https://dx.doi.org/10.4314/gjas.v57i1.4

Economics of bio-fortified cassava varieties (BCVs) adoption and its gender implication among farmers in Oyo State, Nigeria

O. T. OLUPONA & A. D. KEHINDE*
(O.T.O.: International Crops Institute for the Semi-Arid Tropics, Nigeria; A.D.K.: Department of Agricultural Economics, Obafemi Awolowo University, Ile Ife, Osun State, Nigeria)
**Corresponding author's email: kehindeayodeji8@gmail.com*

ABSTRACT

Cassava bio-fortification is presented as a cost-effective approach, and it is predicted to provide some economic benefits to its adopter. On the other hand, gender-blind agricultural innovation delivery strategies impede short- and long-term impact among adopters. Due to a disregard for gender differences, many agricultural programs fall short of their objective. Recent studies in Nigeria are yet to adequately capture the gender differentials in the economic implication of BCVs adoption. This study, therefore, investigates the gender differentials in the economic implication of BCVs' adoption among farmers in Oyo State, Nigeria. A multistage sampling procedure was used to select a total of 180 respondents for the study. Data collected were analyzed using descriptive statistics and budgetary techniques. Descriptive statistics revealed a significant difference between the socio-economic characteristics of male and female cassava farmers. The results suggested that BCVs' production is profitable and can serve as a panacea for the economic improvement of households. Study findings thus concluded that the adoption of BCVs is economically beneficial to cassava farmers and thus recommended that concerted efforts are made to ensure all farmers adopt BCVs for planting. The study proposes an integration of gender-responsive strategies to further enhance the delivery of BCVs in Nigeria.

Keywords: Gender; bio-fortified cassava varieties; economic implications; budgetary techniques; Oyo State

Original scientific paper. Received 12 Oct 2020; revised 05 Oct 2021

Introduction

Cassava (*Manihot esculenta,* Crantz) is a staple food crop grown on marginal lands, particularly in Africa, Asia, and Latin America. Nigerian cassava production contributed 19% to the world cassava output from 2015 to 2018 (FAOSTAT, 2015; FAO, 2018) and Nigeria is currently the largest producer of cassava in the world with an annual output of over 59 million tons (FAOSTAT, 2019; Adeyemo & Kehinde, 2019; Kehinde & Olatidoye, 2019; FAOSTAT, 2019; Kehinde & Adeyemo, 2020; Ogunyinka & Oguntuase, 2020). Cassava is predominantly cultivated by over 30 million smallholder farmers as well as large numbers of processors and traders who depend on seasonal rainfall for its production (Tahirou *et al*. 2014; Afolami *et al*., 2015). This is possible because cassava has the capacity to give significant yield under conditions of marginal soil and climate change; hence the crop is drought tolerant (Anikwe & Ikenganyia, 2018; Ekeleme *et al*., 2021).

Cassava is relatively resource-conserving and cheaper to produce (Obisesan, 2013; Sangoyomi, 2013); hence its role in improving the livelihood of farmers and food security of the nation cannot be over-emphasized. Cassava is the most important root crop providing over 50% of the calorie consumption of more than 200 million people (Oparinde *et al*., 2012). This is ascribed to the fact that the root crop can be processed into various products such as garri, fufu, tapioca, chips, and cassava flour for human consumption (Tahirou *et al.,* 2014). As a result, cassava plays a leading role in the local food economy, especially in rural households (Hartmann, 2011, FAOSTAT, 2013, FAOSTAT, 2019). Research has shown that four out of five Nigerians in the rural area eat a cassava-based meal at least once a week (Nweke *et al*., 2002; Ezedinma *et al*., 2007; Aghaji *et al*., 2019). This is attributed to the fact that cassava-based meal, containing about 25% to 35% starch, is an inexpensive and dependable source of carbohydrates for most rural resource-poor households (Azaino, 2008).

Despite the fact that cassava is the main source of carbohydrates for rural resource-poor households, it lacks some nutrients such as protein, vitamins, and minerals (Phillips *et al*., 2004; McNulty & Oparinde, 2015). Though cassava in most cases provides a solution to hunger and starvation, it does not solve the problem of malnutrition otherwise known as “hidden hunger”. According to Stein & Qaim (2007), HarvestPlus (2014), FAO *et al*. (2018), and FAO (2020), more than 850 million people suffer from hidden hunger in the world, Nigeria inclusive. However, frequent consumers of cassava are at greater risk in terms of malnutrition, especially deficiencies in vitamin A, iron, and zinc compared with consumers of other diets (Phillips *et al*., 2004; Gegios *et al*., 2010; McNulty & Oparinde, 2015). Micronutrient malnutrition, for instance, vitamin A deficiency, results in societal costs including learning disabilities among children, increased mortality rates, lower worker productivity, and high healthcare costs (Welch & Graham, 2004; Grebmer *et al*., 2014).

Micronutrient malnutrition has serious negative health implications on both men and women but affects women more (Micronutrient Initiative, 2014; Aghaji *et al*., 2019). Currently, Nigeria has a high vitamin-A deficiency (VAD) problem as over 30% of pregnant women and 20% of children under the age of five are vitamin-A deficient, resulting in different categories of illnesses, and even death in most cases (Maziya-Dixon et al., 2006; WHO, 2009; Micronutrient Initiative, 2014; Ayinde & Adewumi, 2016; and Aghaji *et al*., 2019). VAD also results in a high rate of impaired vision in Nigeria such as night blindness and xerophthalmia (Ayinde & Adewumi, 2016; Aghaji *et al*., 2019).

In the light of the foregoing, the Harvest-Plus programme was initiated under a collaborative effort of the International Institute for Tropical Agriculture (IITA), National Root Crop Research Institute (NRCRI) Umudike, as well as other local partners and Obafemi Awolowo University Ile-Ife, to develop vitamin A-rich cassava varieties suitable for many agro-ecological conditions. This was to help solve the problem of malnutrition among resource-poor households in Nigeria (Oparinde *et al*., 2014). The first wave of vitamin A cassava varieties (UMUCASS 36, UMUCASS 37, and UMUCASS 38) was released in 2011 and the second wave (UMUCASS 44, UMUCASS

45, and UMUCASS 46) was released in 2013 (IITA, 2012; Oparinde *et al*., 2012; Harvest Plus, 2014). They are commonly referred to as NR07/0220, IITA-TMS-IBA070593, and IITA-TMS-IBA070539.

The Harvest-Plus project is built on the existing delivery pathway that empowers the rural population, where hidden hunger is prominent, to scale-up production and processing of vitamin A cassava to meet both food and income needs. Four states, which are Oyo, Imo, Akwa Ibom, and Benue States, were selected as centers to multiply them with all other states in Nigeria. In 2013, over 650 hectares of the three BCVs were multiplied in 272 villages while in 2014, the average stem yield on multiplication farms increased from 200 to 500-1000 bundles (HarvestPlus, 2014). Harvest-Plus also worked with the Ministries of Agriculture and Health. The Federal Ministry of Agriculture integrated the development and dissemination of bio-fortified food crops into the Agricultural Transformation Agenda (ATA) of the Federal Government in 2014 while the Ministry of Health included bio-fortified cassava in the new Micronutrient Deficiency Control Guidelines approved by the National Health Council in August 2013.

BCVs offer a low-cost strategy that improves the nutritional requirement of people and economic livelihood opportunities for all ages (Olaosebikan *et al*., 2019). The Federal Government of Nigeria and other international agencies envisaged that BCVs would alleviate malnutrition in addition to hunger through their ability to yield about 32 – 36 tons/ha, therefore generating an average annual farm income of about ₦55, 395 per ha (IITA, 2014; Afolami *et al*., 2015). BCVs also contain nutrients at least six times more than the common white-fleshed cassava because of the presence of beta-carotene thus making basic nutrients available to poor households, especially in rural communities (HarvestPlus, 2014).

The BCVs have provided up to 25% of the daily vitamin A requirements of children and women (Sagar *et al*., 2009; Omodamiro *et al*., 2012). Apart from the nutritional benefits accruing to bio-fortification, it is also a cost-effective means. Bio-fortified cassava assured the farmers of a greater yield and better income. Results on bio-fortified roots show that the monetary benefit associated with reduced health burden would be between ₦3.4 – ₦11.5 billion (771,654.00 USD – 90,551,181.00 USD) per year in the pessimistic and optimistic scenarios (Bamire *et al.,*2004; Afolami *et al*., 2015). Also, potential benefits from Vitamin A bio-fortification are estimated at 1.1 billion USD – 1.4 billion USD in Nigeria while the costs per DALY saved are estimated at 4 USD to 6 USD for Nigeria, which compares very favorably with the costs for alternative methods such as fortification and supplementation (Nguema *et al*., 2011). They also serve as means for crop diversification and increase employment opportunities for women through cassava processing (IITA, 2013).

Despite the nutritional, health, and economic benefits embedded in the improved cassava varieties, their adoption by farmers has been discouraging. Given this situation, it is expected that many research efforts will be focused on this direction. Many studies abound that assessed factors militating against the adoption of improved cassava varieties (Adesina & Baidu-Forson, 1995; Agwu & Anyaeche, 2007; Ezeburio *et al*., 2010), the determinants of BCVs adoption in Nigeria (Olatade *et al*., 2016; Ayinde, 2017; Onyeneke *et al*..2020), risk analysis in the production of vitamin A cassava variety (Ayinde, 2017), the physio-chemical properties and sensory attributes of BCVs (Alake *et al.*, 2016; Edoh *et al.*, 2016), consumer acceptance and demand for BCVs (Oparinde *et al.*, 2016; Birol *et al.*, 2015), and expected economic benefits of BCVs (Ayinde & Adewumi, 2016). These studies only captured the determinants of BCVs and their acceptance but no studies exist on the economic implications of the adoption of bio-fortified cassava varieties.

Although Olaosebikan *et al.* (2019) carried out a gender-based study on the constraints affecting BCVs production, processing, and marketing of adopters, this study differs from other studies as it aimed at gender differentials in the economic implication of the adoption of bio-fortified cassava varieties. None exists to the best knowledge of the author, even though, studies revealed that there are gender variances in the adoption of innovation and the economic consequence of the adoption on both genders (Doss & Morris, 2001; FAO, 2014; Obisesan, 2014; Mishra & Sam, 2016; Gaya *et al.,* 2017, Theis *et al*., 2018; Aduwo *et al*., 2019). There is thus the need to investigate the gender differentials in the economic implication of BCVs adoption in Oyo State, Nigeria.

Consequently, this study assesses the gender differentials in the economic implication of the adoption of bio-fortified cassava varieties among farmers in Oyo State, Nigeria. Specifically, it describes the socio-economic characteristics of cassava farmers in the area by gender; examines the gender differentials in the intensity of adoption, and estimates the cost of and return to BCVs by gender in Oyo State. Our empirical evidence shows that BCVs production is profitable and can serve as a panacea for the economic improvement of households. This is reflected in the fact that BCVs adopters earn higher net income than non-adopters although female adopters and non-adopters of BCVs have higher net income than their male counterparts.

The result stemming from this study will contribute to the body of literature by providing important information for implementing well-informed and gender-based policies relating to the cultivation of BCVs. Moreover, there exist research gaps in the literature on the adoption of and economic considerations of improved varieties of cassava, as well as gender differentials in the economic implication of BCVs. The result of this research will specifically contribute to the design and implementation of gender equitable strategies to upscale BCVs in Nigeria.

Materials and Methods

Study area

The study was carried out in Oyo State in the southwestern part of Nigeria. The State covers a total of 28,454 sq. km. of land mass and an estimated agricultural landmass of 27,000 sq km and a favourable climate for equatorial crop production and livestock rearing. The State is bounded with Ogun, Kwara, Republic of Benin, and Osun in the South, North, West, and East respectively (Sodiya & Oyeniran, 2014). The topography of the State is of gentle rolling low land and well-drained with rivers flowing from the upland in the North-South direction. The average daily temperature ranges between 25°C and 35°C and a vegetation pattern of rain forest in the south and guinea savannah in the north (Muhamad-Lawal *et al*., 2012). The State has a total population of 6,591,589 as of the 2013 census with a larger percentage being males (Sodiya & Oyeniran, 2014). The favorable climate of the area has encouraged around 70% of the inhabitants to engage in small-scale agriculture. Agriculture is the main occupation of the people of Oyo State. The state is divided into four agricultural zones and two ecological zones. This favour the cultivation of different crops like maize, yam, and cassava among others which altogether boost the income of farmers, thereby improving their livelihood. Oyo is the state with the highest number of cassava growers in South-West Nigeria, cultivating ten thousand (10,000) hectares of land (FMARD, 2017).

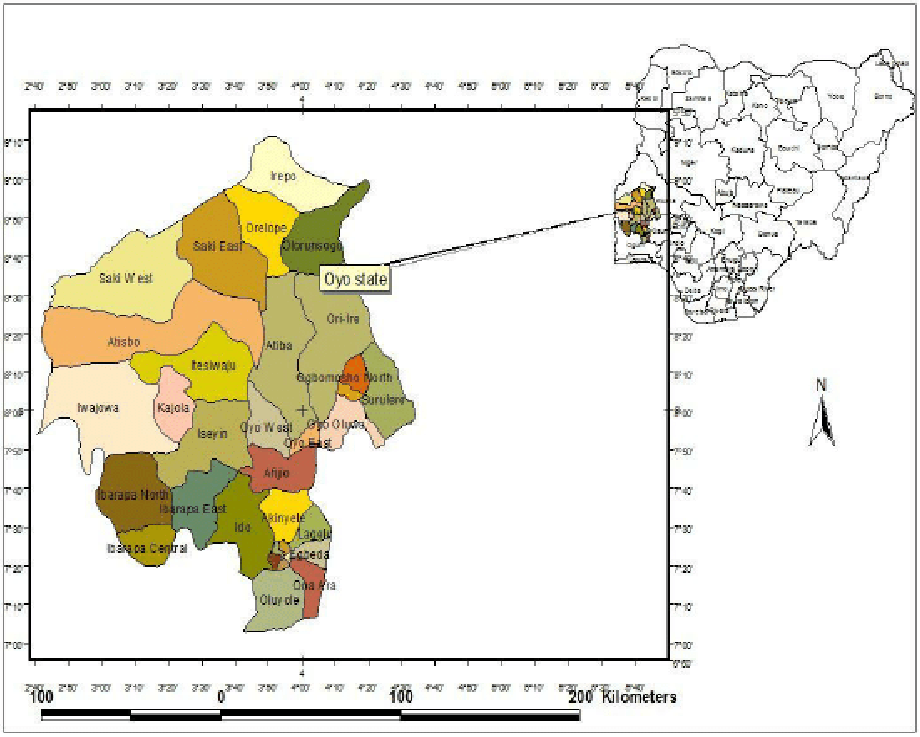

Fig. 1: Map of Oyo State

Sampling procedure and sampling size

A multi-stage sampling procedure was used to select respondents for the study. The first stage involved a purposive selection of the Oyo State one of the states into which BCVs were introduced. The second stage involved purposive sampling to select three local government areas (LGAs) – i.e. Orire, Afijio, and Akinyele LGAs – with the highest population of cassava farmers. In the third stage, two villages were purposively selected in each of the three LGAs based on the fact that they have the highest population of cassava farmers in each LGA. In each village, a simple random technique was used to select a total of 30 respondents, comprising 107 male farmers and 73 female farmers making a total of 180 farmers.

Data collection and analysis

The data collected were for the 2016/ 2017 cropping season. Data were collected on farmers' socio-economic characteristics such as age, education, gender, household and farm size, adoption status of the farmer, and intensity of use of BCVs. Data were analyzed with the use of descriptive statistics and budgetary techniques such as gross margin and returns. The budgeting technique compares the costs and benefits of different choices by estimating the difference in gains or costs expected from them. Descriptive statistics were then used to describe gender differentials among study variables which involved the computation of means, standard deviation, frequency, and percentages.

Following Tufa *et al.* (2019) and Kehinde (2020), the adoption intensity was measured on the portion of land allotted to BCVs out of the total farm size. It is expressed in terms of the adoption index.

$$AI = \frac{\sum_{i=1}^{n} \beta v}{\sum_{i=1}^{n} Lt} \quad (1)$$

Where AI = adoption index

βv = land grown to BCVs by farmer i (i= 1, 2, 3,………..n) and

Lt = total land area grown to cassava by the farmer.

Following Akinola & Owombo (2012), Ojo & Ogunyemi (2014), Itam *et al*. (2018), and Kehinde & Adeyemo (2020), the budgetary technique was employed to estimate the economics of BCVs' adoption by looking at the costs and returns that accrue to the improved crop technology adoption. It also involves the use of gross margin (GM) and returns to analyze and compare profitability.

$$TR = P \times Q \quad (2)$$

$$GM = TR - TVC \quad (3)$$

$$\Pi = TR - TC \quad (4)$$

$$NI = GM - TFC \quad (5)$$

$$\text{Percentage GM} = \frac{GM}{TR} \times 100 \quad (6)$$

$$\text{Profitability Index} = PI = \frac{NI}{TR} \quad (7)$$

$$\text{Rate of Return on Investment} = RRI = \frac{NI}{TC} \quad (8)$$

Where;

P is price of cassava per ha.

Q is quantity of cassava per ha.

Π is profit per ha.

TR is the total revenue which is the income from sales (₦/ha).

TVC is the total variable cost of production, defined as the cost of cuttings, fertilizer, labour, herbicides, transportation, pesticides, and others (₦/ha).

TFC is the total fixed cost of production, defined by the cost of land, hired land, and major farm equipment (₦/ha).

TC is the total cost of production (₦/ha).

RRI is the rate of return on investment per ha

GM = Gross margin (₦/ha) and

NI = Net income (₦/ha).

The test statistic: t-test

This involved an independent sample t-test.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (9)$$

$\bar{x}_1$ = Mean NI, GM, PI, and RRI of adopters and non-adopters disaggregated by gender.
$\bar{x}_2$ = Mean NI, GM, PI, and RRI of adopters and non-adopters disaggregated by gender.
S_1 = Standard deviation of male adopters,
S_2 = Standard deviation of female adopters,
n_1 = sample of adopters.
n_2 = sample of non-adopters.

Statements of hypothesis
H_0= There is no significant difference in the NI, GM, PI, and RRI of adopters and non-adopters of BCVs. i.e. H_0: $NI_1 = NI_2$
H_a: $NI_1 \neq NI_2$
H_0= There is no significant difference in the net income of male and female adopters of BCVs
H_a= There is a significant difference in the net income of female and male adopters of BCVs.

Results and Discussion

Socio-economic characteristics of cassava farmers by gender
The age range with the highest frequency is 41 – 60 years among both adopters and non-adopters, followed by 21 – 40 years among adopters and non-adopters (over 26%). This shows the majority of the farmers are between 20 – 60 years and corroborates Mohammad-Lawal *et al*. (2012) and Durojaye & Ogunjimi's (2015) findings that the majority of the cassava farmers in Oyo State are in their active years of production. The result shows that 37.08% of the non-adopters have between 1 – 10 years' experience while 39% of adopters have over 20 years' experience. This suggests that an average adopter is more experienced in farming than a non-adopter which would give the ability to exact the appropriateness of new technology for efficient production, hence standing a better chance of making accurate decisions (Kehinde *et al*., 2018).

Education is an important factor that enhances the proper decision on the adoption of new technology. From Table 1, the proportion (72.53%) of adopters who have access to education between primary school to tertiary institutions is greater than that of non-adopters (66.59%) while a greater proportion of non-adopters did not go to school at all. This indicates that adopters are generally more learned than non-adopters; therefore, adopters stand a better chance of making helpful judgments in their decision-making. This contrast with the findings of Tesfaye *et al*. (2016) but supports Owombo *et al*. (2012) that non-adopters are more educated than adopters. Also, 67.03% of adopters and 58.43% of non-adopters practice farming on a part-time basis. This implies that a greater proportion of adopters are more involved in part-time farming; this enables them financially to maximize the adoption of BCVs than non-adopters since they have other means of income to weather any unforeseen contingencies that may later arise.

The household size is an indication of the potential family labour available for farm work. There is a significant difference ($p \leq 0.05$) between the mean household size of adopters (5.98 ±1.54) and non-adopters (4.97 ± 1.59). This suggests that adopting households have larger family sizes which gave an edge in labour supply over non-adopting households and is in line with many studies in Sub-Saharan Africa (Asfaw *et al.,* 2012; Kehinde & Adeyemo, 2017).

TABLE 1

Socio-economic characteristics of cassava farmers by gender

Variables	**Pooled (n = 180)**		**Adopters (n = 91)**			**Non-adopters (n = 89)**		
	Adopters		**Males**	**Females**	**t-test**	**Males**	**Females**	**t-test**
Age (%)								
0-20	1.1	0	0	2.63		0	0	
21-40	26.37	32.58	16.98	39.47		35.19	28.57	
40-60	53.84	46.07	58.49	47.37		35.19	63.86	
> 60	18.68	21.35	24.53	10.53		29.63	8.57	
Mean			52.2	45.1	**3.00*****	50.9	48.1	1.10
Farming experience 1-10 (%)								
11.20	30.77	37.08	20.75	44.74		35.19	40	
> 20	29.67	33.71	30.19	28.95		31.48	37.14	
	39.56	29.21	49.06	26.32		33.33	22.86	
Mean			21.8	17.2	**2.17****	17.9	15.7	1.24
Education (%)								
None	16.48	26.97	11.32	23.68		18.52	40	
Koranic	4.40	2.25	7.55	0		3.70	0	
Adult	2.20	0	3.78	0		0	0	
Primary	39.56	37.38	32.08	50		35.19	40	
Secondary	30.77	29.21	33.96	26.30		35.19	20	
Tertiary	6.59	4.49	11.32	0		7.40	0	
Nature of farming (%)								
Part-time	67.03	58.43	54.72	84.21		59.25	57.14	
Full-time	32.97	41.57	40.74	15.79		40.74	42.86	
Household size (Number)								
Mean	5.9	4.9			**4.33*****			
Farm size (AC) (Mean)	4.6	3.9	6.2	2.4	**3.61*****	4.9	2.4	**2.91*****

Note: Figures in parentheses () are standard deviations; ***, **Significant at 1% 5% respectively.

Source: Field survey, 2018

From the gender analysis, while the majority of male adopters and non-adopters have over 20 years' experience in farming, the majority of their female counterparts had between 1 – 10 years' experience. This suggests that males are generally more experienced than females and cannot be far-fetched from the fact that there have been institutional barriers to farming among women decades back (Doss & Morris, 2001). Furthermore, both male adopters and non-adopters have larger farm holdings than females. This suggests that males own more land than women and are more opportune to maximize adoption (Doss *et al.*, 2015, Kieran *et al.*, 2015, Kieran *et al.*, 2017). This implies the larger the size of the farm, the larger the size of land a farmer would likely devote to the cultivation of BCVs.

Also, the majority of the females either did not go to school at all or have only primary education, non-adopters especially. It thus implies that women are still generally less educated than men. This agrees with Adeyemo & Kehinde (2020) and Alao *et al.* (2020) that although female child education has increased over the year, there exists an education gap between men and women in sub-Sahara Africa. The study shows that about 54.72% of male and 84.21% of female adopters practice farming on a part-time basis while 59.25% of male and 57.14% of female non-adopters were involved in part-time farming. This means generally, women operate farming on a part-time basis than men. This is not surprising as women engage in processing and petty trade more than men.

The intensity of BCVs adoption by gender

The majority (67.03%) of the male farmers only devote 30% or less portion of land to BCVs cultivation while about 23.08% devote between 31% - 50% of their land to BCVs. This suggests that some reasons (like a small portion of the farm, inadequate capital, and inaccessibility of stems) as stated by some respondents are responsible for the relatively low intensity of adoption despite their high level of awareness. Among the males, 73.58% devote 30% or less portion of their land to BCVs cultivation while 16.78% use between 31% - 50% of their farms for BCVs. Furthermore, 57.89% and 31.58% of females devote between 0-30% and 31% - 50% of their farms to BCVs respectively. The intensity of adoption was generally low in the area as shown in the results despite the high level of awareness. This corroborates the findings of Afolami *et al.* (2015) that adoption rates of improved cassava varieties are low in the study area. Interestingly, male farmers adopted the technology more than their female counterparts and the difference is statistically significant (*t-value* = 2.88).

TABLE 2

Intensity of BCVs adoption by gender

Portion of land (%)	Pooled (%) (n=91)	Males (%) (n=53)	Females (%) (n=38)	**T-test**
0-30	67.03	73.58	57.89	
31-50	23.08	16.98	31.58	
51-70	5.49	5.66	5.26	
71-100	4.40	3.77	5.26	
Mean	0.57	0.62	0.51	2.88***

Source: Field survey, 2018

Costs and returns to adopters and non-adopters of BCVs by gender

The results of costs and returns to BCVs production in the study area presented in Table 3 show that the average cost of the adopters (₦30,325.44/$100) is less than that of the non-adopters (₦36,711.24/$121). Also, the average variable cost of the adopters (₦14,989.61/$49) is significantly ($p \leq 0.05$) less than that of the non-adopters (₦21,546.95/$71). The lower costs incurred by adopters might be because of favorable innate properties of BCVs that led to less expenses by adopters. The net income of adopters is significantly higher than that of non-adopters at $p \leq 0.05$ with a difference of ₦15,569.02/$51. The percentage gross margin of adopters is 0.09 higher than that of non-adopters. This is in line with Awotide *et al.* (2015) that technology adoption has a positive effect on income (net income and gross margin).

Among the adopters, the average cost for males is less than that of females. Also, the variable and fixed costs of female adopters (₦17,263.02/$57 and ₦20,469.10/$67) are considerably higher than those of male adopters (₦13,359.62/$44 and ₦11,655.36/$38) at $p \leq 0.05$. This shows that female adopters incur higher costs of production at all levels than male adopters in cassava production in the study area. This might be due to the high labour cost faced by women. This is in consonance with Alderman *et al.* (1996) that women spend more on labour than men which all together increases their cost of production.

However, the total revenue of female adopters is significantly higher than that of males while their net income is also higher than that of their male counterparts at $p \leq 0.05$. Also, the gross margin of female adopters has an average of ₦72,191.09/$237 higher than the males, with a percentage gross margin and profitability index of 0.82 and that of males 0.73 at $p \leq 0.05$. In addition, the profitability index of female adopters (1.19) is higher than that of male adopters (0.70) at $p \leq 0.05$. These suggest that females are able to make a higher profit per unit cost in the production of BCVs than their counterparts in spite of the higher costs incurred by females.

TABLE 3

Per hectare costs and returns structure to cassava varieties by gender

Variable	All				Adopters			Non-adopters		
	Pooled (*n* = 180)	Adopters (*n* = 91)	Non-adopters (*n* = 89)	t-test	Males (*n* = 53)	Females (*n* = 38)	t-test	Males (*n* = 54)	Females (*n* = 35)	t-test
TC	33482.86	30325.44	36711.24	1.63*	25014.98	37732.12	3.38***	35100.51	39196.37	0.58
TCV	18231.85	14989.61	21546.95	2.25**	13359.62	17263.02	1.98**	18544.15	26179.84	1.35*
TFC	15251.01	11655.36	15164.3	0.08	11655.36	20469.10	3.13***	16556.37	13016.53	1.31*
TR	82640.12	87180.7	77997.49	0.82	61714.95	122698.70	4.45***	63632.71	100160.3	2.16**
NI	49157.26	56855.27	41286.25	1.72**	36700	84966.58	4.11***	28532.20	60963.94	2.49***
GM	64408.26	72191.09	56450.55	1.58*	48355.34	105435.7	4.50***	45088.56	73980.46	0.48
%GM	0.75	0.77	0.68	1.58*	0.73	0.82	2.69***	0.68	0.70	1.99**
PI	0.91	0.91	1.14	1.04	0.70	1.19	2.02**	1.02	1.32	0.79
RRI	1.87	2.28	1.46	2.06**	1.75	3.01	1.84**	1.21	1.84	1.57*

Note: figures in parentheses are standard deviations, ***, ** and * indicates significance 1%, 5% and 10% respectively.

Source: Data Analysis, 2018

The higher revenue and net returns realized by females might be attributed to their involvement in processing cassava into other products (e.g. gari, flour, fufu, starch, even chips) all of which attract higher incomes than the mere sale of cassava tubers which is what men majorly engage in. This contradicts the findings of Naved (2000) and CIAS (2004) that women do not make substantial incomes from improved seed technology as men. Similarly, among the non-adopters, the total revenue of males (₦63,632.71/$209) is found to be less than that of females (₦100,160.3) at $p \leq 0.05$. Also, female non-adopters have ₦32,431.74/$107 higher than males at $p \leq 0.05$ while their percentage gross margin is 0.02 higher than that of males at $p \leq 0.05$. This is also in contrast with CIAS (2004) that women make low income from crop production.

Conclusion and Recommendation

This study assessed the gender differentials in the economic implication of BCVs adoption in the study area. This study shows that non-adopters (especially males) were relatively older in the study area. Most of the cassava-growing farmers are educated while the majority of respondents (especially females) practice farming on a part-time basis. Men generally own more land than females. This is in consonance with Doss & Morris (2001) and Adeyemo & Kehinde (2020) that a greater proportion of women are landless and as such, they occupy a rather tenuous position with regard to access to land. The majority of the farmers are aware of BCVs which only about average have adopted, with a lower percentage being females.

Results confirmed the importance of the adoption of BCVs as it increased the income (gross margin and net income) of adopters over non-adopters. Also, Female farmers incur higher costs (Total Cost, Variable Cost, and Fixed Cost) than male farmers. However, they made higher returns (Total Revenue, Gross Margin, and Net Income). Also, females have a higher percentage gross margin and profitability index. This confirms the fact that female farmers are more efficient in the area of income and returns to cassava production than men. Moreover, the females are involved in the processing and sales of cassava by-products like gari, fufu, starch, snacks, etc., which command more income than the mere sale of cassava tubers which is what most male farmers engage in.

Hence, females are good at processing and marketing products, and this gives them a comparative advantage over males. These indicate that the adoption of BCVs is generally a cost-effective means. From the findings of this study, it was observed that although women incurred higher production costs than men, they also had higher net income, profitability index, and rate of return on investment than men. This cannot be farfetched from the fact that women engage in processing activities more than men, which bring more money than sales of harvested tubers which men engage in mostly. Hence, it is recommended that the processing of cassava (i.e. value addition) should be more encouraged among the farmers, women especially.

Also, barriers to ownership of land by women should be removed as it has been observed from studies that land is pivotal to increasing the intensity of adoption, whereas both male adopters and non-adopters had a significantly larger expanse of land than their female counterparts. Based on the findings of this study, it is concluded that the adoption of BCVs for planting is profitable and capable of providing the necessary impetus for improving the livelihood of households. Awareness of BCVs among farmers should be intensified in order to facilitate increased adoption. Since education plays a major role in adoption, it is imperative that farmers in the area be enlightened on BCVs, extension approach used in the area should be participatory in nature.

Farmer Field School should be encouraged in the study area as it provides a better forum for farmers' education. From the age distribution of respondents, it was quite obvious that the youth were not actively involved in cassava farming. It is therefore strongly recommended that the youth in the area should be encouraged to get involved in BCVs farming by providing them with loans and other necessary services. This study further suggests the formulation of gender-sensitive policies such as land reforms and affordable education for women farmers to reduce the gender gap and advance women empowerment in BCVs cultivation. These policies should also include creating equal opportunity access to credit institutions and public services such as extension services. Also, there is a need for the provision of various societal beneficial groups to the female household heads as this will improve their level of exposure and most importantly it will improve their income generating capacity.

REFERENCES

Abdoulaye, T., Bamire, A. S., Oparinde, A. & Akinola, A. A. (2015) Determinants of adoption of improved cassava varieties among farming household in Oyo, Benue and Akwa Ibom States of Nigeria. HarvestPlus working paper No 20. Washington DC: HarvestPlus.

Adesina, A. A. & Baidu-Forson, J., (1995) Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. Agricultural Economics, 13, 1 – 9.

Adeyemo R. & Kehinde A. D. (2019) Community-Based organization and land management practices in cassava-based smallholder farming system in Osun State. Agricultura 111 – 112 (3 – 4), 270 – 281.

Adeyemo, R. & Kehinde, A. D. (2020) Membership in association, gender and adoption of land-enhancing technologies among arable farmers in Ogun State, Nigeria. Agricultural Science and Technology, 12 (2), 189 – 201.

Aduwo, O. E., Aransiola, J. O., Ikuteyijo, L. O., Alao, O. T., Deji, O. F., Ayinde, J. O., Adebooye, O. C. & Oyedele, D. J. (2019) Gender differences in agricultural technology adoption in developing countries: A systematic review. Acta Hortic. 1238, 227 – 238. https://doi.org/10.17660/ActaHortic.2019.1238.24.

Afolami, C. A., Obayelu, A. E. & Vaughan, I. I. (2015) Welfare impact of adoption of improved cassava varieties by rural households in South-western Nigeria. Journal of Agricultural and Food Economics, 3 (18), 9 – 10.

Aghaji, A. E., Duke, R. & Aghaji, U. C. W. (2019) Inequitable coverage of vitamin A supplementation in Nigeria and implications for childhood blindness. BMC Public Health, 19, 282.

Agwu, A. E. & Anyaeche, C. L. (2007) Adoption of improved cassava varieties in six rural communities in Anambra State, Nigeria. Afr. J. Biotechnol. 6 (2), 89 – 98.

Akinola, A. A. & Owombo, P. (2012) Economic analysis of adoption of mulching technology in yam production in Osun State, Nigeria. International Journal of Agriculture and Forestry, 2 (1), 1 – 6.

Alake, O. O., Babajide, J. M., Adebowale, A. A., & Adebisi, M. A. (2016) Evaluation of physico-chemical properties and sensory attributes of cassava enriched custard powder. Cogent Food & Agriculture, 2 (1). DOI: 10.1080/23311932.2016.1246116.

Alao, T.B., Bamire, A.S. & Kehinde, A.D. (2020) Gender analysis of agricultural financing in cocoa-based farming systems in Oyo and Osun States of Southwestern Nigeria. Ghana Journal of Agricultural Science, 55 (1), 34 – 42.

Alderman, H., Chiappori, P. A., Haddad, L., Hoddinott, J. & Kanbur, R. (1996) Unitary versus collective models of the household: is it time to shift the burden of proof? World Bank Research Observer, 10 (1), 1 – 19.

Anikwe, M. A. N. & Ikenganyia, E. E. (2018) Ecophysiology and production principles of cassava (Manihot species) in Southeastern Nigeria cassava. Intechopen, London: in World's largest Science, Technology & Medicine; Chapter 7, pp. 105 – 121. http://dx.doi.org/10.5772/intechopen.70828.

Asfaw, S., Kassie, M., Simtowe, F. & Lipper, L. (2012) Poverty reduction effects of agricultural technology adoption: micro-evidence from rural Tanzania. Journal of Development Studies, DOI:10.1080/00220388.2012.671475.

Awotide, B. A., Abdoulaye, T., Alene, A. & Manyong, V. M. (2015) Impact of access to credit on agricultural productivity: evidence from smallholder cassava farmers in Nigeria. A Contributed Paper prepared for Oral Presentation at the International Conference of Agricultural Economists (ICAE) Milan, Italy, August 9 – 14.

Ayinde, O. E. & Adewumi, M. O. (2016) Risk and adoption analysis of innovation in cassava production in Oyo State, Nigeria: A case study for vitamin A variety. World Congress on Root and Tuber Crops Nanning, Guangxi, China, January 18 – 22, 2016.

Ayinde, O. E. (2017) Risk analysis in innovation system: a case study of production of vitamin A cassava variety among farmers in Oyo state, Nigeria, J. Agric. Faculty Gaziosmanpasa Univ. JAFAG 34 (3), 263 – 270.

Ayinde, O.E., Adewumi, M. O., Ajewole, O. O. & Ologunde, O. O. (2017) Determinants of adoption of vitamin A bio-fortified cassava variety among farmers in Oyo State, Nigeria. Croat. J. Food Sci. Technol., 9 (1), 74 – 79.

Azaino, E. (2008) Business opportunities in the cassava value chain in Nigeria. http://uptonvilleoginstu.org/cassava.htm; accessed 12 February 2010.

Bamire, A. S., Manyong, V. M., Sanusi, I. O. & Awotide, D. O. (2004) Ex-ante cost-benefit analysis of biofortification of cassava roots in Nigeria. Summary: International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Birol, E., Meenakshi, J. V., Oparinde, A., Perez, S. & Tomlins, K. (2015) Developing country consumers' acceptance of bio-fortified foods: a synthesis. Food Security, 7 (3), 555 – 568.

Center for Integrated Agricultural Systems (2004) Women on Dairy Farms; Juggling Roles and Responsibilities. Centre for Integrated Agricultural Systems (CIAS). Retrieved November 14, 2007, from www.cias.wisc.edu/archives.

Dinku, A. & Beyene, F. (2019) Adoption determinants of row planting for wheat production in Munesa district of Oromia Region, Ethiopia. Journal of Agricultural Extension and Rural Development, 11 (2), 25 – 34. https://doi.org/10.5897/JAERD2018.0993.

Doss, C. R. & Morris, M. L. (2001) How does gender affect the adoption of agricultural innovation? The case of improved maize technologies in Ghana. Journal of Agricultural Economics, 25, 27 – 39.

Doss, C., Kovarik, C., Peterman, A., Quisumbing, A. & Van den Bold M. (2015) Gender inequalities in ownership and control of land in

Africa: myth and reality. Journal of Agricultural Economics, 46, 403 – 434.

Durojaiye, A. M. & Ogunjinmi, O. O. (2015) Technical efficiency analysis of mechanized cassava farmers in Afijio local government area of Oyo State, Nigeria. Global Journal of Biology, Agriculture and Health Sciences, 4 (3), 113 – 117.

Edoh, N. L., Adiele, J., Ndukwe, I., Ogbokiri, H., Njoku, D. N. & Egesi, C. N. (2016) Evaluation of high beta carotene cassava genotypes at advanced trial in Nigeria. The Open Conference Proceedings Journal, 7, 144 – 148.

Ekeleme, F., Dixon, A., Atser, G., Hauser, S., Chikoye, D., Korie, S., Olojede, A., Agada, M. & Olorunmaiye, P. M. (2021) Increasing cassava root yield on farmers' fields in Nigeria through appropriate weed management. Crop Protection, Volume 150, 2021,105810, ISSN 0261-2194. https://doi.org/10.1016/j.cropro.2021.105810.

Ezeburio, N. C, Ironkwe, A. G., Ugbaja, C. I. & Okoro, B. O. (2010) Adoption of improved cassava varieties by women in Umuahia agricultural zone of Abia State, Nigeria. Nigerian Journal of Rural Sociology, 10 (1), 17 – 26.

Ezedinma, C. I., Kormawa, P. M., Manyong, V. M. & Dixon, A. G. O. (2007) Challenges, opportunities and strategy for cassava sub sector development in Nigeria. Proceeding of the 13th ISTRC Symposium. 2007. Pp. 627 – 640.

Federal Ministry of Agriculture and Rural Development (2017) Registered cassava growers' data. Federal Ministry of Agriculture and Rural Development (FMARD), Oyo State, Nigeria.

Food Agricultural Organization (2018) FAO Food Outlook - Biannual Report on Global Food Markets – November 2018. Rome (2018), p. 104

Food Agricultural Organization (2013) The interaction between social protection and agriculture: review evidence; Food and Agricultural Organization of United Nations: Rome, Italy.

Food Agricultural Organization (2015) FAO Report on Regional Conference on Cassava in the Caribbean and Latin American, 10–12 February 2014, Food and Agriculture Organization of the United Nations, Rome (2015)

Food Agricultural Organization (2019) FAOSTAT Statistical Database, Statistical division Rome.

Food Agricultural Organization (2020) FAOSTAT Statistical Database, Statistical division Rome.

Gaya, H. I., Tegbaru, A., Bamire, A. S., Abdoulaye, T., & Kehinde, A. D. (2017) Gender differential and adoption of drought tolerant maize varieties among farmers in Northern Nigeria, European Journal of Business and Management, 9(5):81-87.

Gegios, A., Amthor, R., Maziva-Dixon, B., Egesi, C., Mallowa, S., Nungo, R., Gichuki, S., Mbanaso, A. & Manary, M. J. (2010) Children consuming cassava as a staple food are at risk for inadequate zinc, iron, and vitamin A intake. Plant Foods for Human Nutrition 65, 64-70.

Hartmann, E. (2011) Value addition crucial to development of nigeria's cassava industry. The Bulletin IITA 2084: 1-2.

HarvestPlus (2014) New, more nutritious vitamin A cassava released in Nigeria. Www.HarvestPlus.org. Date accessed: 2015.

HarvestPlus (2014). Delivery of Vitamin A Cassava in Nigeria. Progress Brief No 35; pp. 67.

International Institute of Tropical Agriculture (2012) Ibadan: IITA GIS Unit.

International Institute of Tropical Agriculture (2013) 2013 Annual report. ISSN 0331 4340, pp. 30.

International Institute of Tropical Agriculture (2014) Ibadan: IITA GIS Unit.

Itam, K. O., Ajah, E. A. & Udoeyop, M. J. (2018) Comparative cost and return analysis of cassava production by adopters and non-adopters of improved cassava varieties among farmers in Ibesikpo, Asutan LGA, Akwa Ibom State, Nigeria. Global Journal of Agricultural Sciences, 17, 33 – 41.

Kehinde A. D. (2020) Does credit access improve adoption intensity of improved maize seed varieties? Cercetari Agronomice in Moldova, 184 (4), 434 – 444.

Kehinde, A. D. & Adeyemo, R. (2020) Effect of social capital dimensions on output and gross margin of cassava farmers in Osun State. Nigerian Journal of Rural Sociology, 20 (1), 37 – 43.

Kehinde, A. D. & Olatidoye, M. S. (2019). Credit constraint and technical efficiency of smallholder cassava farmers in Osun State, Nigeria. Agricultura, 16 (1-2), 27 – 33.

Kehinde, A. D., Adeyemo, R., Oke, J. T. O. & Ogunleye, A. S. (2018) Effects of access to credit and membership in farmers' cooperatives on improved technologies adoption categories in cocoa-based farming systems of South-western Nigeria, International Journal of Cooperatives Studies, 7 (2), 22 – 29.

Kieran, C., Sproule, K., Quisumbing, A. R. & Doss, C. R. (2017) Gender gaps in land ownership across and within households in four Asian Countries. Journal of Land Economics, 93 (2), 342 – 370.

Kieran, C., Sproule, K., Doss, C., Quisumbing, A. & Kim S. M. (2015) Examining gender inequalities in land rights indicators in Asia. Journal of agricultural economics, 46, 119 – 138.

Maziya-Dixon, B., Akinyele, I. O., Sanusi, R. A., Oguntona, T. E., Nokoe, S. K., & Harris, E. W. (2006) Vitamin A deficiency is prevalent in children less than five years of age in Nigeria. J Nutr. 136, 2255 – 2261.

McNulty, E. & Oparinde, A. (2015) Cassava value chain in Nigeria: A review of the literature to inform the integration of vitamin A cassava. HarvestPlus Research for Action, No. 4.

Micronutrient Initiative (2014) www.micronutrient.org/english/View.asp?x=596. Accessed October 11, 2017.

Micronutrient Initiative (2009) Investing in the future: Global Report 2009. http://www.unitedcalltoaction.org/documents/Investing_in_the_future.pdf.

Mishra, K. & Sam, A. G. (2016) Does women's land ownership promote their empowerment? Empirical evidence from Nepal. World Development, 78, 360 – 371.

Muhammad-Lawal, A., Salau, S. A. & Ajayi S. A. (2012) Economics of improved and local varieties of cassava among farmers in Oyo State, Nigeria. Ethiopian Journal of Environmental Studies and Management, 5 (2).

Naved, R. T. (2000) Intra-household impact of the transfer of modern agricultural technology: A gender perspective. Editorial by Quisumbing R. A. in Household Decisions, Gender, and Development; A Synthesis of Recent Research, pp.103 – 106.

Nguema, A., Norton, G. W., Fregene, M., Sayre, R. T., & Manary, M. (2010) Economic benefits of meeting nutritional needs through bio-fortified cassava: an example from Nigeria and Kenya. Af. J. Agric. Resour. Econ. 6, 1 – 17. doi: 10.22004/ag.econ.156956.

Nweke, F. I., Spencer, D. S. C., & Lynam, J. K. (2002) The Cassava Transformation: Africa's best kept secret. Michigan State University, East Lansing, Michigan, pp. 273.

Obisesan, A. A. (2014) Gender differences in technology adoption and welfare impact among Nigerian farming households. http://mpra.ub.uni-muenchen.de/58920/ [Google Scholar]

Obisesan, A. A. (2013) Credit accessibility and poverty among smallholder cassava farming households in South-West, Nigeria, Greener. J. Agric. Sci. 3 (2), 120 – 127.

Ogunyinka, O. & Oguntuase, A. (2020) Analysis of cassava production and processing by various groups in support of cassava value chain in the south west of Nigeria. ISABB Journal of Food and Agricultural Sciences, 9 (1), 11 – 19.

Ojo, S. O. & Ogunyemi, A. I. (2014) Analysis of factors influencing the adoption of improved cassava production technology in Ekiti State, Nigeria. International Journal of Agricultural Sciences and Natural Resources 1 (3), 40 – 44.

Olaosebikan, O., Abdulrazaq, B., Owoade, D., Ogunade, A., Aina, O., Ilona, P. & Parkes, E. (2019) Gender-based constraints affecting bio-fortified cassava production, processing and marketing among men and women adopters in Oyo and Benue States, Nigeria. Physiological and Molecular Plant Pathology, 105, 17 – 27.

Olatade, K. O., Olugbire, O. O., Adepoju, A. A., Aremu, F. J. & Oyedele, P. B. (2016) How does farmers' characteristics affect their willingness to adopt agricultural innovation? The case of bio-fortified cassava in Oyo State, Nigeria. International Journal of Science and Technology, 5 (2), 59 – 75.

Omodamiro, R., Oti, E., Etudaiye, H., Egesi, C., Olasanmi, B. & Ukpabi, U. (2012) Production of fufu from yellow cassava roots using the odourless flour technique and the traditional method: Evaluation of carotenoids retention in the fufu. Adv. App. Sci. Res. 3 (5), 2566 – 2572.

Onyeneke, R. U., Amadi, M. U. & Anosike, F. C. (2019) Bio-fortification in Nigeria: A systematic review. AIMS Agriculture and Food, 4(4), 892–906.

Onyeneke, R. U., Emenekwe, C. C., Munonye, J. O., Olaolu, M. O., Izuogu, C. U., Ibrahim-Olesin, S., Njoku, C. L. & Obi, J. N. (2020) Adoption of bio-fortified pro-vitamin-A cassava and health outcome of farming households in Abia and Anambra States, Nigeria. Journal of Agricultural Extension, Vol. 24 (2), 80 – 91.

Oparinde, A., Banerji, A., Birol, E. & Ilona, P. (2016) Information and consumer willingness to pay for bio-fortified yellow cassava: Evidence from experimental auctions in Nigeria. Agricultural Economics, 47 (2), 215 – 233.

Oparinde, A., Bamire, S., Adepitan, A., Ajayi, A., Ala, M., Birol, E., Asare-Marfo, D., Tahirou, A. & Ilona, P. (2012) Situation analysis of cassava farmers' current varieties and practices in Oyo State, Nigeria. HarvestPlus Qualitative Draft Report. Washington, D.C., USA: International Food Policy Research Institute.

Oparinde, A. A., Banerji, E. B. & IIona, P. (2014) Information and consumer willingness to pay for bio-fortified yellow cassava evidence from experimental auctions in Nigeria. HarvestPlus working Paper No. 13. Washington DC: International Food Policy Research Institute.

Owombo, P. T., Adiyeloja, D. K., Koledoye, G. F. & Ijigbide, M. A. (2012) Gross margin analysis of Amaranth vegetable production in Ondo State, Nigeria: A gender perspective. Journal of Agriculture and Biodiversity Research, 1 (6), 91 – 96.

Phillips, T. P., Taylor, D. S., Sanni, L. & Akoroda, M. O. (2004) A cassava industrial revolution in Nigeria: The potential for a new industrial crop. Food and Agriculture Organization of the United Nations, Rome, Italy.

Sagar, K. T., Huo, T., Maziya-Dixon, B. & Faila, M. L. (2009) Impact of processing on retention and bio-accessibility of carotene in cassava (*Maniholt esculanta,* Crantz). J. Agric. Food Chem. (57), 1344 – 1348. https://doi.org/10.1021/jf803053d.

Sangoyomi, T. E. (2013) Status of cassava production, distribution and utilization in Osun State, Nigeria. International Journal of Agricultural Science and Research (IJASR), 3 (1), 1 – 6.

Sodiya, C. I. & Oyediran, W. O. (2014) Contribution of melon production to livelihood sustainability of rural farming households in Oyo State, Nigeria. Journal of Biology, Agriculture and Healthcare, 4 (12).

Stein, A. J. & Qaim, M. (2007) The human and economic cost of hidden hunger. Food and Nutrition Bulletin. 28 (2), 125.

Tahirou, A., Abass, A., Maziya-Dixon, B., Tarawali, G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V. & Ayedun, B. (2014) Awareness and adoption of improved cassava varieties and processing technologies in Nigeria. Journal of Development and Agricultural Economics, 6 (2), 67 – 75.

Tesfaye, K., Zaidi, P. H., Gbegbelegbe, S., Boeber, C., Rahut, D. R., Getaneh, F., Seetharam, R., Erenstein, O. & Stirling, C. (2016) Climate change impacts and potential benefits of heat-tolerant maize in South Asia. Theor. Appl. Climatol, 130, 959 – 97.

Theis, S., Lefore, N., Meinzen-Dick, R. & Bryan, E. (2018) What happens after technology adoption? Gendered aspects of small-scale irrigation technologies in Ethiopia, Ghana, and Tanzania. Agric. Hum. Values 35, 671 – 684. https://doi.org/10.1007/s10460-018-9862-8.

Tufa, A. H., Alene, A. D., Manda, J., Akinwale, M. G., Chikoye, D., Feleke, S., Wossen, T. & Manyong, V. (2019) The productivity and income effects of adoption of improved soybean varieties and agronomic practices in Malawi. World Development, 124 (C), 1-1.

Usman, M. B., Aaasa, O. S., Balogun, O. S. & Yahaya, U. F. (2020) Profitability and Productivity analysis of tractorized and non-tractorized maize production in Lere Local Government Area of Kaduna State, Nigeria. International Journal of Research and Innovation in Applied Science (IJRIAS), 5 (1), 2454 – 6194, ISSN.

Welch, R. M. & Graham, R. D. (2004) Breeding for micronutrients in staple food crops from a human nutrition perspective. Journal of Experimental Botany, 55 (396), 353 – 364.

World Health Organization (2009) Global prevalence of vitamin A deficiency in populations at risk: 1995 – 2005. WHO Global Database on Vitamin A Deficiency; Geneva: 2009.