for Nigeria than for Ghana. Rent on land was the most expensive fixed-cost item, with farmers in Ghana spending US \$ 42.29/ha and US \$ 43.39/ha in PS-technique and Non-PS-technique communities, respectively (Table 6). Nigeria had a similar trend, such that land rent/ha was US \$40.39/ha and US \$ 40.56/ha for PS-technique and Non-PS-technique communities, respectively (Table 6).

3.3. Profitability of positive selection

Production of seed yam with PS technique was profitable across study areas (Table 7). Farmers in PS-technique communities generated US \$ 9,435.53/ha, US \$ 3,483.91 and US \$ 3,417.98 as total revenue, gross margin and net return, respectively (Table 7). Gross margins from this study were higher than those reported by Ibitoye and Onimisi (2013) (\$ 437.86/ha) and by Aidoo et al. (2011) (\$ 530.96) for small-scale seed-yam operations in Ghana. The huge difference between this study and Ibitoye and Onimisi (2013) and Aidoo et al. (2011) was the use of improved production practices such as planting on ridges, soil treatment using neem leaf powder, use of the miniset technique and application of PS technique.

Net returns were also higher than those reported by Eniola (2015) in Kwara State of Nigeria (\$ 535.44/ha and \$ 503.57) for male and female-headed households, respectively. Zaknayiba and Tanko (2013) also reported a net farm income of (\$ 574.88/ha) for small-scale yam farmers in Karu local government area, Nigeria, which is lower than estimates from this study due to the use of improved production practices in study areas.

Table 7. Profitability of seed yam production in Ghana and Nigeria

	GHANA		NIGERIA		ALL	
	PS [†]	Non-PS ^{††}	PS	Non-PS	PS	Non-PS
<i>Revenue</i>						
Output (t/ha)	5.12	4.43	5.56	4.41	5.3306	4.42
Price/t (US\$)	1740.55	1778.02	1802.17	1734.27	1770.069	1755.47
Total Revenue (TR)	8909.35*	7875.57	10,021.88***	7651.42	9435.53***	7759.90
<i>Variable Cost (VC)</i>						
Seed	502.72	519.79	511.32	505.91	506.84	512.64
Insect	20.41	20.67	23.38	22.8589	21.8329	21.79
Fungi	22.47	22.77	34.277	35.01	28.13	29.08
Neem	157.967	170.153	439.237	424.53	292.71	301.24
Labor	4945.99	5210.16	5271.9	4863.88	5102.11	5031.70
TVC	5649.55	5943.55	6280.11	5852.18	5951.62	5896.46
Gross Margin (GM)	3259.79*	1932.01	3741.77***	1799.25	3483.91***	1863.44
<i>Fixed Cost</i>						
Land	42.29	43.39	40.39	40.57	41.38	41.94
Cutlass	10.27	12.21	8.66	8.17	8.87	9.40
Hoe	7.63	8.82	24.48	23.74	15.68	16.51
TFC	60.18	64.43	73.48	72.48	65.92	67.85
Total Cost (TC)	5709.74	6007.98	6353.59	5924.67	6017.55	5964.31
Net Return (NR)	3199.61*	1867.59	3668.29***	1726.77	3417.98***	1795.58
Benefit Cost Ratio (BCR)	1.56	1.31	1.58	1.29	1.57	1.30
Return on Investment (ROI)	56.04	31.09	57.74	29.15	56.80	30.11

Source: Field Survey, 2018.

*, **, and ***, indicate significance at the 10%, 5%, and 1% levels, respectively.

The high returns from PS-technique communities were attributable to the ability of PS to lower disease load and improve output. The output difference between PS-technique and Non-PS-technique communities was 17.1% and was highly significant in generating higher profitability. This high level of profitability led to higher returns on investment, such that the PS-technique communities generated a return on investment of 56.80% as compared to 30.11% for the Non-PS-technique communities. The seed-yam farmers could therefore improve their return on investment by 26.69% with PS technique.

Profitability between PS-technique and Non-PS-technique communities in Nigeria was significantly higher than that in Ghana (Table 7). This was largely driven by output difference between PS-technique and Non-PS-technique communities in the two countries. PS-technique communities in Ghana had a 13.5% higher output than Non-PS-technique communities (Table 3). This was lower compared to Nigeria where farmers in PS-technique communities had 20.7% higher output than those in Non-PS-technique communities (Table 3).

3.4. Determinants of profitability

The sex of the farmer (1 =Male 0 =Otherwise) was significant in Ghana and Nigeria with coefficients of 0.101 and 0.220 (Table 8) respectively. This implies that male seed yam farmers in Nigeria were more profitable than those in Ghana since males dominate yam production in Nigeria (Table 1).

Farmer experience was significant for both Ghana and Nigeria with coefficients of 0.248 and 0.422 respectively. This indicates the importance of farmer experience such that an increase in the number of years of experience can lead to 42.2% and 24.8% increase in profit for the seed yam farmer, respectively. More experienced farmers normally turns to accept new technologies since they might have come into contact with several researchers and other dissemination agents and might have developed trust.

The level of education of the farmer plays an important role in technology dissemination and adoption. Educated farmers are more likely to accept new technologies since they can read materials provided on such technologies. This explains why there was a positive relationship between the level of education and profitability of seed yam production in Ghana (0.449) and Nigeria (0.710). The effect in Nigeria was however higher since spending an extra year in school will lead to 71.0% change in profitability as compared to 44.9% in Ghana.

The effect of being a native was only significant and positive for Nigeria (0.401) since production was mostly by natives (Table 1). Being a native facilitates access to land and other resource, which has influence on profitability. Ghana on the other hand had migrants heavily involve in production (Table 1). The non-significant effect from Ghana indicates its not just enough being a native but this must be accompanied with efficient use of resources.

The role of extension in technology dissemination is highly essential since they are the first source of information for farmers. This explains the significant and positive effects of extension contact for both countries (Table 8). The difference between countries (Ghana 0.304 and Nigeria 0.307) is however minimal.

Table 8. Determinants of profitability in quality seed yam production

Variable	Ghana		Nigeria		ALL	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Sex	0.101***	0.043	0.220***	0.022	0.253***	0.091
Experience	0.248**	0.033	0.422***	0.090	0.373**	0.221
Edu	0.449**	0.053	0.710**	0.202	0.229***	0.019
Native	0.621	0.075	0.401**	0.053	0.346**	0.056
Ext	0.304**	0.066	0.307***	0.055	0.841***	0.068
Household labor	0.960	0.507	0.453	0.608	0.394	0.840
Off farm Income	0.134***	0.040	0.533***	0.030	0.728***	0.045
Positive Selection	0.087***	0.022	0.529***	0.060	0.194***	0.067
Constant	0.788*	0.091	0.572	0.528	0.881	0.577
N	166		164			330
F-Stat	5.82***		5.01***			5.41
R ²	67.5		65.2			66.3

Source: Field Survey, 2018. SE denotes standard errors. The asterisks, *, **, and ***, indicate significance at the 10%, 5% and 1%

The effect of off-farm income in determining farmer profitability cannot be under estimated. This provides a means of capital for investment into seed, farming tools, land and other resources required. Both Countries in this study (Ghana and Nigeria) had positive and significant effects (Table 8). The effect for Nigeria (0.533) is however higher than Ghana (0.134). This is as a result of some farmers in Nigeria being civil servants, traders, etc (Table 1) and who took farming as a secondary occupation, which provided more resources to be invested in their farming operations.

Use of the PS technique had a positive effect on profitability with Nigeria having the highest effect (Table 8). Profitability in Nigeria can increase by 52.9% as a result of the use of PS technique as compared to Ghana (8.7%). The difference can be attributed to a number of factors, which may include the fertility of the soil, rainfall pattern, source of seed, etc. This implies for profitability enhancement, the seed yam farmer must consider other critical factors as mentioned in addition to use of quality seed from PS technique.

4. Conclusion

From this study, it can be concluded that the role of socio-demographic variables in determine the profitability of seed yam farmers is critical. It is clear that a change in the number of years spent in school leads to a corresponding change in profitability. Being a native does not guarantee profitability unless combined with efficient use of resources. This explains why about 52.9% and 72.2% of farmer in Ghana were natives in PS and non-PS communities, respectively, but had no effect on profitability. The role of off-farm income in enhancing profitability is critical learning from Nigeria where some farmers were engaged in other occupations as their primary source.

Labour is the highest contributor to TVC with an average of about 85.73% of TVC (Table 5), which demonstrates the limited use of machinery in yam production in Ghana and Nigeria. Seed yam cost was less than 9% due to the use of the minisett technique, which goes to emphasized the ability of improved technique as cost reduction strategy.

The use of PS technique leads to increase in gross margin, net returns and return on investment. Seed yam farmers can therefore increase net return and return on investment by US\$ 1,691/ha and 26.69%, respectively, through the use of PS. These returns can further be enhanced when seeds are from clean sources such as tissue culture as was the case for Nigeria. Farmers should therefore be encouraged to continuously use PS technique to maintain the quality of their seed yam

Sex of the farmer, experience, education, contact with extension, nativity, access to off-farm income and the use of PS technique were the key determinants of profitability. These determinants have a positive effect on profitability with education (number of years in school) having the highest effect for Ghana (0. 449) and Nigeria (0.710). This underscore the importance of education in technology dissemination and adoption since a more literate farmer turns to appreciate improved technologies better. Their ability to read dissemination materials becomes an advantage over their colleagues.

List of abbreviations

Positive Selection (PS), Yam Mosaic Virus (YMV), Community Action for farmer saved seed Yam (CAY seed), Total Variable Cost (TVC), Net Farm Income (NFI), Total Cost (TC), Total Variable Cost (TVC), Total Fixed Cost (TFC), Total Revenue (TR), United States (US).

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Author details

Jonas Osei-Adu^{1,2}
E-mail: aduseiz@yahoo.co.uk
Robert Aidoo
ORCID ID: <http://orcid.org/0000-0002-8496-5787>
Simon Cudjoe Fialor
Stella Ama Ennin²
Kingsley Osei²

Bright Owusu Asante

¹ CSIR-Crops Research Institute-Ghana, Economics and Biometrics Division.

² Department of Agricultural Economics, Agribusiness and Extension, KNUST, Kumasi, Ghana.

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Notes

- Household labour was computed by the number of youthful age bracket multiplied by the number of hours spent on the farm and the number of days.
- [†]PS and ^{††}Non-PS denotes Positive Selection and Non-Positive Selection.
- [†]PS and ^{††}Non-PS denotes Positive Selection and Non-Positive Selection, ^{ae}SD represents standard deviation.
- [†]PS and ^{††}Non-PS denotes Positive Selection and Non-Positive Selection, ^{ae}SD represents standard deviation.
- [†]PS and ^{††}Non-PS denotes Positive Selection and Non-Positive Selection, respectively. NS denotes differences in means are not significant between PS and Non-PS groups.
- [†]PS and ^{††}Non-PS denotes Positive Selection and Non-Positive Selection, respectively. ⁵TVC represents Total Variable Costs.
- [†]PS and ^{††}Non-PS denotes Positive Selection and Non-Positive Selection, respectively. ⁵TFC represents Total Fixed Costs, NS denotes differences in means are not significant between PS and Non-PS groups.
- [†]PS and ^{††}Non-PS denotes Positive Selection and Non-Positive Selection, respectively. ⁵TFC represents Total Fixed Costs, TVC represents the Total Variable Costs, NS denotes differences in means are not significant between PS and Non-PS groups.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Authors' contributions

JO collected and analysed the data as well as developed the initial draft of the manuscript, RD and SCF reviewed the manuscript, SAE designed the agronomic aspect of the study, KO designed the procedure for positive selection, BOA designed survey tool and took part in data analysis

Availability of data and material

Data for this article is available from the corresponding author upon request

Ethics approval and consent to participate

Informed consent was sought from each participant prior to the conduct of interviews. They were made to understand the rational of the study and assurance of keeping their data private upon which they freely and willingly agreed to be part.

Consent for publication

As authors we do hereby indicate our consent for publication having played an active role in preparing this manuscript.

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