



Assessment of some plant growth promoting rhizobacteria on the seedling vigor index, growth of kenaf (*Hibiscus cannabinus* L. *Malvaceae*) and soil chemical properties

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Abstract

A screen house study was carried out at the Institute of Agricultural Research and Training, Ibadan, Nigeria to evaluate the effect of plant growth promoting rhizobacteria (PGPR), as biofertilizers on the growth of kenaf and on the soil chemical status. A seed germination bioassay was carried out to screen ten PGPR isolates for their effects on the germination and growth of kenaf. Two most effective PGPR were further assessed by pot experiments at two different cropping cycles using two varieties of kenaf (IfeKen DI 400 and Cuba 108). The treatments used include *Bacillus subtilis* 1, *Stenotrophomonas maltophilia*, *Bacillus subtilis* 1 + *Stenotrophomonas maltophilia*, NPK fertilizer and the un-inoculated control. The seed germination bioassay showed that some of the PGPR significantly ($P < 0.05$) influenced the number of germinated seeds, length and vigour index of the seedlings when compared to the control. *Bacillus subtilis* 1 and *Stenotrophomonas maltophilia* had the highest vigour index of 1048.0 and 1049.6 for Cuba 108 and 1074.6 and 1088.0 for Ifeken DI 400, respectively.

Inoculation of Cuba 108 and Ifeken DI 400 with PGPR showed enhanced plant heights with increase of 2.22 to 16.0% and 0.8 to 89.7% respectively when compared to the un-inoculated control during both cropping cycles. An increase of 2.1 to 35.3% and 2.2 to 47.5% in the stem girth was recorded for Cuba 108 and Ifeken DI 400, respectively over the un-inoculated control. The effects of the bio-fertilizers on soil micro and macro-nutrients showed significant differences ($P < 0.05$) between the cropping cycles, varieties and the treatments applied. During the first cropping cycle, the PGPR effectively enhanced the soil status for some of the macro and micronutrients but was not effective for most chemical parameters during the second cropping cycle. The application of the PGPR enhanced the growth of the two kenaf varieties as well as the availability of some micro and macro nutrients and thus can be seen as prospective bio-fertilizers which can be incorporated into kenaf production for enhanced growth.

Keywords: *Bacillus subtilis*, Bio-fertilizer, crop performance, effective PGPR, germination percentage, *Stenotrophomonas maltophilia*

Introduction

Kenaf (*Hibiscus cannabinus* L. *Malvaceae*) is an annual fibre crop closely related to cotton (*Gossypium hirsutum* L. *Malvaceae*) and okra (*Abelmoschus esculentus* L. *Malvaceae*) (Webber *et al.*, 2002). It can be successfully produced in many countries including Nigeria due to its ability to adapt to various ecological zones, its environmental friendliness and low gestation period (Ibrahim and Ogunwusi,

2017). It belongs to the genus *Hibiscus* that comprises about 400 annual and perennial species. Kenaf is originally from Africa, more specifically Tanzania and Kenya (Xu *et al.*, 2013). Kenaf is a good source of low cost natural fibre for a wide range of industrial products such as building materials, adsorbents textiles, livestock feed and fibres, and pulp for paper industries (Taylor and Kugler, 1992; Webber and Bledsue, 1993). The demand

for energy, chemicals, and fibers is presently as vital as food, mostly because the consumption rate keep increasing (Hein, 2005; Sims *et al.*, 2006).

Proper fertility maintenance, especially supplemental nitrogen application, is needed to optimize kenaf yields, and minimize production costs. Agronomic practices such as soil amendment may be able to improve its productivity and biomass quality (Alexopoulou *et al.*, 2007). However, as a result of the inherent differences between soil types with respect to soil fertility, soil texture, organic matter, and pH, there is a wide range of reported responses to fertilizer applications on kenaf crop production (Webber *et al.*, 2002). Fertilizer application rates for kenaf differ from one place to another, depending on the nutrient status of such soils. The fertilizer recommendation for kenaf fibre production is 60 kgN/ha of N.P.K. (20:10:10) and 40 kgN/ha for seed production (Ogunbodede and Adediran, 1996). Chemical fertilizers have been widely used in agriculture but by reason of irregular application of chemical fertilizers and their detrimental effects on human and soil health a lot of emphasis is being laid to sustainable alternatives such as bio-fertilizers to provide nutrition requirement of plants (Astarai and Kochaki, 1996; Zakaria, 2009). Bio-fertilizers are defined as products containing active or latent strains of soil microorganisms, either bacteria alone or in combination with algae or fungi that increase the availability and uptake of mineral nutrients by plants (Malusa and Vassilev, 2014). They are composed of a large population of a specific or a group of beneficial microorganisms which colonizes the rhizosphere or the interior of

the plant when applied to seeds, plant surfaces, or soil, and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Vessey, 2003). Bio-fertilizers in comparison with chemical fertilizers have enormous economic and environmental advantages, they are eco-friendly, in-expensive, utilize renewable resources. Hence, they are becoming increasingly popular in many countries and for many crops (Sahoo and Tuteja, 2013).

The microorganisms in bio-fertilizers restore soil's natural nutrient cycle and build soil organic matter, improve soil fertility and maintain the natural habitat of the soil (Jacoby *et al.*, 2017). Hence they have been shown to have a special importance as appropriate replacement for chemical fertilizers, through the improvement of soil fertility and providing nutrition requirement of plants (Komalah, 2010). An important group of soil microbes which have generated interest as biofertilizers due to their plant growth beneficial traits are the Plant growth-promoting rhizobacteria (PGPR). The use of PGPR as bio-fertilizers stimulate plant growth through various mechanisms such as nutrient acquisition, mobilization, storage and cycling, phytohormone production, bio-control activities, organic matter transformation and soil structure improvement (Hayat *et al.*, 2010; Ahemad, 2012).

There is dearth of information on the effect of plant growth promoting rhizobacteria on the growth of kenaf and on soil chemical properties in Nigeria. Thus, this present study was conducted to identify effective plant growth promoting bacteria suitable for bio-fertiizer development for the sustainable production of kenaf.

Methodology

Study area

The study was carried out at the Institute of Agricultural Research and Training (7° 23' N; 3° 51'E and 160 m above mean sea level), Obafemi Awolowo University, Moor Plantation Ibadan South Western Nigeria.

Source of seeds

Two varieties of kenaf: Ifeken DI 400 and Cuba 108 were used for the research work. The kenaf seeds were sourced from the kenaf and Jute programme of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan.

Source of PGPR

Ten plant growth promoting rhizobacteria (PGPR) that have been identified through molecular characterization were collected from the soil microbiology laboratory of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan. The ten PGPR collected and used for the study include the following; *Bacillus subtilis*, *Bacillus cereus* 1, *Bacillus subtilis* 2, *Stenotrophomonas maltophilia*, *Pseudomonas aeruginosa* 1, *Bacillus megaterium* 1, *Pseudomonas aeruginosa* 2, *Bacillus subtilis* 3, *Bacillus megaterium* 2 and *Bacillus cereus* 2.

Preparation of PGPR inoculum

McCartney bottles containing 10 ml of prepared and sterilized Luria-Bertani broth were inoculated with the plant growth promoting bacteria. These were incubated at 30 °C in an orbital incubator shaker for 3 days at 130 rpm after which the bacterial cells were harvested by centrifugation at 4000 rpm for 10 mins and the bacterial cells

were adjusted to 10⁸ cfu/ml in sterile normal saline water.

Seed Sterilization and Inoculation

Kenaf seeds were surface-sterilized with 70% ethanol for 2 minutes and in 2% sodium hypo chloride for 2 minutes followed by washing in sterile distilled water for ten times. The surface sterilized seeds were inoculated by soaking in the respective PGPR suspension for 45 minutes at 30 °C.

Seed germination bioassay

In order to determine the effect of the isolates on germination and seedling vigour, 10 seeds each were inoculated with each of the 10 isolates and incubated in ten 9 cm petri dishes on two layers of moistened filter paper while seeds treated with sterile normal saline served as the control. In order to maintain sufficient moisture for germination, 5 ml distilled water was added to the petri dishes every other day, and seeds were incubated at 28 ± 2 °C in a light incubator. The experiment was replicated three times and the number of germinated seeds, the root and shoot length were measured after the seventh day. The germination percentage and vigour index was also calculated as stated below.

Germination rate (%) =

$$\frac{\text{number of seeds germinated}}{\text{total number of seeds}} \times 100$$

Vigour Index = % germination × mean seedling length (root + shoot)

Screen-house studies

Two PGPR that showed the highest vigour index were selected for further studies. Treatments used include; T1: *Bacillus subtilis*; T2: *Stenotrophomonas maltophilia*; T3: *Bacillus subtilis* +

Stenotrophomonas maltophilia; T4: 60kg/ha NPK; T5: Un-inoculated control. The Soils were sterilized and filled in 5 kg pots, four seeds were inoculated by soaking them in the respective rhizobacterial suspension and they were planted in the pots. The treatments were carried out in three replicates, pots were arranged in a Completely Randomized Design (CRD) and the plants were later thinned to two plants per pot after two weeks. Data were collected for plant height, number of leaves per plant and stem from two weeks after sowing (WAS) up till 6 WAS.

Soil chemical analysis

Chemical analyses were carried out for the pre-cropping and post-harvest soil samples collected, by following standard procedures. Chemical properties of soils were determined by standard methods. Soil pH was determined in 1:1 soil/water suspension using the pH-meter (Rowell, 1994), organic carbon content by the Walkley-Black method (Bahadori and Tofghi, 2016), total nitrogen by the Kjeldahl method (Tel and Jansen, 1992) and available P by the method of Olsen *et al.* (1954). Exchangeable bases were extracted with 1 M NH₄OAc (pH 7.0) to determine K and Na using flame photometer and exchangeable Mg and Ca by atomic absorption spectrophotometer (Sparks, 1996).

Statistical analysis

Data collected were subjected to analysis of variance using Statistical Analysis System (SAS, version 9.0, 2004), and means separated using Duncan's Multiple Range Test (DMRT), where means were found to be significant at 5% level of probability.

Results

Seed germination bioassay

The effects of 10 PGPR on the growth and vigor index of kenaf is presented in Table 1. Both *Bacillus subtilis* 1 and *Stenotrophomonas maltophilia* significantly ($P < 0.05$) enhanced higher seed germination, seedling length and vigour index of the plants than other bacteria strains in Ife Ken D1400 and Cuba 108. The seed germination percentage ranged from 33.3% to 83.3% for both Ife Ken D1400 and Cuba 108 variety of kenaf. The highest seed germination was recorded by seeds inoculated with *Bacillus subtilis* 1 for Ife Ken D1400 while seeds inoculated with *Stenotrophomonas maltophilia* showed the highest germination percentage for Cuba 108. The bacteria isolates also enhanced the kenaf seedling length when compared to the un-inoculated control seeds, Ife Ken D1400 had a seedling length of 9.5 to 13.6 cm while a range of 7.1 to 13.1 cm was recorded for Cuba 108. Out of the tested isolates, only *Bacillus subtilis* 3 showed a lower seedling length than the control for Ife Ken D1400 while *Bacillus cereus* 1, *Bacillus subtilis* 2 and *Pseudomonas aeruginosa* 1 showed lower seedling lengths than the control for Cuba 108. For Ife Ken D1400, *Stenotrophomonas maltophilia* showed the highest effect on the seedling length while the highest effect on the seedling length for Cuba 108 variety was induced by *Bacillus subtilis* 1. The vigour index ranged from 269.7 to 1088 for Ife Ken D1400, the highest value of vigour index was recorded by *Stenotrophomonas maltophilia* treated seeds and this was followed closely by *Bacillus subtilis* 1 while the lowest value

Table 1: Effect of plant growth promoting bacteria on seed germination and vigor index of kenaf

Kenaf variety	Isolate code	Germination rate (%)	Mean seedling length (cm)	Vigor index
Ife Ken D1400	<i>Bacillus subtilis1</i>	83.3 _a	12.9 _a	1074.6 _a
	<i>Bacillus cereus1</i>	33.3 _d	8.1 _c	269.7 _c
	<i>Bacillus subtilis2</i>	43.0 _{cd}	10.8 _b	464.4 _d
	<i>Stenotrophomonas maltophilia</i>	80.0 _a	13.6 _a	1088.0 _a
	<i>Pseudomonas aeruginosa1</i>	60.0 _b	10.1 _b	606.0 _c
	<i>Bacillus megaterium 1</i>	63.0 _b	10.4 _b	655.2 _c
	<i>Pseudomonas aeruginosa2</i>	80.0 _a	11.9 _b	952.0 _b
	<i>Bacillus subtilis3</i>	63.0 _b	9.5 _c	598.5 _c
	<i>Bacillus megaterium2</i>	53.3 _{bc}	10.5 _b	559.7 _{cd}
	<i>Bacillus cereus2</i>	50.0 _c	12.7 _a	635.0 _c
Control	60.0 _b	9.75 _c	585.0 _{cd}	
Cuba 108	<i>Bacillus subtilis1</i>	80.0 _a	13.1 _a	1048.0 _a
	<i>Bacillus cereus1</i>	53.3 _{bc}	7.1 _d	378.4 _d
	<i>Bacillus subtilis2</i>	33.0 _d	9.1 _c	300.3 _e
	<i>Stenotrophomonas maltophilia</i>	83.3 _a	12.6 _a	1049.6 _a
	<i>Pseudomonas aeruginosa1</i>	63.0 _b	9.4 _c	592.2 _c
	<i>Bacillus megaterium 1</i>	43.0 _{cd}	10.8 _b	464.4 _d
	<i>Pseudomonas aeruginosa2</i>	80.0 _a	12.1 _a	968.0 _b
	<i>Bacillus subtilis3</i>	63.0 _b	10.1 _b	636.3 _c
	<i>Bacillus megaterium2</i>	46.7 _c	11.5 _b	537.1 _{cd}
	<i>Bacillus cereus2</i>	56.7 _{bc}	11.6 _b	657.7 _c
Control	56.7 _{bc}	9.55 _c	541.5 _{cd}	

Means values followed by different letters along the same column are significantly different according to Duncan multiple range test at P < 0.05.

was observed by *Bacillus cereus1* treated seeds. A range of 300.3 to 1049.6 was observed for the vigour index of Cuba 108 variety, the highest was recorded by *Bacillus subtilis 1* which was followed closely by *Stenotrophomonas maltophilia* treated seeds (1048.0) while the lowest value was recorded by *Bacillus subtilis 2* treated seeds. The result further showed that 80% of the screened isolates showed a greater vigour index than the un-inoculated control for Ife Ken D1400 while 60% of the isolates showed a greater vigour index than the control for Cuba 108.

Effect of plant growth promoting rhizobacteria on kenaf growth parameters in the screen house

Effect of PGPR inoculation on the plant height of kenaf

Results from this study revealed that the applied PGPR strains significantly increased plant height of kenaf over un-inoculated control during both cropping cycles (Table 2). During the first cropping cycle, The result obtained at 6 WAS was similar to what was obtained at 4 WAS. The highest plant height (55.00 cm) was

observed in Ifeken DI 400 plants inoculated with *Stenotrophomonas maltophilia*, followed closely by Cuba 108 plants inoculated with *Stenotrophomonas maltophilia* + *Bacillus subtilis* (51.00 cm). The un-inoculated control had the lowest plant height for both Cuba 108 (44.000 cm) and Ifeken DI 400 (29.00 cm). During the second cropping cycle, At 6 WAS the plant height ranged from 45.00 to 53.67 cm and 41.67 to 51.67 cm, for Cuba 108 and Ifeken DI 400 respectively. The highest plant heights were observed in plants fertilized with NPK while the lowest plant heights were observed in the un-inoculated control

treatment for both varieties. Furthermore, the plant heights recorded in the second cropping were higher although not significantly different from the first cropping, also Cuba 108 appeared to have a higher plant height than Ifeken DI 400 in the first cropping cycle meanwhile in the second cycle, Ifeken DI 400 was higher than Cuba 108.

Effect of PGPR inoculation on the stem girth of kenaf

Similar to the result obtained in plant height, applied PGPR strains also significantly ($P < 0.05$) increased stem girth of kenaf over un-

Table 2: The effect of microbial inoculation on kenaf plant height

Cropping period	Kenaf Variety	Treatments	Plant height (Cm)			
			2 WAS	4 WAS	6 WAS	
First	Cuba108	T1	13.67 ^{bcdefg}	28.33 ^d	46.33 ^{ab}	
		T2	12.67 ^{cdefgh}	27.67 ^d	46.67 ^{ab}	
		T3	14.33 ^{abcdef}	33.67 ^{bcd}	51.00 ^{ab}	
		T4	14.67 ^{abcdef}	34.00 ^{bcd}	49.00 ^{ab}	
	Ifeken DI 400	T5	12.67 ^{cdefgh}	25.67 ^d	44.00 ^{abc}	
		T1	12.33 ^{defgh}	50.00 ^a	55.00 ^a	
		T2	9.67 ^h	35.00 ^{bcd}	39.33 ^{bcd}	
		T3	13.67 ^{bcdefg}	28.00 ^d	33.00 ^{cd}	
		T4	11.33 ^{fgh}	43.33 ^{ab}	49.67 ^{ab}	
		T5	10.50 ^{gh}	25.33 ^d	29.00 ^d	
	Second	Cuba108	T1	17.33 ^a	34.33 ^{bcd}	46.00 ^{abc}
			T2	16.67 ^{ab}	34.67 ^{bcd}	49.67 ^{ab}
			T3	15.00 ^{abcde}	35.33 ^{bcd}	49.00 ^{ab}
			T4	16.33 ^{ab}	41.33 ^{abc}	53.67 ^a
IfekenD1400		T5	15.50 ^{abcd}	28.00 ^d	45.00 ^{abc}	
		T1	16.50 ^{ab}	30.00 ^{cd}	42.00 ^{abc}	
		T2	13.67 ^{bcdefg}	31.67 ^{cd}	42.33 ^{abc}	
		T3	11.83 ^{efgh}	35.67 ^{bcd}	46.67 ^{abc}	
		T4	13.33 ^{bcdefg}	34.87 ^{bcd}	51.67 ^{ab}	
		T5	16.17 ^{abc}	28.67 ^d	41.67 ^{abc}	

Means values followed by different letters along the same column are significantly different

according to Duncan multiple range test at $P < 0.05$.

T1: *Stenotrophomonas maltophilia*; T2: *Bacillus subtilis*, T3: *Stenotrophomonas maltophilia*

+ *Bacillus subtilis*; T4: NPK; T5: un-inoculated control

Table 3: Effect of microbial inoculation on kenaf stem girth

Cropping period	Kenaf variety	Treatments	Stem girth (cm)		
			2 WEEKS	4 WEEKS	6WEEKS
First	Cuba 108	T1	0.63 _{cd}	1.43 _{bcd}	2.20 _{cde}
		T2	0.53 _{cd}	1.47 _{abcd}	2.07 _{cde}
		T3	0.80 _{abcd}	1.80 _a	2.03 _{cde}
		T4	0.70 _{bcd}	1.40 _{bcd}	2.27 _{cd}
		T5	0.57 _{cd}	1.23 _{cdef}	1.60 _{fghi}
	IfekenD1400	T1	0.67 _{cd}	1.73 _{ab}	2.70 _{ab}
		T2	0.57 _{cd}	1.37 _{bcd}	2.37 _{bc}
		T3	0.47 _d	1.10 _{def}	1.87 _{def}
		T4	0.73 _{bcd}	1.53 _{abc}	2.80 _a
		T5	0.53 _{cd}	1.00 _{ef}	1.83 _{efg}
Second	Cuba 108	T1	0.77 _{abcd}	1.17 _{cdef}	1.46 _{fghi}
		T2	0.60 _{cd}	1.17 _{cdef}	1.43 _{ghi}
		T3	0.67 _{cd}	1.13 _{def}	1.47 _{fghi}
		T4	0.50 _d	1.23 _{cdef}	1.57 _{fghi}
		T5	0.47 _d	0.97 _f	1.40 _{ghi}
	IfekenD1400	T1	0.87 _{abc}	1.10 _{def}	1.40 _{ghi}
		T2	0.80 _{abcd}	1.23 _{cdef}	1.60 _{fghi}
		T3	1.10 _a	1.40 _{bcd}	1.80 _{efgh}
		T4	0.63 _{cd}	1.20 _{cdef}	1.47 _{fghi}
		T5	1.03 _{ab}	1.00 _{ef}	1.33 _i

Means values followed by different letters along the same column are significantly different according to Duncan multiple range test at $P < 0.05$.

T1: *Stenotrophomonas maltophilia*; T2: *Bacillus subtilis*, T3: *Stenotrophomonas maltophilia* + *Bacillus subtilis*; T4: NPK; T5: un-inoculated control

inoculated control during both cropping cycle (Table 3). Significant ($P < 0.05$) increase in stem girth of inoculated and fertilized kenaf over the un-inoculated control were observed at 2 WAS and at 4 WAS. During the first cropping, at 6 WAS, the stem girth for Cuba 108 ranged from 1.60 cm (un-inoculated control) to 2.27 cm (NPK fertilizer), while the stem girth of Ifeken DI 400 ranged from 1.83 cm (un-inoculated control) to 2.80 cm (NPK fertilizer). Although NPK fertilizer

treatments had the highest stem girths for both kenaf varieties, the plants inoculated with PGPR also significantly increased the stem girth when compared to the un-inoculated control. During the second cropping, the stem girth for Cuba 108 ranged from 1.40 cm (un-inoculated control) to 1.57 cm ((NPK fertilizer), while the stem girth of Ifeken DI 400 ranged from 1.33 cm (un-inoculated control) to 1.80 cm (*Stenotrophomonas maltophilia* + *Bacillus subtilis*). The highest stem girth observed in

Table 4: Effect of microbial inoculation on number of leaves per plant of kenaf

Cropping period	Kenaf variety	Treatments	Number of leaves per plant		
			2 WEEKS	4 WEEKS	6 WEEKS
First	Cuba 108	T1	6 _{bc}	7 _{cd}	11 _{bc}
		T2	5 _{cd}	6 _{cd}	9 _c
		T3	6 _{bc}	9 _{bc}	13 _{ab}
		T4	5 _{cd}	8 _{bcd}	12 _{bc}
		T5	4 _d	5 _d	9 _c
	IfekenD1400	T1	6 _{bc}	10 _{bc}	12 _{bc}
		T2	5 _{cd}	12 _{ab}	13 _{ab}
		T3	6 _{bc}	9 _b	11 _{bc}
		T4	6 _{bc}	14 _a	16 _a
		T5	6 _{bc}	8 _{bcd}	11 _{bc}
Second	Cuba 108	T1	7 _{ab}	9 _{bc}	11 _{bc}
		T2	6 _{bc}	9 _{bc}	11 _{bc}
		T3	7 _{ab}	10 _{bc}	12 _{bc}
		T4	6 _{bc}	9 _{bc}	11 _{bc}
		T5	6 _{bc}	9 _{bc}	12 _{bc}
	IfekenD1400	T1	7 _{ab}	9 _{bc}	12 _{bc}
		T2	7 _{ab}	10 _{bc}	13 _{ab}
		T3	8 _a	10 _{bc}	14 _{ab}
		T4	7 _{ab}	10 _{bc}	12 _{bc}
		T5	7 _{ab}	9 _{bc}	11 _{bc}

Means values followed by different letters along the same column are significantly different according to Duncan multiple range test at $P < 0.05$.

T1: *Stenotrophomonas maltophilia*; T2: *Bacillus subtilis*, T3: *Stenotrophomonas maltophilia* + *Bacillus subtilis*; T4: NPK; T5: un-inoculated control

NPK fertilizer treatment for Cuba 108 during the second cropping was significantly higher than other treatments but not significantly different from plants inoculated with *Stenotrophomonas maltophilia* + *Bacillus subtilis*. On the other hand, the highest stem girth (1.80 cm) observed in *Stenotrophomonas maltophilia* + *Bacillus subtilis* for Ifeken DI 400 was significantly different from the others. In addition, to the variations observed in stem girths on weekly basis, results obtained also showed that stem girth measurement recorded in the first cropping were significantly higher than the second

cropping. It was also observed from result obtained that the stem girth values of Ifeken DI 400 was higher than stem girth recorded for Cuba 108 during both cropping cycles, these values were however significantly higher in the first cropping but not significantly different in the second cropping.

Effect of PGPR inoculation on the number of leaves per plant of kenaf

The effect of the PGPR inoculants on the number of leaves per plant of kenaf are shown in Table 4. In the first cropping and at 6 WAS, the kenaf plants varied significantly

Table 5: Effect of PGPR inoculation on primary and secondary soil nutrients

TREATMENTS		pH (H ₂ O)	T.N	P	K	Org. M	S	Na	Ca	Mg	ECEC	
			g kg ⁻¹	mg kg ⁻¹	Cmol kg ⁻¹	g kg ⁻¹	mg kg ⁻¹			cmol kg ⁻¹		
1st	T1	6.16f	0.09bcd	6.88g	0.63c	2.05h	2.05h	7.81l	0.35cd	1.97ghi	0.38de	3.43fg
Cuba108	T2	6.39cd	0.11abc	2.75r	0.57de	2.05h	2.05h	10.15i	0.35cd	1.85hi	0.533cde	3.39g
	T3	6.33de	0.12ab	4.2033n	0.58d	2.47d	2.47d	10.63f	0.53a	2.05fgh	0.26e	3.56efg
	T4	5.78i	0.08cde	6.75h	0.74b	3.54a	3.54a	11.3d	0.35cd	2.89a	0.33e	4.44bcd
	T5	5.57j	0.09bcd	5.89k	0.54def	2.28f	2.28f	6.89m	0.35cd	2.46cd	0.39de	3.84cdefg
	T1	5.96h	0.12ab	5.33l	0.72b	2.75b	2.75b	10.89e	0.35cd	2.25def	0.32e	1.69h
IfekenD1400	T2	6.48ab	0.08cde	3.54p	0.86a	2.14g	2.14g	12.24b	0.42b	1.99ghi	1.3ab	0.65i
	T3	6.52a	0.12ab	3.46q	0.53ef	2.13g	2.13g	12.48a	0.32cd	2.43cd	0.32e	3.743defg
	T4	5.44k	0.14a	3.75o	0.58d	2.66c	2.66c	10.31h	0.32cd	1.943ghi	0.22e	3.19g
	T5	5.37k	0.12ab	4.94m	0.55def	2.38e	2.38e	11.63c	0.35cd	2.783ab	0.39de	4.16bcdef
	2nd	T1	6.04gh	0.06de	8.73d	0.37hi	1.4005l	1.4005l	8.73k	0.36c	2.1fgh	1.33ab
Cuba108	T2	5.95h	0.07de	10.22b	0.47g	1.3832l	1.3832l	6.29p	0.33cd	2.16efg	1.08abcd	4.14bcdef
	T3	6.42bc	0.09bcd	10.51a	0.33ij	1.0201o	1.0201o	6.42o	0.33cd	1.76i	1.14abc	3.65efg
	T4	6.18f	0.07de	10.04c	0.4h	1.5907k	1.5907k	11.38d	0.36c	2.39cde	1.18abc	4.44bcd
	T5	6.25ef	0.07de	8.16f	0.52f	1.3256m	1.3256m	6.08q	0.33cd	1.52j	1.08abcd	3.53fg
	T1	6.06g	0.05e	3.55p	0.28k	1.2449n	1.2449n	9.26j	0.33cd	2.63bc	1.25abc	4.54abc
IfekenD1400	T2	6.18f	0.11abc	8.51e	0.37hi	1.7636j	1.7636j	10.2267hi	0.34cd	2.94a	1.48ab	5.23a
	T3	5.99gh	0.07de	5.95k	0.47g	1.608k	1.608k	5.97r	0.33cd	2.73ab	0.94bcde	4.58abc
	T4	6.02gh	0.09bcd	6.07j	0.3967h	1.9883i	1.9883i	10.4333g	0.33cd	2.143fg	1.75a	4.42bcd
	T5	5.97gh	0.09bcd	6.54i	0.31jk	1.7636j	1.7636j	6.77n	0.31d	2.45cd	1.67ab	4.85ab

Means values followed by different letters along the same column are significantly different according to Duncan multiple range test at P < 0.05.
 T1: *Stenotrophomonas maltophilia*; T2: *Bacillus subtilis*; T3: *Stenotrophomonas maltophilia* + *Bacillus subtilis*; T4: NPK; T5: un-inoculated control

Table 6: Effect of PGPR inoculation on soil micronutrients

TREATMENTS		Mn	Zn	B	Fe	Cu	
		mg kg ⁻¹					
1st	T1		44.64fg	1.09i	0.13de	108.88q	1.54ab
Cuba108	T2		28.11k	1.19efghi	0.2b	96.77t	1.62a
	T3		20.72m	1.56ab	0.13de	157.98h	1.22bcd
	T4		38.97ij	1.28defgh	0.11efg	142.65k	1.39abc
	T5		44.6fg	1.32cdef	0.14cd	123.12n	1.18bcde
	T1		40.15i	1.36cd	0.13de	128.12m	0.97defg
IfekenD1400	T2		45.34f	1.14ghi	0.14cd	104.96r	1.07cdef
	T3		14.59o	1.173fghi	0.06ij	115.29o	1.36abc
	T4		16.94n	1.22defghi	0.12def	103.92s	1.14cde
	T5		60.54c	1.287defg	0.42a	110.65p	1.51ab
	2nd	T1		52.12e	1.12hi	0.09ghi	145.93i
Cuba108	T2		38.53j	1.26defgh	0.05j	202.33a	1.053cdefg
	T3		42.46h	1.35cde	0.1fgh	158.27g	0.913defg
	T4		70.52b	1.31cdef	0.07hij	180.233c	0.907defg
	T5		69.8b	1.46bc	0.05j	174.83d	1.39abc
	T1		42.77h	1.13ghi	0.05j	133.3l	0.69g
IfekenD1400	T2		84.59a	1.62a	0.14cd	163.487e	1.073cdef
	T3		24.45l	1.32cdef	0.05j	159.43f	0.73fg
	T4		43.4gh	1.65a	0.17bc	143.05j	1.227bcd
	T5		56.62d	1.51ab	0.05j	182b	0.83efg

Means values followed by different letters along the same column are significantly different according to Duncan multiple range test at P < 0.05.

T1: *Stenotrophomonas maltophilia*; T2: *Bacillus subtilis*; T3: *Stenotrophomonas maltophilia* + *Bacillus subtilis*; T4: NPK; T5: un-inoculated Control

($P < 0.05$) in the number of leaves produced. The highest number of leaves (13) produced by Cuba 108 was observed in the treatment with *Stenotrophomonas maltophilia* + *Bacillus subtilis* and it was significantly higher than the other treatments, this was followed closely by NPK fertilizer (12 leaves per plant). On the other hand, the highest number of leaves recorded for Ifeken DI 400 in the first cropping (16) was observed in treatment with NPK fertilizer, this was followed by 13 leaves per plant obtained in treatment with *Bacillus subtilis*. The un-inoculated control however recorded the lowest number of leaves for Cuba 108 (9 leaves per plant) and Ifeken DI 400 (10 leaves per plant). During the second cropping, the number of leaves obtained from kenaf varieties in all the treatments was not significantly different from each other. However, the highest number of leaves per plant recorded for Cuba 108 (12) was obtained in treatments with NPK fertilizer and *Stenotrophomonas maltophilia* inoculated plants while the highest number of leaves per plant for Ifeken DI 400 (14) was obtained in NPK fertilizer treatments. This was however followed closely by treatment with *Stenotrophomonas maltophilia* + *Bacillus subtilis* (13 leaves per plant).

Soil chemical analyses

The results of the soil analysis carried out at first and second cropping cycle showed that there were significant differences in most of the soil chemical parameters determined (Table 5 and Table 6). The pH of the soils as a result of the inoculation of the PGPR was slightly acidic while total N was low. Inoculation with *Bacillus subtilis* was effective in increasing the soil pH over the control (6.25) while the two PGPR were not

effective for increasing the total N. Available P was low as a result of the inoculation of the kenaf seed. Exchangeable K increased over the control and was either moderately available or high as a result of the inoculation of the seeds with *Bacillus subtilis* for plots with Ifeken DI 400. Organic matter was low as a result of the inoculation of both PGPR either singly or when combined and this signifies the ability of these organisms for nutrient uptake and not nutrient retention. Exchangeable Na and Mg were also highly available due to the sole and combined effect of the inoculated PGPR. The capacity of the soil to retain nutrients was low irrespective of the PGPR used. For the micronutrients, available Mn, Zn and Fe increased in the second cropping cycle. Available Mn, Zn and Cu were moderately available while Fe was the most abundant. The two varieties of kenaf responded positively to the treatments applied and this was evident in the result showing the effect of the PGPR on the varieties of Kenaf.

Discussion

In the present study, the inoculation of kenaf seeds with selected isolates improved seedling emergence and growth. The findings of the study is in conformity with those of Sakthivel *et al.* (2009) who observed that seeds treated with *Pseudomonas fluorescens* enhanced the seed germination and vigor index of tomato. Ashrafuzzaman *et al.* (2009) also reported that seed bacterization have better germination and emergence of rice seedlings. Increase in seedling length as a result of seed inoculation with PGPR has also been reported by Suryanto *et al.* (2010) who showed an increase of 54.55% increase in seedling length over absolute

control. The enhancement of the germination and seedling growth could be as a result of one of many mechanisms exhibited by PGPR which are achieved simultaneously or independently at different stages of plant growth to increase the growth and improve development of plants. These mechanisms include phosphorus solubilization, improvement of plant nutrients uptake and phytohormone production (Zaidi *et al.*, 2009). Other mechanisms such as ability of the PGPR isolates to reduce the incidence of seed mycoflora have been suggested to be one of several mechanisms which may indirectly enhance seed germination and vigour index (Begum *et al.*, 2003).

PGPR inoculation with *Stenotrophomonas maltophilia*, *Bacillus subtilis* and their consortium (*Stenotrophomonas maltophilia* + *Bacillus subtilis*) significantly significantly increased growth parameter such as plant height, stem girth and number of leaves of kenaf plant under greenhouse conditions. Several researchers have also reported increased plant growth as one of the benefits of microbial inoculants (Botelho *et al.*, 1998; Babalola and Glick, 2012). The increase in plant heights observed in some of the kenaf plants inoculated with PGPR could be as a result of one or more of the various mechanisms employed by PGPR for plant promotion as stated earlier. In addition, the increase in plant height could be due to synthesized auxins an important phytohormone which can influence root development which improves uptake of essential nutrients thus increasing plant agronomic traits (Vikram, 2007). According to Alori *et al.* (2019), increase in maize plant height, plant girth, and leaf length were observed in both screen house

and field experiments with *PGPR inoculation*. Alemu and Alemu (2015) also reported ability of microbial inoculants to improve plant growth and productivity as well as plant nutrient uptake over the uninoculated treatments. Agreeing with several research findings, this study also follows the thought that the impact of microbial inoculants on kenaf growth were influenced by strains of microbial inoculants and crop genotype. Even though the microbial inoculants performed in varying degree as to how it influenced the growth of kenaf.

Nitrogen, phosphorus and potassium among other nutrients and factors have been considered as the major limiting factors in the development of kenaf (Adekunle *et al.*, 2014). In addition, kenaf has high fertilizer requirement (FAO, 2002) and therefore supplementary addition of fertilizers has been established as being necessary in kenaf production (Agbaje *et al.*, 2008). Different organic sources have been used for the production of kenaf especially the use of compost (Hossain *et al.*, 2011) but with constraints of bulkiness and the high rate of application. However, the use of organisms as bio-inoculants for increased plant growth and nutrients have been discovered as an alternative and more eco-friendly organic source. The increase in soil pH observed as a result of the inoculation of the kenaf seeds with the organisms could have been due to the observed increase in the soil organic matter (Opala *et al.*, 2012). Rhizobacteria has been screened and discovered to be phosphorus solubilizers (Krey *et al.*, 2013) and this was evident in the moderate availability of P. The increase in exchangeable K observed as a result of the seed inoculation with *Bacillus subtilis* could be attributed to the

organism ability to increase soil micro and macro nutrients (Yolcu *et al.*, 2012). Increase in available S observed would be a contributing factor to the plant growth observed and subsequently the crop yield. The secondary nutrients were also significantly increased and this could be one of the multiple effects of the seed inoculation with bacteria, which will promote plant growth and the availability of nutrients (Turan *et al.*, 2014). *Bacillus subtilis* have been discovered to increase soil micronutrients (Radhakrishnan *et al.*, 2017) but this was also observed for soils where *Stenotrophomonas maltophilia* was inoculated. However, soil micro and macro nutrients could not be retained in the soil and this was evident in the decrease in soil nutrient observed for most of the chemical parameters determined after the second cropping cycle. This could be due to the fact that kenaf, with its deep tap root and wide spreading lateral root system, is considered to be an excellent user of residual nutrient from previous cropping (Wilson, 2003). Generally, plant growth promoters have been known to increase plant nutrient uptake rather than retain the nutrients (Bargaz *et al.*, 2018).

Conclusion

The use of plant growth promoting bacteria for the germination and growth of kenaf is a promising area in agriculture which should be exploited. *Stenotrophomonas maltophilia*, *Bacillus subtilis* and their consortium can be seen as a potential bio-fertilizer for kenaf production. However, the result of this research work is not conclusive as further research work to determine the effect of these bacteria on all growth parameters of kenaf, nutrients concentration in plant tissue and

subsequently the yield of kenaf would contribute to the sustainable production of kenaf whereby the overdependence on agrochemicals for its production is reduced.

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Prospects of Combined Peroxide Oxidation, Aeration and Adsorption-Filter Treatment Processes in Abatement of Pollution Characteristics in Cassava Processing Wastewater

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Abstract

The study investigated the efficacy of a treatment sequence consisting of a peroxide oxidation, aeration and adsorption-filtration at four different carbon depths in controlling pollution parameters from cassava processing wastewater. Analysis of results obtained revealed that concentration of selected physico-chemical parameters of effluent drawn from the established treatment lines were all within the Federal Environmental Protection Agency's standards for discharge to water bodies with the exception of Total Suspended Solids (TSS). Statistical analysis of results using ANOVA showed that the effect of carbon depth on concentration of considered parameters was not significant ($p > 0.05$) for iron, manganese, calcium and zinc while all other parameters were significant. The separation of effluent parameter means done by Duncan multiple range tests also revealed that the means of values from the four columns were not significantly ($p > 0.05$) different for iron, manganese, mercury, nickel, zinc and phenol ions while those for colour, nitrate, TDS and TSS solids were all significantly different. All other considered parameters however had two or more parameters sharing mean values that were grouped as not being significantly different. The particle index comparison for the treatment processed revealed that the dual filter media columns exhibited a more stable working when it came to turbidity treatment. The study concluded that the effluent from the sand filter and 5 cm carbon depth dual media treatment process could be safely discharged to watercourse or used for irrigation purposes.

Keywords: Aeration, Cassava, Filtration, Hydrogen peroxide, Wastewater

Introduction

In most developing countries, the issue of land and water pollution resulting from activities of large cassava processing communities has been given very little attention due to the uncoordinated nature of the industry. In cassava processing communities, huge quantity of wastewater and solid waste are generated and could constitute an environmental menace where not adequately managed. In Nigeria, high levels of cassava effluent are produced daily and indiscriminately drained onto nearby, streams, rivers and agricultural

lands, thereby, constituting a serious environmental hazard. Not only does the effluent result in a strong stench, it could also result in loss of aquatic life due to its toxic nature. More recently the problem of effluent from processing operation and their disposal has gained public recognition. In many areas of the world, especially the developing countries, these environmental issues are the same (Okonko *et al.*, 2006; Shittu *et al.*, 2007). In South Western Nigeria, cassava mill is one of the major industries and the mills are on many occasions sited in areas where the effluent is

capable of causing pollution on arable lands and fresh water sources. According to Izonfuo *et al.* (2013) and Ehiagbonare *et al.* (2009) evidence have shown that concentration of contaminants present in soil samples obtained around cassava processing sites were higher than recommended values.

Pollution from cassava processing wastewater has been observed to be responsible for a number of agricultural and environmental issues which include inducement of stresses and delay in germination of plants (Nwaogu *et al.*, 2011), mutation of plant genes (Olorunfemi *et al.*, 2011) etc. According to Wade *et al.* (2002) and Ariyomo (2017) effluent from cassava processing has also been observed to have toxic effects on aquatic life. There is therefore the need for treatment of wastewater from agricultural processing activities before they are discharged into the water courses or open fields in order to reduce potential environmental hazards as suggested by Ewemoje *et al.*, (2011).

Water is a resource that is unique to the earth and also crucial to the existence of life. Many authors have argued that access to clean water is gradually dwindling due to continuous pollution of existing water bodies. Over the last century, continued population growth and industrialization have resulted in the degradation of various ecosystems on which human life relies on (Chan *et al.*, 2009). As the world population increases the availability of clean water becomes a critical issue. According to Rowell (2006) it is estimated that by the year 2025, there would be an additional 2.5 billion people on the earth that will live in a region already lacking sufficient clean water. The study is therefore aimed at establishing four different treatment lines

and comparing the efficiencies of these four treatment sequences to confirm if any of them could offer a viable option for recycling wastewater from cassava processing activities for use in irrigation and safe discharge to water courses.

Materials and Methods

The treatment process consisting of a peroxide oxidation process followed by an aeration process then simultaneous filtration and adsorption-filtration processes was set up at the Department of Agricultural and Environmental Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria. The schematic of the treatment process employed is shown in Figure 1. Wastewater used for the treatment process was collected from a cassava processing industry in airtight opaque containers and kept in ice bag while transporting to maintain biological state at source.

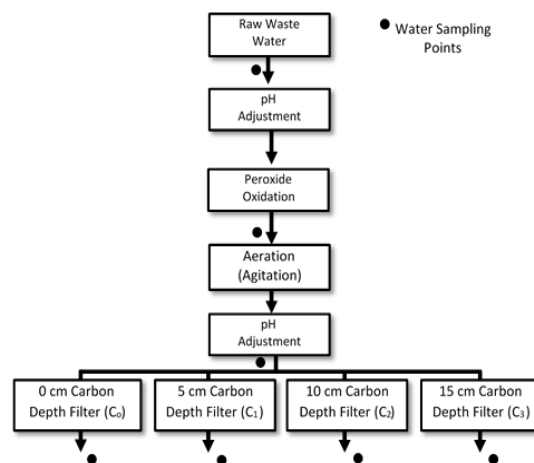


Figure 1: Schematic diagram of treatment process

Peroxide Oxidation Process

The collected wastewater was adjusted to a pH range between 10 and 11 by adding 0.5 M of NaOH to the oxidation tank in order to have the CN content in solution as

suggested by Caruso (1995) in order to have 99% CN remain in solution. Hydrogen peroxide at 50% concentration was then added at 0.025 ml/l of wastewater (about 0.5 g H_2O_2 /g of CN) for the oxidation process. The wastewater was thereafter left for a period of 3 hrs to ensure a reasonable level of oxidation and cyanide destruction. A sample of the effluent from the aeration chamber was obtained in a clean sterilised PET bottle and stored in an ice bucket to preserve it until end of the treatment process.

Aeration Process

After the peroxide oxidation process an aeration chamber incorporating a vertical axis paddle aeration system powered by a fractional power electric motor with dimensions as shown in Figure 2 was used in the aeration process.

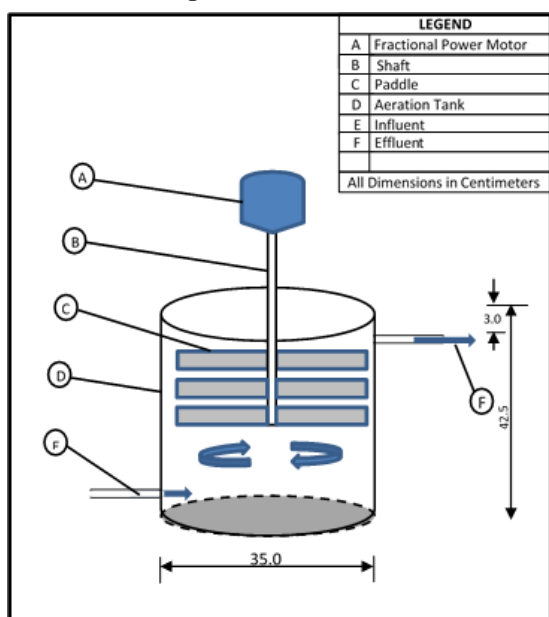


Figure 2: Aeration chamber

The wastewater was agitated by the aerator's paddle system for a period of 1 hour at a speed of 65 rpm as recommended

by Omotosho (2017). The effluent in the chamber was displaced from by fresh effluent which was released into the chamber from the inlet of the aeration chamber to effect slow displacement at a rate of 0.25 l/min to ensure that the system does not become overloaded. A sample of the effluent from the aeration chamber was obtained in a clean sterilised PET bottle and also stored in an ice bucket to preserve it until end of the treatment process.

Filtration and Adsorption-Filter Processes

Three adsorption-filtration dual media columns and one control column with external dimensions 0.18 m \times 0.18 m square base and 0.65 m height were constructed from 4 mm thick transparent Perspex materials and filled with sand and charcoal varied at three different levels. The control was filled with only the washed, graded sand while the three adsorption filter columns (C_1 - C_3) were filled with the washed, graded sand (0.5-2.0 mm) and charcoal (50-300 μ m) in alternate formation thereby making it a dual media filter. The dimensions and configuration of sand and carbon materials in the columns from bottom to top were:

C_0 = 65 cm sand.

C_1 = 50 cm sand followed by 5 cm carbon followed by 10 cm sand.

C_2 = 45 cm sand followed by 10 cm carbon followed by 10 cm sand.

C_3 = 40 cm sand followed by 15 cm carbon followed by 10 cm sand.

The oxidized and aerated wastewater was then introduced simultaneously into the control and dual filter media (Figure 3) columns at a flowrate of 1.0×10^{-2} l/s as recommended for intermediate slow sand

filter media by Environmental Protection Agency (1995). Flow was maintained for a period of 6 hrs and filtrate was collected from the bottom of the columns at an interval of 1hr in clean sterilized PET bottles then kept in an ice bucket for preservation before analysis. The experimental procedure was done in 4 replicates. Physical parameters such as colour, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), turbidity, odour, were determined in accordance with WHO/EC combined standards, following the methods described by Ademoroti, (2006). Chemical parameters such as light and heavy metals like Cadmium(Cd), Zinc (Zn), Nitrogen (N), Chlorine (Cl), Phosphorus (P), Iron (Fe), Nickel (Ni), Magnesium (Mg), Manganese (Mn), Mercury (Hg) and Calcium (Ca) were determined by spectrophotometry using AAS machine with HNO_3 as the reagent. Biological parameters such as Biochemical Oxygen Demand (BOD_5) and Dissolved Oxygen (DO) were determined in accordance with WHO/EC combined standards, following the procedures described by Ademoroti (2006). The analysis of cyanide content of the water was carried out with the aid of a spectrophotometer (Spectrumlab 23A) using the alkaline picrate method. The sample was first be subjected to centrifuging at the speed of 4,200 rpm for about 6 min. The obtained clear supernatant was separated and used for the test using a spectrophotometer at the recommended wavelength and pH range. Blanks which contained pure distilled water were also placed together with the samples in the spectrophotometer, these were used for calibration and quality check.

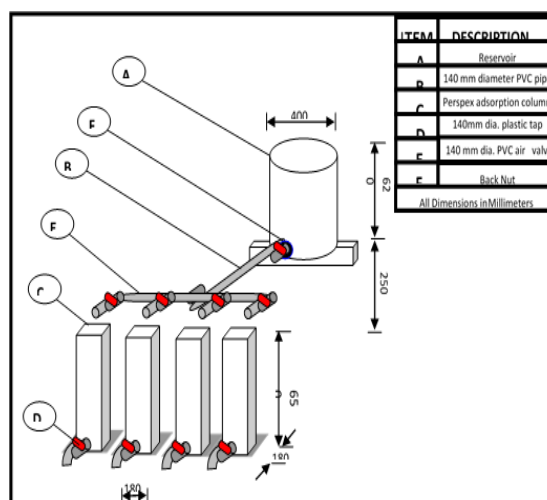


Figure 3: Filtration and adsorption-filtration setup

Turbidity of water samples were used as a measure of the filter medium straining efficiency and was measured using a turbidimeter (HACH-2100) while the escaped particles were analysed by particle diameter measuring meter (LATS-1) as suggested by ASTM (2007). Indices, which were considered for evaluation of filter efficiency, were the EPN (escaped particle number) and the PI (particle index). The PI was calculated by multiplying the EPN with particle diameter (PD) as suggested by Gholikandi *et al.* (2012).

After the hydrogen peroxide oxidation process (Table 1) it was observed that the concentration of cyanide dropped by 0.34 mg/l which signified an 85% reduction, this may have been principally due to cyanide destruction process which converts cyanide to cyanate as stated by Young and Jordan (1995). All other physico-chemical parameters present were also reduced this may have been due to a number of reactions such as peroxide stabilization/decomposition and metal ion precipitation as observed by different authors, Haber and

Table 1: Comparison of initial and final water quality of the treatment lines with FEPA/NESREA standards and separation of significant means within measured parameters using Duncan's Multiple Range Tests

S/N	Parameter*	FEPA/NESREA Standard		O	A	B	Final Water Quality [?]				P-value
		Water	Land				C ₀	C ₁	C ₂	C ₃	
1	Colour ^m	7	-	3.12	2.33	3.13	2.03 ^a	1.67 ^b	1.50 ^{b,c}	1.33 ^c	0.0011
2	Mg ²⁺	200	-	45.00	33.83	30.17	29.33 ^a	26.6 ^a	23.33 ^b	23.33 ^b	0.0024
3	CN ⁻	0.1	-	0.40	0.06	0.02	0.02 ^a	0.02 ^a	0.00 ^b	0.00 ^b	<0.0001
4	SO ₄ ²⁻	500	1,000	15.3	7.42	4.65	3.89 ^a	2.37 ^b	2.17 ^c	2.13 ^c	<0.0001
5	NO ₃ ⁻	20	-	1.35	0.75	0.45	0.32 ^a	0.28 ^{a,b}	0.22 ^{b,c}	0.18 ^c	0.0336
5	Fe ²⁺	20	-	0.85	0.62	0.57	0.50 ^a	0.50 ^a	0.47 ^a	0.43 ^a	0.2886
7	PO ₄ ³⁻	5	10	0.97	0.53	0.33	0.23 ^a	0.17 ^{a,b}	0.17 ^{a,b}	0.13 ^c	0.0375
3	Mn ²⁺	5	-	0.05	0.03	0.02	0.02 ^a	0.02 ^{a,b}	0.02 ^{a,b}	0.02 ^b	0.0896
9	Cl ⁻	600	-	36.45	21.82	18.28	17.37 ^a	15.47 ^b	14.68 ^c	14.38 ^c	<0.0001
10	Cd ²⁺	< 1	-	0.04	0.02	0.02	0.02 ^a	0.02 ^a	0.01 ^b	0.01 ^b	0.007
11	Hg ²⁺	0.05	-	0.00	0.00	0.00	0.00 ^a	0.00 ^a	0.00 ^a	0.00 ^a	--
12	Ni ²⁺	< 1	-	0.04	0.02	0.02	0.01 ^a	0.01 ^a	0.01 ^a	0.01 ^a	--
13	Ca ²⁺	200	-	250.67	82.00	73.67	74.33 ^a	72.00 ^{a,b}	71.50 ^{a,b}	69.67 ^b	0.0676
14	Zn ²⁺	< 1	-	0.82	0.52	0.43	0.37 ^a	0.37 ^a	0.37 ^a	0.30 ^a	0.2424
15	Phenol	0.2	-	0.09	0.01	0.00	0.00 ^a	0.00 ^a	0.00 ^a	0.00 ^a	--
16	TDS	2,000	200	612.50	759.56	863.67	603.56 ^a	198.22 ^b	193.00 ^c	107.67 ^d	<0.0001
17	TSS	30	-	2318.44	2166.33	1972.11	1263.33 ^a	1746.67 ^b	1716.67 ^c	1668.33 ^d	<0.0001
18	Coliform Count ⁿ	400	500	36333.30	12666.70	2466.70	323.33 ^a	450.00 ^a	730.00 ^b	753.00 ^b	0.0005
19	BOD ₅	50	500	111.33	76.89	67.33	40.44 ^a	24.00 ^b	16.11 ^c	16.89 ^c	<0.0001

^m Lovibond Units

ⁿ Most Probable Number (MPN)/100 ml

* All units mg/l unless otherwise stated

? Superscripts with the same letters along the row are not statistically different at $p < 0.05$.

O = Raw wastewater, A = Peroxide oxidised wastewater, B = Aerated wastewater,
C₀ = Carbon depth 0 cm, C₁ = Carbon depth 5cm, C₂ = Carbon depth 10 cm,
C₃ = Carbon depth 15cm

Weiss (1934); Baciocchi *et al.* (2004); Mecozzi *et al.* (2006); Badmus *et al.*, (2007); Omotosho and Amori (2015) and Dongwook *et al.* (2015). Biological Oxygen Demand was also observed to have reduced by 31.44 mg/l this may also have been due to the effect of release of oxygen during the peroxide decomposition process leading to increase in Dissolved Oxygen (Sindhi and Mehta, 2014) content which is usually in inverse proportion to BOD. The coliform count value in the water was also observed to have reduced after the process. This trend may have been due to coliform inactivation by hydrogen peroxide as observed by Vargas *et al.* (2013). The aeration process was observed to have no effect on the heavy metal (mercury, cadmium and nickel) content of the wastewater. The concentrations of other physico-chemical parameters were however observed to have reduced after the aeration process. BOD₅ level was also

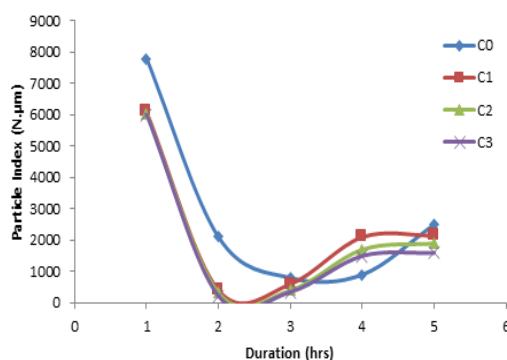
observed to have further reduced after the process. This reduction may have been caused by increase in dissolved oxygen resulting from agitation of the wastewater which would have caused trapping of atmospheric oxygen in the water as the process went on this reduction in BOD₅ values after aeration process was also observed by Lalwani and Devadasan (2013). The coliform count was observed to have dropped by 10,200 MPN/100 ml after the wastewater passed through the aeration process this trend was also observed by Radhi and Borghei (2017) and this may have been due to elimination of weak coliform matter by physical agitation.

Concentration of physico-chemical parameters in the effluent drawn after the filtration process (C₀) as revealed in Table 1 shows that all parameters were below FEPA/NESREA's upper limits for discharge to land and water course with the exception of TSS. This reveals that there is a

need for inclusion of a sedimentation tank at the end of the treatment line. The BOD₅ and coliform count levels were also within limits of the effluent standard. Analysis of effluent drawn from the adsorption-filter columns (C₁, C₂ and C₃) reveals that similar to the filtration process, the concentration of all the physico-chemical parameters were also below the FEPA/NESREA's discharge limits for land and water with the exception of TSS. However the coliform count level observed in the 10 and 15 cm carbon depth columns (C₂ and C₃) were above FEPA/NESREA's upper limits for discharge to land and water. The result obtained from the 5 cm carbon depth column (C₁) was within the limit for land application but above the limit for water discharge. This reveals that only the C₁ column could be considered for irrigation. The trend in coliform count as observed in the adsorption-filter processes could have been due to the moisture retention capacity of the carbon contents of the columns which offered favourable environment for microbial culturing during periods of dormancy. The BOD₅ concentration of effluents from all the adsorption-filters were below FEPA/NESREA's standard for discharge to land and water. It was also noticed that the BOD₅ reduction increased with increase in carbon depth.

The particle index (P.I.) comparison graph (Figure 4) revealed that dual media filters (C₁, C₂ and C₃) exhibited a very sharp reduction to their respective lowest values over the first 1 hour of filter operation before the index began to rise back their respective equilibrium positions this noticed trend was different for the sand filter column which exhibited a continuous decrease in P.I. over the first 3 hours before

picking up to a P.I. value which was higher than what was obtainable in the dual filter media. The trend noticed was similar to what was observed by Gholikandi *et al.* (2012), however for this system the quick response and stabilisation time may have been due to the effect of carbon particle adsorption within the filter medium thus improving the filter medium efficiency. In summary it can be deduced that the adsorption-filters could offer a viable option of treatment if sedimentation and chlorination treatment lines were incorporated to the setup.



The *p*-value obtained from ANOVA showed that the effect of carbon depth on concentration for considered parameters were not significant ($p < 0.05$) for iron, manganese, calcium and zinc only while all others were significant. The separation of effluent parameter means done by DMRT revealed that the mean of values from the four columns were not significantly ($p > 0.05$) different for iron, manganese, mercury, nickel, zinc and phenol ions while those for colour, nitrate, total dissolved solids and total suspended solids were all significantly different. All other parameters however had two or more parameters sharing mean values that were grouped as not being significantly different.

Conclusions

The treatment of effluent from cassava processing was successfully carried out using the treatment lines combining peroxide oxidation, aeration, filtration and adsorption-filtration processes. The result showed that treatment lines were able to bring BOD₅ as well as considered physico-chemical parameters below the upper limits for discharge to water and land with the exception of TSS. The C₂ and C₃ treatment lines were however unable to reduce Total coliform count to acceptable range for discharge to land and water. Effluent from C₁ treatment line was within the limit for discharge to land but above that for discharge to water course. The C₀ (without carbon) treatment line was adequate in controlling the coliform count to range below the limit for land and water discharge. The treatment line C₀ was the most effective in treating the wastewater. It can therefore be concluded that the treatment line offered the most viable option in terms of cassava processing wastewater recycle and reuse and could serve as an asset for agricultural production especially in areas with limited water supply.

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Economic Analysis of Swine Production in Osun State, Nigeria

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Abstract

Pork plays a very important role in bridging the protein gap in Nigeria by increasing the potential of protein intake in households. This study aimed to determine the socio-economic characteristics, costs, returns and the constraints affecting swine production in Osun State, Nigeria. Primary data were collected with the aid of well-structured questionnaires from 100 respondents using multistage sampling techniques. Data were analysed using descriptive statistics and budgetary analysis. The results showed that most (82 %) of the respondents were male, married (84 %), had tertiary education (68 %), have family size 4-6 (72 %), had more than 5 years' experience (70 %), kept 50-150 (62 %), had no access to formal credit (58 %), were not visited by extension agents (62 %) and 86 per cent got their replacement stock from on-farm birth. Budgetary analysis revealed that average revenue per farmer was ₦ 2,134,575.00; Gross margin was ₦ 693,238.00 and Net Farm Income was ₦ 641,094.00. The major constraints facing swine production are feeding cost, cost of medication, lack of fund. It was concluded that swine production is a profitable business.

Keywords: Budgetary, Economics, Osun, Production, Swine

Introduction

Agriculture is considered a major sector of Nigeria's economy. It is a source of employment and accounts for more than one-third of the total Gross Domestic Product (GDP) and labour force (FAO, 2003). As a result of the ever increasing human population in Nigeria and virtually static agricultural productivity, the animal protein consumption among Nigerians has worsened in the past few years (Okpor, 2009). The FAO (2003) recommended that on the average basis, a man's daily protein intake should be between 65-75g and 53 % should be animal-based. However, the average daily intake in Nigeria has been found to be below this level. Ajala *et al.* (2007) observed that only 8.4g of the recommended 53.8g of protein consumption levels of Nigerians is derived from animal sources which means there is

less than 16% contribution of animal products to protein consumption of Nigerians. Studies by Ogunniyi and Omoteso (2011) revealed that animal protein has become a luxury instead of a dietary necessity since only a certain class of citizens find it convenient to buy. Ugwu (2006) observed that animal protein, apart from its palatability, is essential for normal physical and mental development of man. In view of this, there is a need to increase the production of domestic animals which are conventional sources of animal protein. Pigs have some desirable characteristics (especially its prolificacy) which make it a good species of animals to multiply extensively to supply animal protein shortages.

A study by Ogunniyi and Omoteso (2011) showed that the neglect or slow growth of the swine industry can be attributed to reasons which include religion, acceptability and above all, management

problems. Social factors that could influence pig production in Nigeria include a general preference for ruminant meat and lack of incentives for investing in large scale pig production due to economic and political factors. There's also a popular belief that pigs are filthy and pose hazard to health because some people are of the belief that pork has too much fat. This is untrue for pigs that are produced under modern intensive husbandry production techniques as pigs can be very clean animals (Ajala *et al.*, 2007) and when fed properly, can have low back fat content. Another important reason is the presence of a large population of Muslims in Nigeria especially in the northern part where eating of pork is a religious taboo.

Nevertheless, swine production has contributed to the socio-economic development of Nigerians through improved income, employment, improved nutrition and wellbeing of the farmers. Pig is an omnivore which in some respect competes with man for food but is also efficient utiliser of by-products and waste from human feeding. One of the major advantages of pigs is their ability to convert different kinds of feed including kitchen waste to meat (Rahman *et al.*, 2008). Another noticeable advantage pig has over other livestock species is good feed-to-meat conversion. Considering general feed conversion, pig is the most efficient farm animal in the conversion of feed energy to body energy (Umeh *et al.*, 2015). This gives them a rapid growth rate and leads to early maturity. The high rate of productivity is another major advantage of pigs. They are highly prolific, polyestrous and capable of producing up to 2-2.5 litters per year (Litter per sow is 9.96) which is as a result of their short gestation period that is between 3-

4months (Okoli, 2006). They have higher carcass weight compared to other red meats producing animals. MSUE (2011) revealed that the pig is a more efficient carcass yielder than cattle, sheep or goat and has an average dressing percentage of about 70 % compared to 62 % for cattle and 50 % for sheep and goat. In addition to this, pig carcasses have a smaller proportion of bones and higher proportion of edible meat. Pig manure is a valuable fertiliser and can be aerobically digested to produce cooking gas. It also stimulates the growth of micro-organisms for feeding fresh water fish and ducks (Okoli, 2006).

In view of the above, the study examined the socio-economic characteristics of pig farmers, evaluated the cost benefit ratio and identified the constraints of swine production among farmers in the study area. Understanding the profitability and constraints associated with swine farming can help improve productivity and gains in swine production. An increase in output will help to meet the present demand for animal protein in Nigeria and in turn increase the profit of farmers. This would make financial institutions willing to give loan to swine farmers with the assurance of getting their money back with interest in due time.

Materials and Methods

The study was conducted in Osun State, Nigeria. The state is located in south west Nigeria and lies within Latitude 7.0° and 9.0° and Longitude 2.8° and 6.8°. Osun State is one of the six states that make up the south west geo-political zone in Nigeria. It has interstate boundaries with Ondo State to the south east, Kwara State to the North, Ekiti State to the north east, Oyo State to the West and Ogun State to the south west.

Osun State has a landmass of 9,251 km². The state has a considerable number of highly urban settlements with a population of about 3,423,535 inhabitants, representing 2.45% of Nigeria's total population. In the rural areas, majority of the inhabitants are farmers cultivating both food and cash crops and rearing livestock while in the urban areas, they are mostly traders, artisans and civil servants.

A multi-stage random sampling procedure was used to collect data from the farmers. The first stage was a purposive selection of Osun East Senatorial district because of the intensity of livestock rearing in the area. The second was the selection of two Local Government Areas (LGAs): Ife Central and Ilesa East Local Government Areas using simple random sampling. The third involved the random selection of five villages from each of the two LGAs. The fourth and final stage was the selection of ten farmers from each of the villages using simple random sampling. This gave a total of 50 respondents from each of the selected LGAs and a sum total of 100 respondents in all.

The primary data were collected using well-structured questionnaires on socio-economic characteristics of the respondents, physical quantities and prices of inputs and output in the area during 2016/17 production season. Data collected were analysed using descriptive statistics and budgetary analysis. Budgetary analysis involves estimation of gross revenue and total cost of production period. The difference between the two estimates gives a measure of net income (Kainga and Seiyabo, 2012). The budgetary model enables the analyst to assess the profitability or otherwise of an agricultural production system. The model delineates

the cost and revenue structure of a production system with a view to estimating its income-generating potential or profitability.

A total farm budget approach was adopted to estimate cost and returns accruing to each of the farmer. A budget can be defined as the quantitative expression of total farm plan, summarising the income, cost and profit. Also the Gross Margin (GM) which is the difference between Total Revenue (TR) and Total Variable Costs (TVC) was calculated. Total Cost (TC) which is the sum of the Total Variable Cost (TVC) and the Total Fixed Cost (TFC) was also evaluated.

$$TC = TVC + TFC \dots\dots\dots (1)$$

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

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

$$\text{Profit } (\pi) = TR - TC \dots\dots\dots (4)$$

Total Variable Cost which is also referred to as the operating cost, is the cost incurred in the purchase of inputs like fertiliser, pesticides, wages paid to labour for different farm operations and the cost incurred in the purchase of farm implements. Total revenue is the sum of all income generated from the sale of all farm output.

Results and Discussion

Social-economic characteristics of the respondents

As indicated in Table 1 only 54 % of the respondents were below 50 years of age and 46 % were above 50. The mean age was 42.6±29.08. This implies that majority of the pig farmers were in their active years. These findings agree with that of Ogunniyi and Omoteso (2011) and Osondu *et al.* (2014) who both reported an average age of 41.38 and 44.38 respectively for swine

farmers. It was observed that majority (82 %) of the respondents were males while only a few (18 %) were females. This is in consonance with Osondu *et al.* (2014) who reported 81.66 % (male) and 18.34 % (female). The reason for a larger number of males compared to that of females in swine farming may be due to the rigours involved in swine farming. Also it is believed that females are more involved in the sales aspect rather than the production aspect. Majority (84 %) of the respondents were married, 12 % were single while the divorced and widowed constituted 2 % each. This agrees with the findings of Umeh *et al.* (2015) who reported 83.3 % married, 10 % single and 6.7 % widowed or divorced among pig farmers. This result implies that majority of the respondents in the study area were married and therefore had the opportunity of getting assistance from their spouses. This is also a reflection of the strong moral values attached to the marriage institution in the study area.

Majority (68 %) of the respondents had tertiary education while 14 % had secondary education. The remaining (12 and 6 %) had just primary and non-formal education respectively (Table 1). This implies that majority of the respondents are well educated and this assists them to take informed decisions on their farming activities for higher productivity. This agrees with findings of Oni (2014) who indicated that high literacy is evident among swine farmers. The average household size was 5.1 ± 1.77 . This result indicates a relatively high household size and this will enhance the availability of family labour for swine farming. The mean years of experience of swine farmers in the study area was 11.5 ± 9.66 suggesting that swine farmers in the area are not new to the

enterprise and are more likely to make better decisions to enhance productivity and profit. This finding conforms to that of Umeh *et al.* (2015) who reported an average number of years of swine farmers' experience to be 11.08 years.

The mean size of production was 96.1 ± 77.14 implying that swine farming is dominated by medium scale farmers. More than half (58 %) of the respondents had no access to formal credit. This implies that policy makers need to sensitise formal institutions on the profitability of swine farming. This agrees with the findings of Osondu *et al.* (2014) who reported that majority of swine farmers had no access to formal credits. The study revealed that majority (86 %) of the farmers got their replacement stock by on-farm births while 14 % got theirs from both birth and purchase. This finding implies that farmers prefer a cheaper way of restocking and have trust in the offspring of their old stock implying that research institutes were not patronized for replacement stock.

Cost and returns (?) in swine farming

The estimated total cost of production was ₦ 1,493,480.00 and total return was ₦ 2,134,575.00 to individual swine farmers in the enterprise (Table 2). The variable inputs were breeding stock, feed, drugs/vaccines and medications, electricity, fuel and transportation, labour, repairs and other costs. Feed constituted the highest percentage (76.62 %) of the total cost. This is in line with reports by Ogunniyi and Omoteso (2011) that feeding constitutes the largest percentage of variable cost in swine production. This was followed by labour (6.40%), fuel and transportation (5.32 %), medication (3.21 %) repairs and other costs (2.9 %), breeding stock (2.0 %) while

Table 1: Socio-economic characteristics of swine farmers in Osun State, Nigeria

Parameter	Frequency	Percentage	Mean
Age range (Years)			
< 30	8	8.0	
30 - 39	14	14.0	42.6
40 - 49	32	32.0	
50 – 59	36	36.0	
>60	10	10.0	
Gender			
Male	82	82.0	
Female	18	18.0	
Marital status			
Married	84	84.0	5.1
Single	12	12.0	
Divorced	2	2.0	
Widowed	2	2.0	
Size of household			
1 - 3	12	12.0	
4 - 6	72	72.0	11.5
7 - 9	16	16.0	
Level of education			
No formal education	6	6.0	96.1
Primary education	12	12.0	
Secondary education	14	14.0	
Tertiary education	68	68.0	
Farming experience			
1-5	30	30.0	
6-10	34	34.0	
11-15	10	10.0	
>15	26	26.0	
Scale of swine production			
<50			
50 – 150	18	18.0	
>150	62	62.0	
Access to formal credits	20	20.0	
Yes			
No	42	42.0	
Source of replacement stock	58	58.0	
Birth	86	86.0	
Purchase	0	0	
Inheritance	0	0	
Gift	0	0	
Birth and Purchase	14	14	

Source: Field Survey, 2017

electricity constituted the least cost (0.1 %). Sharma *et al* (1997), Adetunji and Adeyemo (2012) reported that labour is a key factor in profitability of pig business in Haiti and Nigeria respectively. The Net Farm Income (NFI) per farm was ₦ 641,094.00 while Gross Margin was ₦ 693,238.00. The Profitability Index was 0.30 while Rate of Return on Investment (RRI) was 42.9. This implies that for every Naira invested in the swine farming enterprise, there was a return

of ₦ 42.9 to the enterprise. Operating Expenses Ratio (OER) was 67.52. This indicates that 67.52 % of revenue was used to cover operating expenses and the remaining 32.48 % was the farmer's equity. The Capital Turnover Value (CTV) was 3.08. This implies that for every Naira invested in swine production, ₦ 3.08 was returned as farm revenue. These measures of performance show that swine production enterprise is viable. This corroborated the

Table 2: Average costs and returns (₦ per farmer) of swine farmers in Osun State, Nigeria

S/N	Item	Mean amount(₦)	Percentage of Revenue/Costs
1	REVENUE		
I	4743.5kg of live pigs at ₦450 per kg	2,134,575	
A	Total Revenue (TR)	2,134,575	
2	VARIABLE COST		
I	Breeding stock	29,178	1.95
Ii	Feeds	1,144,356	76.62
Iii	Medication	47,882	3.21
Iv	Electricity	1,504	0.10
V	Fuel/Transportation	79,656	5.33
Vi	Labour	95,560	6.40
Vii	Repairs and other costs	43200	2.89
B	Total Variable Cost (TVC)	1,441,336	96.51
C	Gross margin (GM) = (TR – TVC)	693,238	
3	FIXED COST		
I	Depreciation on building	38,544	2.58
Ii	Depreciation on reservoir	600	0.04
Iii	Opportunity cost of land	13,000	0.87
D	Total Fixed Cost (TFC)	52,144	3.49
E	Total Cost (TC) = (TFC + TVC)	1,493,480	
F	Net Farm Income (NFI) = (TR – TC)	641,094	
G	Rate of Return on Investment (ROI) = F/E * 100		42.93
H	Operating Expenses Ratio (OER) = B/A * 100		67.52
I	Capital Turnover (CTO) = A/C		3.08
J	Profitability Index (PI) = F/A		0.30

Source: Field Survey, 2017

Constraints in Swine Production

Farmers were faced with many problems in the study area. Nine of these problems were analysed and ranked in order of importance (Table 3). They were; poor quality of breeding stock, high cost of feeding, inadequacy of fund, susceptibility to diseases and sensitivity to environmental factors, high cost of drugs and vaccines, loss of swine to theft, disease outbreak, injuries and weather conditions. Similar production constraints were reported by Muhanguzi *et al* (2012) in Uganda; by Petrus *et al* (2011) in Namibia; by Kagira *et al* (2010) in western Kenya. The constraints were on a scale of 1 to 5 in order of importance to individual farmers: Very important problem (1), important problem

(2), less important problem (3), not important problem (4) and not a problem at all (5). This is in line with the study of Nabikyu and Kugonza (2016) who researched on profitability analysis of selected piggery businesses in peri-urban communities of Kampala Uganda.

High cost of feeding ranked first with a mean value of 1.18. This agrees with the earlier findings of Khem *et al* (1997) and Babovic *et al* (2011) who reported increase in feed costs as one of the major challenges in the pig enterprises, which in turn leads to reduction in profits. The assertion is corroborated by Hofstrand (2009) who reported that higher feed prices can quickly convert profits into losses. High cost of drugs and vaccines with a mean value of

Table 3: Constraints in swine production

Variables	Very important problem	Important problem	Less important problem	Not important problem	Not a problem at all	Mean	Rank
Poor quality of breeding stock	4(4.0)	56(56.0)	28(28.0)	12(12.0)	0(0.0)	2.48	4th
High cost of feeding	86(86.0)	12(0.0)	2(0.0)	0(0.0)	0(0.0)	1.18	1st
Inadequate fund	42(42.0)	40(40.0)	18(0.0)	0(0.0)	0(0.0)	1.76	3rd
Susceptibility to disease & env.	0(0.0)	0(0.0)	8(8.0)	92(92.0)	0(0.0)	3.92	6th
High cost of drugs & vaccines	86(86.0)	12(0.0)	2(0.0)	0(0.0)	0(0.0)	1.20	2nd
Loss of swine to theft	0(0.0)	0(0.0)	0(0.0)	8(8.0)	92(92.0)	4.92	9th
Disease outbreak	8(8.0)	0(0.0)	2(2.0)	50(50.0)	40(40.0)	4.14	7th
Injuries	0(0.0)	6(6.0)	30(30.0)	62(62.0)	2(2.0)	3.60	5th
Weather condition	0(0.0)	0(0.0)	8(8.0)	10(10.0)	90(90.0)	4.90	8th

Source: Field survey, 2017

1.20 ranked second. Inadequacy of fund ranked third with a mean value of 1.76. Poor quality of breeding stock ranked fourth with a mean value of 2.48. Injuries ranked fifth with a mean value of 3.60. Susceptibility to diseases and sensitivity to environmental factors ranked sixth with a mean value of 3.92. Disease outbreak ranked seventh with a mean value of 4.14 while weather conditions and theft ranked eighth and ninth respectively with mean values of 4.90 and 4.92 respectively.

Strategies to combat swine production constraints

With the information obtained from the farmers, various strategies have been developed to solve the constraints faced. The problem of high feeding cost was managed by giving animal locally available feedstuff, crop residues and household wastes. High cost of drugs and vaccines though difficult to avoid was reduced through sanitation and cleanliness in the swine house and its surroundings. When in need of capital, funds can be borrowed from friends and family or mature pigs can be sold since there is usually market for them to raise the younger ones. Breeding stock should be sourced from reputable farms with trusted stock if the ones on the farm are not performing to standard. Injuries should be treated as quickly as possible to avoid infection thereby increasing cost of production as medication will need to be administered. Susceptibility to diseases and environmental factors can also be reduced through proper sanitation. Disease outbreak can be controlled by separating sick animals from the rest of the herd immediately it is noticed. A diagnosis of the disease should be carried out

promptly and when the disease is untreatable the animal should be culled.

Weather conditions are not really a problem for pigs but they can be given more feed in cold weather because some of their feed are used to generate heat. Water pits should be provided in their pens where they can cool off when the weather is hot or the animals can be sprayed with water by the farmer in the absence of that. The problem of theft can be controlled by fencing the pens but almost all the farmers claimed their pigs never get stolen.

Conclusion

Based on the findings from the study, it was concluded that majority of the pig farmers were males below 50 years of age, married, had household size above 5, and had tertiary education. The largest proportion of swine production was on medium scale. Most had no access to formal credits facilities, were not visited by extension agents and got their replacement stock through on-farm births. It was also revealed through the budgetary analysis that swine production is a profitable enterprise. The main problems facing swine production in order of importance were high cost of feeding, high cost of drugs and vaccines, inadequacy of fund, poor quality of breeding stock, injuries, susceptibility to diseases and sensitivity to environmental factors, disease outbreak, weather conditions and theft.

Recommendations

Based on the findings from this study, the following recommendations were made in order to improve the profitability of swine production in Osun State, Nigeria.

Government should establish feed mills to help in the production of swine feeds so as to reduce scarcity and hence help bring down

the cost of feeds which is the major constraint in swine production.

Extension workers should be adequately equipped so that they can make regular visits to swine farms. This will increase their level of productivity through the information given to farmers for improvement in their profits.

Breeding stock should be got from reliable source to ensure the production of good and viable offspring. Research institutes can be contacted for good stock.

Credit facilities should be made available with low interest rate so that fund will be readily available to swine farmers to expand their enterprise or for a start-up.

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Determinants of Adoption of Cocoa Rehabilitation Techniques among Cocoa Farmers in Boki Local Government Area of Cross River State, Nigeria

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Abstract

The study assessed the determinants of cocoa rehabilitation techniques (CRTs) among farmers in Boki Local Government Area (LGA) of Cross River State, Nigeria. The study employed a multistage random sampling technique to select cocoa farmers. The first stage was a purposive selection of the LGA. A total of eighty seven (87) cocoa farmers were randomly selected in the LGA. Well-structured questionnaire was used to elicit information from the farmers. CRTs considered in the study were coppicing, complete replanting, side grafting, top grafting, phased farm replanting, fertilizer application and planting under cocoa trees. Data was analyzed using simple descriptive statistics (means, frequencies, percentages), and inferential statistics. Semi-log function was chosen based on the R² value and number of significant variables. About 77.0% and 96.6% percent of the farmers were male and married, respectively. Mean age, household size, farming experience, age of cocoa farms and variance inflation factor (VIF) were 46years±10, 12±7, 24 years ±9 and 18 years±10 and 1.75, respectively. It was revealed that age of farmers, farming experience and educational level of farmers significantly determined CRTs at 1 percent level of probability, respectively. Therefore, it is thus recommended that cocoa farmers in the study area should be encouraged to stay on the farms through provision of infrastructure to reduce rural-urban migration. Credit should be made accessible to the farmers so that they will be able to afford the costs involved in the practice of CRTs. CRIN and other stakeholders in cocoa production should ensure that farmers are encouraged to adopt and practice other CRTs.

Keywords: Determinants, Cocoa Rehabilitation Techniques, Cocoa farmers,

Introduction

Nigeria is the World's fourth largest cocoa producer after Ivory Coast, Ghana and Indonesia, producing about 12 percent of the total world production and Nigeria is the third producer in Africa (World Cocoa Foundation, 2014). Cocoa is the most prominent export crop in Nigeria in terms of production and export capacities (Nwachukwu *et al.*, 2012). According to Adebile and Amusan (2011) cocoa contributes about 15 percent to the total Nigerian export in 1970 and also contributes \$900 million to Nigeria's

economy in 2012 (The Sun, 2013). Nigeria's cocoa production in 2011/12 was put at 300,000 MT, up from 280,000 MT in 2011. The projected increase is based on a favorable weather outlook and significantly higher grower prices, which encouraged farmers to increase the cultivated area (David and Nzeka, 2011). Nigeria's cocoa production continued to increase both in absolute quantity and as a proportion of total world production. Export of cocoa products from Nigeria was \$822.8 million in 2010. This represents about 35 percent of the \$2.32 billion earnings from non-oil

exports in 2010 for Nigeria (Mejabi, 2012). However, the main importers of cocoa from Nigeria are United States of America, Spain, France, Germany and Netherlands. Cocoa and its products exported from Nigeria to these countries include cocoa beans (whole or broken, raw or roasted), chocolate and other food preparations containing cocoa, cocoa paste (whether or not defatted) cocoa powder and cake and cocoa butter (World Cocoa Foundation, 2014). The abundance of suitable land and availability of farm labour enabled the peasant farmers to expand their cocoa hectareage without having to give up the production of their traditional crops (Oni, 2000). However, the fortune of cocoa turned upside down with the discovery of oil in large quantity and this has brought a downward trend in Nigerian cocoa production and position in the world market (Ayoola *et al*, 2000). It was reported that Nigerian cocoa output declined from 399, 200 tonnes in 2010 to about 298, 029 tonnes in 2016 with a growth rate declining from 16.2% to about 12.2% during the period (FAO, 2019). Cote d'ivoire which was placed at a distant third position in Africa with 143,000 tonnes behind Nigeria's 196,000 tonnes in 1970 is now the largest producer of cocoa in the whole world with 12, 824, 717 tonnes while Nigeria with 298,029 tonnes is currently the fourth largest producer after Cote d'ivoire, Ghana and Indonesia (FAO, 2019; ICCO, 2015). Rehabilitation as a word has been used in many different ways and contexts. It has long not had a merging conceptual framework. Traditionally, the word has been used to describe a range of responses to incapability. Rehabilitation in this context is to enable cocoa farms with weaknesses to attain and maintain their

maximum potentials during their life cycle.

According to Opeke (2005), rehabilitation is in two ways, the first is putting a cocoa field back into good condition, while the second way is clearing the old cocoa trees and replanting with young seedlings. It should be noted that the former way is seen to be more preferable to the farmers. This is because, it is cost effective, it enhances early maturity of cocoa trees and it generates quick returns to the farmers than the later. Rehabilitation techniques developed by the Institute include coppicing, complete replanting, side grafting, top grafting, phased farm replanting, fertilizer application and planting under cocoa trees. Empirical studies have been carried out by some authors on the number of years the productivity of cocoa tree is observed to be diminishing. The highest cocoa yield is achieved between 15 and 25 years and a profitable life span may be 50 years. In addition, yield declines gradually and production cost rises steadily from the 26th year of planting (Montgomery, 1981; Olayia, 2001).

Over the years, some of these cocoa trees are seen to be diminishing in productivity due to old age and lack of adequate knowledge of rehabilitation of the old farms among the farmers. Hence, to address these issues, Cocoa Research Institute of Nigeria (CRIN) developed various Cocoa Rehabilitation Techniques (CRTs). This was done to regenerate old cocoa trees on cocoa farms and improve the income and livelihood of the farmers. In addition, it was observed that farmers are usually unwilling to destroy an old farm. In a bid to sustain and perhaps improve Nigeria's position on global scale in cocoa production, Cocoa Research Institute of

Nigeria (CRIN) has developed and disseminated different improved production packages on cocoa to farmers in Nigeria. These efforts have achieved some of its objectives. Productivity among farmers has been greatly enhanced and income increased. The study therefore addressed the question of type of techniques, farmers' knowledge of cocoa rehabilitation techniques, and factors that determined cocoa rehabilitation techniques among farmers.

Objectives

The specific objectives of the study were to: profile the socio economic characteristics of the farmers in the study area ascertain types of cocoa rehabilitation techniques prevalent in the study area ascertain farmers knowledge of cocoa rehabilitation analyse the determinants of cocoa rehabilitation techniques among farmers in the study area

Methodology

The study was carried out in Boki Local Government Area (LGA) of Cross River State, Nigeria in 2016. Boki LGA has a population of about three hundred persons. It is bounded in the West by Ogoja, North by Obudu, South by Ikom Local Government Areas (LGAs). The study area is an agrarian LGA. Major crops grown include cocoa, coffee, timber and palm products. There are cocoa estates in the LGA. These include Integrated cocoa estates, Iso-Bendeghe cocoa estate, Boje cocoa estate, Integrated cocoa estate, Wula, Integrated cocoa estate, Banba and Integrated cocoa estate, Benyia Uman (Kekerete.tripod.com).

The study employed a multistage sampling technique to select cocoa farmers. The first stage was a purposive selection of

the LGA. This is because of the volume of cocoa production in the LGA. The second stage was a random selection of two villages (Ochor and Orimekpa) from the eleven (11) wards in the LGA. The third stage was a random selection of eighty seven (87) cocoa farmers in the LGA. Primary and secondary data were used for the study. Well structured questionnaire was used for the primary data. Secondary data was by the use of literatures. Data were collected on age of the farm, age of the farmers, marital status, household size, farming experience, educational level, membership of farmers' association, farm distance, tenure type, knowledge on cocoa rehabilitation, and type of cocoa rehabilitation techniques (CRTs). CRTs considered in the study were coppicing, complete replanting, side grafting, top grafting, phased farm replanting, fertilizer application and planting under cocoa trees. Data was analyzed using simple descriptive statistics (means, frequencies, percentages), and inferential statistics. Multicollinearity test was carried out.

The model was explicitly specified as

$$\text{LnFARMAGE} = \alpha + \beta_1 \text{AGE} + \beta_2 \text{GENDER} + \beta_3 \text{HHSIZE} + \beta_4 \text{MASTAT} + \beta_5 \text{EDLEVEL} + \beta_6 \text{MEMASS} + \beta_7 \text{FRMEXP} + \beta_8 \text{KOREHAB} + \beta_9 \text{CRDTACC} + \beta_{10} \text{FRMDIST} + e$$

Where:

LnFARMAGE = Log of Age of the cocoa farm (Years)

AGE = Age of farmers (Years)

GENDER = Gender of farmers (1= Male; 0=Otherwise)

HHSIZE = Household Size (No. of person)

MASTAT = Marital Status (1= Single; 2=Married; 3=Divorced; 4=Widowed)

EDLEVEL = Educational Level (1=Primary; 2=Secondary; 3=Tertiary)

MEMASS= Membership of Association
(1=Yes; 0=Otherwise)

FRMEXP= Farming Experience (1=1-10;
2=11-20; 3=Above 20)

KOREHAB=Knowledge of cocoa
rehabilitation techniques (1= Yes;
0=Otherwise)

CRDTACC= Credit Accessibility (1= Yes;
0=Otherwise)

FRMDIST = Farm Distant (1=Homestead;
0=Otherwise)

α =intercept

β = parameter estimates

e= Stochastic random error.

Results and Discussion

Socioeconomic characteristics of cocoa farmers.

Table 1 shows the socio-economic characteristics of cocoa farmers in Boki Local Government Area (LGA) of Cross River State. The table reveals that majority (77.01%) of the farmers were male. The implication of this is that cocoa farming in the study area is largely dominated by male gender and thus may be able to withstand the tasks of CRTs. Similarly, Girei *et al* (2013) reported that in Africa, men are more in a crop that is perceived to have commercial value. In addition, the result conforms to the findings by Taiwo *et al* (2015) who reported that about 68.7% of farmers that practiced cocoa rehabilitation techniques (CRTs) in Southwest and South-South agro-ecological zones of Nigeria are male. In addition, the table reveals that majority (96.6%) of the farmers were married. Moreover, the mean age of the farmers is 46 years. The implication of this is that cocoa farmers in the LGA are still in their productive years and thus cocoa production in the study area is expected to

be on the increase. However, this is not in consonance with the findings by Adeogun *et al* (2010) and Adebisi and Okunlola (2013) who reported that cocoa farmers in selected states of Nigeria were old and that most of the cocoa farmers in Oyo State have passed their productive age. Similarly, the table reveals that highest proportion (56.3%) of the farmers had access to secondary education. The implication of this is that the farmers may perhaps have access to information on good agricultural practices (GAP) with respect to cocoa production and farm rehabilitation. Furthermore, the table reveals an average household size of 12 persons with a Standard Deviation (SD) of ± 7 . This implies that the farmers may perhaps utilize members of the household as labour for some operations relating to cocoa production and farm rehabilitation. This may reduce some production costs that may be incurred on the crop. Mean age of cocoa farms in the study area was about 18 years. This means that the cocoa farms are in their productive years. This is contrary to findings by Adeogun *et al* (2010) that cocoa farmers in selected states of Nigeria had aged trees that are older than thirty (30) years and it is expected that diminishing return on production will set in. Furthermore, the table shows that about 55.2% of the cocoa farmers had above 20 years farming experience. In addition, majority (95.4%) of the farmers reported that they have knowledge of cocoa rehabilitation and 70.1 percent of the respondents practiced side grafting as the most prevalent CRTs. This perhaps may be due to the awareness and trainings conducted by CRIN and other stakeholders in cocoa production. This is in conformity with the findings by Taiwo *et al* (2015).

Table 1: Socio economic characteristics of Cocoa Farmers

Variables	Frequency	Percentage (%)	Mean	Std. Deviation
Sex				
Male	67	77.01		
Female	20	22.99		
Age (Years)				
29- 38	28	32.18		
39- 48	19	21.84		
49 -58	34	39.08		
Above 58	6	6.90	46	10
Marital Status				
Married	84	96.55		
Separated	1	1.15		
Widowed	2	2.30		
Educational Level				
Primary	27	31.04		
Secondary	49	56.32		
Tertiary	11	12.64		
Membership of Farmers' Group				
Yes	85	97.70		
No	2	2.30		
Household Size				
1-10	41	47.13		
11-20	35	40.23		
Above 20	11	12.64	12	7
Age of cocoa farm (Years)				
Below 11	12	13.79		
11-30	67	77.01		
Above 30	8	9.20	18	8
Farming Experience (Years)				
1-10	7	8.00		
11-20	32	36.80		
Above 20	48	55.20	24	9
Farm Distance				
Homestead Farm	15	17.24		
Distant Farm	72	82.76		
Knowledge of cocoa Rehabilitation				
Yes	83	95.40		
No	4	4.60		
Side Grafting				
Yes	61	70.12		
No	27	31.03		

Source: Field Survey, 2016 Std. Dev: Standard Deviation

Test for Multicollinearity

Table 2 shows the result of the test for multicollinearity. Variance Inflation Factor (VIF) shows how multicollinearity has increased the instability of the coefficient estimates (Freund and Littell, 2000). The result revealed that multicollinearity among the variables considered was not a problem since the Variance Inflation Factor (VIF) values of the variables in the model are less than the critical value of 10. The estimated VIF results range from 1.14 to 3.65 with a mean value of 1.75. This shows that multicollinearity is not an issue in the model as these values for the explanatory variables are less than 10. The result is similar to Osman (2015), Kleinbaum *et al* (2014) and Tazeze *et al* (2012) who reported a VIF of less than 10.

Determinants of cocoa rehabilitation techniques (CRTs) among Cocoa Farmers

Table 3 shows the determinants of cocoa rehabilitation techniques (CRTs) among cocoa farmers. The table reveals that age of the farmers was highly significant at 1%

level of probability with positive coefficient. The implication of this is that farmers in the study area are taking advantage of their productive years to practice CRTs. This perhaps may mean that the younger the farmers, the more they practice CRTs (*Ceteris paribus*). In addition, the table reveals that educational level and farming experience of the cocoa farmers are highly significant at 1% level with positive coefficient. The implication of this is that these variables have direct proportion to the practice of CRTs in the study area. This means that the higher the level of education and farming experience the higher the practice of CRTs. This conforms to the findings by Taiwo *et al* (2015) who reported positive but significant relationships between CRTs and level of education and farming experience, respectively. However, sex, membership of association and credit accessibility have negative coefficients but are significant at 1% level of probability. This is contrary to *a priori* expectation. The implication of this is that the farmers even though belonged to an association may perhaps not have access to

Table 2: Result for test of Multicollinearity

Variable	VIF	1/VIF
Age of the farmer	3.65	0.27
Gender	1.41	0.71
Household size	1.38	0.72
Marital Status	1.27	0.79
Educational level of farmers	1.55	0.65
Farming experience	3.53	0.28
Farm Distance	1.14	0.87
Membership of Association	1.24	0.81
Knowledge of Rehabilitation	1.16	0.86
Credit Accessibility	1.19	0.84
Mean VIF	1.75	

Source: Data Analysis, 2016

Table 3: Factors Influencing the Adoption of Cocoa Rehabilitation Techniques

Variable	Coefficient	Standard Error	t-Value
Age of the farmer	0.0040***	0.0011	3.64
Gender	0.1079***	0.0181	-5.96
Household size	0.0013	0.0010	-1.30
Marital Status	0.0036	0.0146	0.25
Educational level of farmers	0.0241***	0.0126	1.92
Farming experience	0.0114***	0.0012	9.50
Farm Distance	0.0197	0.0181	-1.09
Membership of Association	0.3489***	0.0476	-7.32
Knowledge of Rehabilitation	0.2589***	0.0329	7.86
Credit Accessibility	0.2126***	0.0300	-7.09
Constant	0.9848***	0.0907	10.86
R ²	0.8945		
Adjusted R ²	0.8806		
Number of Observation	87		

Source: Data Analysis, 2016

trainings on CRTs and money is needed to practice these rehabilitation techniques.

Types and Knowledge of cocoa rehabilitation techniques (CRTs)

Table 4 shows the types and knowledge of cocoa rehabilitation techniques (CRTs) among farmers in the study area.

The table revealed that all the farmers have knowledge of CRTs. This is expected based on the awareness and series of trainings on these techniques carried out by CRIN. In addition, the results are confirmation of the positive impacts the Ajassor sub -station of the Institute is making on cocoa farmers. The sub-station is located in the State. However, largest proportion (70.1%) of the farmers has knowledge of coppicing while 39.1% has knowledge of fertilizer application. The implication of this is that the farmers may perhaps develop more knowledge of coppicing because it is easily done when a

cocoa tree is diseased and old. Hence, farmers see this as a technique that may result into little or no loss to them as the new shoots will derive nutrients from the old and mother tree. Moreover, the result on fertilizer application is expected because fertilizer is not always available and affordable. Hence, cocoa farmers may not be willing to practice this technique.

Conclusion and Recommendations

It was revealed that age of farmers, farming experience and educational level of farmers positively determined CRTs in the study area. It was also observed that credit accessibility, membership of association and sex negatively determined the farmers' practices of CRTs in the study area. Therefore, it is thus recommended that cocoa farmers in the study area should be encouraged to stay on the farms through provision of infrastructure since majority of the farmers are in their productive years.

Table 4: Types and Knowledge of cocoa rehabilitation techniques (CRTs)

Types of CRTs	Knowledge of CRTs (%)	
	Yes	No
Coppicing	41.4	58.6
Complete replanting	41.4	58.6
Side grafting	70.1	29.9
Top grafting	63.2	36.8
Phased farm replanting	59.8	40.2
Fertilizer application	39.1	60.9

Source: Field Survey, 2016

This will reduce rural-urban migration. In addition, credit should be made accessible to the farmers so that they will be able to afford the costs involved in the practice of CRTs. Moreover, they should be encouraged to take active roles in the association by participating in all activities directed to CRTs in order to get up to date information on the advantages inherent in cocoa farms rejuvenation. Furthermore, CRIN and other stakeholders in cocoa production should endeavor to develop new CRTs that are gender friendly. This will ensure that cocoa farmers are encouraged to adopt and practice other CRTs irrespective of gender. Moreover, fertilizer should be made available and affordable to cocoa farmers to encourage the practice of this technique. Further studies should be carried out to ascertain the adoption of these techniques and the most preferable CRTs among cocoa farmers in the study area based on the results of high knowledge level.

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Assessment of Maize Farmers' Knowledge and Level of Adoption of Improved Practices as well as Yield of Maize under Research-Extension-Farmers-Input-Linkage-System in Nigeria

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Abstract

The study assessed maize farmers' knowledge, adoption of improved practices and yield under Research-Extension-Farmers-Input-Linkage System (REFILS) in Nigeria. Multi-stage random sampling technique was used to select 198 maize farmers from 3 agricultural zones (Northwest, Northcentral and Southwest) in Nigeria. Data were collected using structured questionnaire. Descriptive statistics (frequencies, percentages and mean) were used to analyse the data, while inferential statistic (ANOVA) was used to test the hypotheses. Results showed that majority (67.7%) of the respondents were male, married (95.5%) and had more than 10 years of farming experience (72.7%). Farmers' knowledge and adoption of improved practices were high across the zones while the lowest yield was recorded in Southwest. There was no significant difference in maize farmers' knowledge of improved practices across the zones ($F=1.291$, $p=0.27$), while a significant difference existed in the level of maize production across the zones ($F=28.059$, $p=0.000$). The study concluded that REFILS has gone a long way in enhancing the capacity of farmers and therefore, concerted efforts should be made to improve the activities of REFILS in Nigeria.

Key words: Adoption, Assessment, Farmers' knowledge, REFILS in Nigeria, Yield

Introduction

Research-Extension-Farmers-Input-Linkage System (REFILS) is defined as the interplay of research, extension, farmers and input supply agencies in a cost-effective manner aimed at rapidly increasing agricultural production and productivity of resource-poor farmers (Adebowale and Amusat, 2005). Research-Extension-Farmers-Input-Linkage System represents the framework of the coordination of research and extension activities in all agricultural zones of the country. The REFILS strategy was initiated in order to minimize or eliminate identified constraints such as linear information flow, basic and upstream research, low adoption of technology, technology development without farmers' involvement and lack of feedback from farmers to research which affect effective research extension farmers'

linkages in the country (Tologbonse, 2012). Research-Extension-Farmers-Input-Linkage System was therefore predicated on the belief that farmers are involved in the whole process of technology development and application resulting from problem identification, technology generation, adaptation and dissemination. The REFILS as designed is expected to bring all the key stakeholders in agriculture together in participatory technology development, adaptation, dissemination and utilisation of sustainable agricultural development. However, it is confronted with several challenges as captured in the Agricultural Transformation Agenda document (FGN, 2012) as follow:

a) Unfriendly policy environment, compounded by policy summersault and poor cum no incentives provided for the private sector thus, triggering

reduced investors' confidence. This has consequently resulted in reduced capital availability for local investors in agricultural development.

- b) A dormant, ineffective and inefficient public agricultural extension service that is characterised by a top-down, supply driven extension system compounded by serious structural, organisational and management challenges.
- c) Grossly inadequate, irregular and untimely release of funds to the agricultural and rural development sector and with concomitant negative effect on agricultural extension and advisory services.

Agricultural extension which is a “vital component” of REFILS has been one of the approaches used to improve agricultural productivity in Nigeria. The extension agencies function as a conduit for bringing agricultural innovations to farmers as well as taking farmers problem to the researchers. Therefore, extension system has been playing the vital role of disseminating various technologies on maize production to farmers in different agricultural zones of the country.

Technologies on maize production ranging from the type of soil, land preparation, improved varieties of maize, planting dates peculiar to different agro ecologies, treatment of maize seeds, spacing, plant population, fertilizer application, weed control methods, pests and diseases control strategies, harvesting and processing have been generated and disseminated under the coordination of REFILS teams and these have supposedly impacted positively on farmers knowledge, adoption of the technologies and consequently maize yield in Nigeria.

Though, it has also been revealed that farmers in some rural communities have never benefitted from the extension service of the Agricultural Development Programs (ADPs) (NAERLS and NPFS, 2011), whereas it is an incontrovertible fact that the gate way to self-sufficiency and sustainable maize production in Nigeria is through adequate and effective agricultural extension delivery system. Adoption of technologies generated and disseminated without farmers' involvement is not encouraging. This has necessitated the introduction of the REFILS strategies which is seen as a concept that starts and ends with farmers. The operational activities of REFILS such as Monthly Technological Review Meeting (MTRM), diagnostic survey (field visits), Zonal REFILS workshop, Fortnightly Training (FNT), On Farm Adaptive Research, Small Plot Adoption Trial/Management Training Plot and media activities (print, radio/television) are presently not at their optimal performance and thereby calls for critical review (Kolo, 2012 and Oluwatosin, 2015). The operators of REFILS are confronted with unfriendly policy environment characterised by ineffective and inefficient public agricultural extension system coupled with poor linkage system among the stakeholders. This has negatively affected the major actors of REFILS especially maize farmers who are always at the receiving ends. The problem of poor linkage system, ineffective information flow and weak interaction among the stakeholders have been a threat to the effectiveness of REFILS for service delivery on maize production and as such detrimental to the overall development of maize farmers in Nigeria.

Since the inception of Research –Extension –Farmers –Inputs –Linkage

Systems over three decades ago, efforts have been made to understand the concept better for more effective delivery. The need for more studies on REFILS, especially its effect on maize production cannot be over emphasized as huge amount of money is being spent on the concept yearly and the attainment of food security depends greatly on the effectiveness of REFILS.

Based on the fact that effective REFILS is a prerequisite for increase in maize farmers' knowledge, adoption and consequently yield; it is imperative to assess maize farmers' knowledge, adoption of improved practices and yield in Nigeria.

Objectives of the study were to

1. determine the personal characteristics of maize farmers in Nigeria.
2. determine the level of knowledge of improved practices among maize farmers in the study area.
3. assess the adoption rate of different technologies on maize in the study area and
4. determine maize farmers yield in the study area.

Hypotheses of the study

Ho1: There is no significance difference in the maize farmers' knowledge of improved practices across the zones

Ho2: There is no significant difference in the production level of maize farmers across the zones.

Methodology

The population of the study consists of maize farmers in the six agricultural zones of the country out of which 50% of the zones were purposively sampled. These are

Northwest, Northcentral and Southwest zones. They were purposively sampled because the zones have comparative advantage in maize production compared to other zones (NAERLS & NPFS, 2011). Moreover, three states were also purposively selected from the three zones sampled (one state from each zone). Oyo state which belongs to South-west agricultural zone, Kaduna state in North-west agricultural zone and Niger state in Northcentral were sampled because of the intensity of maize production in the states. Multi-stage sampling procedure was used to select maize farmers for the study. The choice of maize farmers for the study was premised on the fact that technologies have been generated and disseminated on maize crop since inception of REFILS. The list of Agricultural Development Programmes (ADPs) registered maize farmers in the two states were obtained and selection was done as follows:

Random sampling of 50% of the zones in the selected states' ADPs was done. Then random sampling of 30% of the ADP blocks in the sampled zones was carried out to give a total of 14 blocks that contained 57 cells. This was followed by random sampling of 20% of the cells in the sampled blocks to give a total of 11 cells with 1989 farmers in the sampled cells. Lastly, 10 % of farmers in the randomly selected cells were sampled to give a total of 198 farmers across the states which were thus used for the study. Data for the study were collected through the administration of pretested questionnaire and analysed with descriptive and inferential statistics such as ANOVA.

Results and Discussion

Personal characteristics of respondents

Table 1 reveals that majority of the

respondents were males (67.7%). This implies that women are less involved in the basic agricultural enterprises involving maize production in the country. The age distribution as shown in Table 1 reveals that 59.6% of maize farmers were within the age bracket of 41-50 years. This is consistent with Onyegbula (2015) who reported the age bracket of 41-50 years for most farmers in rain forest and guinea savannah agro ecological zones of Nigeria. The data on age shows that most of the maize farmers are still in their active years, implying availability of physical strength and mental alertness in adopting improved technologies which is a core objective of Research-Extension-Farmers-Input-Linkage System (REFILS).

Majority (95.5%) of the total maize farmers were married as shown in Table 1. This illustrates the importance of marriage institution in the study area. The finding on maize farmers' educational attainment across the zones shows that 37.4% of the total maize farmers had no formal education, while 34.3% were educated up to secondary level. It was also revealed that 21.5% of farmers in Northwest had tertiary education compared to 2.8% in Northcentral and 8.1% in Southwest who also had tertiary education. On the whole, 62.6% of the respondents had education ranging from primary six to tertiary level. This implies that majority of the respondents are literates and this is in line with Oladeji (2011), who asserted that farmers are not totally illiterates but had one form of education or the other. The mean annual income for the maize farmers in the study area was N327,795.46. More than half of the farmers (53.2%) in Southwest had between N100,001- N300,000 as their annual income, while 36.9% and 54.9% of

respondents from Northwest and Northcentral zones, respectively had annual income ranged from N300,001- N500,000. This implies that respondents from Northwest and Northcentral zones realised more income from their maize production enterprise and would be able to earn better living conditions than their counterpart from Southwest zone. Table 1 reveals that majority of maize farmers in Northwest (61.5%) possessed farm sizes of between 4-6 hectares, while in Northcentral, a little above average (56.4%) and in Southwest majority (71.0%) possessed between 4-6 and 1-3 hectares, respectively. The average farm size was 3.54 ha. This implies that maize cultivation is still at subsistence level. The result on farming experience reveals that only 27.3% had below 10 years of experience. This infers that majority of farmers in the study area had reasonable years of farming experience.

Farmers' knowledge of improved practices on maize production

Possession of knowledge on maize production technologies by farmers will build their capacity on maize production and will consequently help them to adopt technologies which will improve their productivity. From the results across the study area (Table 2a), the knowledge of maize farmers was ranked first on the technology that 'farm hygiene can curb the incidence of disease outbreak and pest on the farm and this was followed by maize should be planted on a well-drained sandy loam /loamy soil while it is not necessary to carry out soil testing was ranked lowest. This is because majority of the maize farmers were small scale farmers who had never tested their soil for the nutrients it

Table 1: Distribution of maize farmers' personal characteristics

Variable	NW (n=65)		NC (n=71)		SW (n=62)		Total n= 198	
	F	%	F	%	F	%	F	%
Age								
= 30	8	12.3	1	1.4	1	1.6	10	5.1
31 – 40	12	1.85	21	29.6	8	12.9	41	20.7
41 – 50	37	56.9	42	59.2	39	62.9	118	59.6
51 – 60	5	7.7	5	7.0	13	21.0	23	11.6
> 60	3	4.6	2	2.8	1	1.6	6	3.0
Mean age	43.9±8.32		44.2±6.80		46.7±6.20		44.8±7.23	
Marital Status								
Single	2	3.1	-	0.0	2	3.2	4	2.0
Married	61	93.9	68	95.8	60	96.8	189	95.5
Divorced	1	1.5	1	1.4	-	0.0	2	1.0
Widowed	1	1.5	2	2.8	-	0.0	3	1.5
Educational level								
No formal	21	32.3	42	59.2	11	17.7	74	37.4
Primary	18	27.7	3	4.2	14	22.6	35	17.7
Secondary	12	18.5	24	33.8	32	51.6	68	34.3
Tertiary	14	21.5	2	2.8	5	8.1	21	10.6
Farm Income								
= 100,000	1	1.5	-	0.0	17	27.4	34	17.2
100,000 – 300,000	22	33.8	32	45.1	33	53.2	71	35.9
300,001 – 500,000	24	36.9	39	54.9	9	14.5	72	36.4
500,001 – 700,000	8	12.3	-	0.0	2	3.2	10	5.1
Above 700,000	10	15.4	-	0.0	1	1.6	11	5.4
Mean Annual income	N339,58		N385,31		N273,4		N332,7	
	5		0		90		95	
Farm size								
< 1 hect	10	15.4	1	1.4	-	0.0	11	5.6
1 – 3 hect	12	18.5	28	39.4	44	71.0	92	46.5
4 – 6 hect	40	61.5	40	56.4	8	12.9	80	40.4
> 6 hect	3	4.6	2	2.8	10	16.1	15	7.5
Mean							3.54	
Farming experience								
< 5 years	8	12.3	5	7.0	5	8.1	18	9.0
5 – 9 years	20	30.8	11	15.5	5	8.1	36	18.2
10 – 14 years	21	32.3	28	39.4	8	12.9	57	28.8
15 – 19 years	11	16.9	19	26.8	38	61.2	68	34.3
> 20 years	5	7.7	8	11.3	6	9.7	19	9.6
Mean	13.6		13.1		18.7		15.3	

Source: Field survey, 2015

contain, even though they were applying fertilizer to the soil. The result is corroborated by the research finding of IAR&T (2013) which stated that majority of farmers in Nigeria have not shown considerable interest in knowing the nutrient status of their soil despite continuous use of the land.

Table 2b reflects the knowledge level of

farmers on maize production practices. Generally, the result reveals that 70.2% of the respondents had high knowledge of maize production practices, while 29.8% had low knowledge. The result implies that most of the respondents are equipped with the recommended maize production packages emanated from research institutes and disseminated by extension personnel of

Table 2a: Distribution of respondents based on knowledge of improved practices on maize production

S/N	Knowledge Statements	North West n = 65	North Central n = 71	South West n = 62	Total n = 198	Rank
		Mean	Mean	Mean	Mean	
1.	Maize should be planted on a well-drained sandy loam /loamy soil	0.9	1.00	1.00	0.96	2nd
2.	Fertile soils with relatively flat topography are preferred for planting maize	0.83	1.00	1.00	0.94	5th
3.	In planting maize, farmers study as much as possible to incorporate residue of the existing plant into the soil	0.75	0.17	0.90	0.87	8th
4.	It is good to plant improved recommended varieties of maize	0.89	0.97	0.98	0.94	4th
5.	T2SR and DMR-LSR are some of the recommended varieties of maize	0.75	0.19	0.94	0.61	14th
6.	Is it true that maize can be planted on flat land	0.83	0.85	0.80	0.83	9th
7.	Depth of planting is 5 – 7cm	0.73	0.67	0.50	0.64	13th
8.	Undue delay in maize harvesting increases damage due to diseases, pest and possible seed germination on cob while on stock	0.83	0.91	0.93	0.89	6th
9.	It is not necessary to carry out soil testing before applying fertilizer on your maize farm	0.63	0.42	0.41	0.48	15th
10.	Phostoxin tablet is used for maize preservation during storage	0.92	0.98	0.98	0.96	3rd
11.	Farm hygiene can curb the incidences of diseases outbreak and pest on the farm	0.95	1.00	1.00	0.98	1st
12.	A farmer can realize 2 – 2.5 tons of maize on a well maintained farm	0.80	1.00	0.20	0.68	12th
13.	Maize on cobs should be stored in cribs using actellic 25EC at 200ml/10litres of water	0.84	0.73	0.83	0.80	10th
14.	Time to do first weeding on maize farm	0.24	0.05	0.79	0.34	16th
15.	Quantity of maize seed to plant on hectare of farm manually	0.47	0.18	1.00	0.22	11th
16.	Ability to mention two improved varieties in respondent's locality	0.75	0.91	0.74	0.88	7th

Source: Field survey, 2015.

Table 2b: Farmers' knowledge level of improved practices on maize production across the zones

Knowledge level	NorthWest (n=65)		NorthCentral (n=71)		SouthWest (n = 62)		Total (n =198)	
	F	%	F	%	F	%	F	%
Low (0-7)	16	24.6	26	36.6	17	27.4	59	29.8
High (8-16)	49	75.4	45	63.4	45	72.6	13	70.2
Mean ± SD							8.11±1.86	

Source: Field survey, 2015

Agricultural Development Programmes (ADPs). Disaggregated data shows that majority of the respondents (75.4%, 63.4% and 72.6%) in Northwest, Northcentral and Southwest, respectively had high knowledge. This is expected because of the long years of farming experience of the respondents coupled with the fact that majority of the respondents have been participating in REFILS since its introduction about three decades ago. Also, majority of the respondents in the study area belong to formidable farmers' associations which are pivotal in the spread of agricultural innovation.

Farmers' adoption of improved practices on maize production

Various recommended practices (technologies) have been adopted by maize farmers over the years to improve maize production in the country. At present, Nigeria is the largest producer of maize in Africa and number ten in the world (IITA, 2010). The different recommended practices were ranked according to the mean values. According to Table 3a, the recommended practices for maize production ranged from land preparation to storage. The data in Table 3a reveals that planting maize on a well-drained sandy loam or loamy soil (0.92), early harvesting of maize to avoid damage due to diseases, pests and possible seed germination on cob while on stock (0.87) ranked 1st and 2nd, respectively in Northwest, while planting on a well-drained sandy loam or loamy soil (1.0), planting on a fertile soil with flat topography (1.00), early harvesting of maize to avoid damage due to diseases, pests and possible seed germination on cob while on stock (1.00) ranked 1st in Northcentral. In the same vein, planting on

a well-drained sandy loam or loamy soil (1.00), planting on a fertile soil with flat topography (1.00), incorporation of residue of the existing plants into the soil before planting maize (1.00); ranked 1st in the Southwest. Also, the practice on the use of one empty beer bottle cap of N.P.K fertilizer for two plants of maize (0.98) and carrying out soil testing before applying fertilizer on the maize farm (0.16) ranked 13th and 14th respectively in the Northwest while in the Northcentral planting of TZSR and DMR-LSR recommended varieties of maize and carrying out of soil testing before applying fertilizer (0.17), (0.14) ranked 14th and 13th, respectively.

In the same vein, planting of maize at a spacing of 75cm×40cm with hands (0.27) and carry out of soil testing before applying fertilizer on the maize farm (0.17) ranked 13th and 14th, respectively in Southwest. The result shows that the mean value of the practice on carrying out of soil testing before applying fertilizer on maize is consistently low in all the zones and ranked 14th, 13th and 14th in Northwest, Northcentral and Southwest, respectively. This might be due to the high cost of carrying out a soil test and non-availability of the laboratory for such in rural areas where farming is practised.

As shown in Table 3b there was an indication of high rate of adoption of maize recommended practices in all the zones in the following proportions; 69.2%, 76.1% and 82.3% in Northwest, Northcentral and Southwest, respectively. From the result, the adoption of recommended practices on maize is high across the zones. This is due to the fact that most of the respondents are highly experienced farmers who had been enjoying a robust relationship with researchers, extension practitioners and

input agents over a long period of time. Also, the extension services of government which disseminate recommended practices on maize production to farmers are also being complemented by private extension services which are being anchored by Non-Governmental Organizations (NGOs) such as Sasakawa Global 2000, USAID phase II, Japan and Korea International Cooperation Agency. According to NAERLS (2012), over fifty NGOs are involved in various types of agricultural extension programmes in Nigeria.

Yield of maize production

Maize yield in Nigeria per hectare is 2,500 - 4,500kg of threshed grains depending on the level of inputs used (WAAPP, 2014). But for year 2011, NAERLS & NPFS report put the national average yield at 1,780 kg (1.78 tons). The result in Table 4 reveals the average maize yield in kilogram per hectare in the study area. Data gathered from the survey reveals that less than half of farmers (46.2%) in the Northwest recorded 2,501 - 4,000kg per hectare, while majority of respondents in the Southwest (88.7%) and

Table 3a: Distribution of farmers based on adoption of recommended practices on maize production

S/N	Adoption statement	North West n = 65	North Central n = 71	South West n = 62	Total n = 198	
		Mean	Mean	Mean	Mean	Rank
1.	Planting on a well-drained sandy loam or loamy soil	0.92	1.00	1.00	0.97	1st
2.	Planting on fertile soil with flat topography	0.86	1.00	1.00	0.95	2nd
3.	Incorporation of residue of the existing plants into the soil before planting	0.72	0.94	1.00	0.88	7th
4.	Planting of T2SR and DMR-LSR recommended maize varieties	0.63	0.14	0.96	0.54	11th
5.	Planting within the depth of 5 – 7 cm	0.73	0.64	0.58	0.65	9th
6.	Buying of seed from reliable/recommended source, e.g. agro-service centre	0.86	0.97	0.96	0.93	4th
7.	Planting of maize at a spacing of 75 x 40 cm with hand	0.67	0.69	0.27	0.55	12th
8.	Use of one empty beer bottle cap of NPK fertilizer for 2 stands of maize	0.98	0.32	0.58	0.48	13th
9.	Carrying out soil testing before fertilizer application on maize	0.30	0.16	0.17	0.21	14th
10.	Weeding of maize farm within 14 – 21 days of planting	0.86	1.00	0.77	0.88	8th
11.	Use of phostoxin tablet for maize storage	0.86	0.92	0.87	0.89	6th
12.	Use farm hygiene to curb pest and disease outbreak on the farm	0.84	0.98	0.96	0.93	5th
13.	Early harvesting of maize to avoid damage	0.87	1.00	0.95	0.94	3rd
14.	Storing of maize on curbs with actellic 25EC at 200ml/10litres of water	0.66	0.25	0.79	0.55	10th

Source: Field survey, 2015.

Table 3b. Farmers' level of adoption of improved practices on maize production across the zones

Adoption level	Score	North West n = 65		North Central n = 71		South West n = 62		Total n = 198	
		F	%	F	%	F	%	F	%
Low	0 – 9	20	30.8	17	23.9	11	17.7	48	24.2
High	10 – 14	45	69.2	54	76.1	51	82.3	150	75.8
Mean ± SD								10.42±2.18	

Source: Field survey, 2015

Table 4. Yield of maize production across the zones

Variable	North West (n = 65)		North Central (n = 71)		South West (n = 62)		Total n = 198	
	F	%	F	%	F	%	F	%
Yield								
= 1,000kg	4	6.2	-	0.0	6	9.7	10	5.1
1,001 – 2,500kg	28	43.1	69	97.2	55	88.7	152	76.8
2,501 – 4,000kg	30	46.2	2	2.8	1	1.6	33	16.6
> 4,001kg	3	4.6	-	0.0	-	0.0	3	1.5
Mean yield		2813.07± 2064.37		2176.05± 1324.90		1204.0± 1340.49		2080.80 ± 1374.3
Total	65	100.0	71	100.0	62	100.0	198	100

Source: Field survey, 2015.

North central (97.2%) recorded between 1,001 - 2500kg per hectare and 1,001 - 2,500kg per hectare, respectively. This shows that Northwest with maize yield average (2,813.07kg) had the highest yield among the three zones. This surpassed 1,780kg which was recorded as the national average in 2011 (NAERLS & NPFS 2011) and falls within the recommended national average of 2,500 - 4,500kg/ha (WAAPP, 2011). Respondents from Southwest had the lowest yield average (1,204.03 kg). This is due to the fact the Northern guinea savannah belt where North-west and Northeast belong supported the growth of maize better than the climatic area of

Southwest zone which is in the rainforest belt (USAID, 2010).

Test of difference in maize farmers' knowledge on improved maize production practices across the zones.

The result in Table 5 indicates that there was no significant difference in maize farmers' knowledge on improved management practices across the zones (F=1.291, p=0.277). This means that the management practices adopted on maize production are similar across the various agricultural zones in Nigeria. This may be due to the fact that maize farmers all over the zones were exposed to agricultural extension services

Table 5: Analysis of variance of maize farmers' knowledge of improved practices across the zones

	Sum of Squares	Df	Mean square	F-value	Sig
Between groups	9.976	2	4.988	1.291	0.277
Within groups	753.479	195	3.864		
Total	763.455	197			

Source: Field study, 2015

and there has been a central coordinating unit on maize production at the national level for a very long time where similar knowledge on maize production practices is shared (Ogunbodede, 2011).

Test of difference in the production level (Yield) of maize farmers across the zones.

The ANOVA result in Table 6a shows a significant difference in the respondents' level of maize production across the zones ($F=28.059$, $p=0.000$). This finding can be attributed to the fact that the three zones which constituted the study area are not under the same agro-ecology. It can be inferred that maize thrives better in Guinea savannah to which Northcentral and

Northwest zones belong, thus the high level of maize production from those zones. This is opposed to the maize production level in Southwest which falls under rainforest/derived savannah. Additionally, the concentration of seed companies, large maize markets especially uptakers of maize and NGOs in Northwest and Northcentral that assist in the provision of agro-inputs to maize farmers could also have accounted for the difference in maize production across the zones since agro-input usage is known to boost agricultural production. This is in line with USAID (2010) that reported that the guinea savannah zones provide the best ecological condition for maize cultivation.

Table 6a. Analysis of Variance on production level (yield) of maize across the zones

	Sum of Squares	Df	Mean square	F-value	Sig
Between groups	831598.382	2	41579949.191	28.059	0.000
Within groups	288967.326	195	1481882.935		
Total	372127070.707	197			

Source: Field study, 2015

The result of Duncan test presented on Table 6b shows the mean score of maize farmers in Northwest as 2813.0769, which is statistically greater than the mean score of Northcentral and Southwest which were 2176.0563 and 1204.0323, respectively. Maize farmers in Northwest thus contributed more to the significant difference that is noticed in the DMRT table, while Southwest had the least significant difference. This result indicates that farmers from Northwest had higher maize yield than their counterparts from Northcentral and Southwest. This may be due to the involvement of Non-Governmental Organisations in maize production activities in the Southwest zone. And the advantage of USAID market phase II which provided the benefit of buying back policy for farmers in the zone. Furthermore, the biggest markets for grains were also located in the Northwest zone.

Conclusions and Recommendations

The study reveals that larger percentage of maize farmers were male, married, had one form of education or the other, reasonable years of experience with farm size of 1-3 hectares and participated actively in REFILS. Maize farmers in Northwest and Northcentral realized better yield and income than their counterpart in Southwest

Nigeria. The study further observes that Research-Extension-Farmers-Input-Linkage system which was introduced to Nigeria over 3 decades ago has gone a long way in enhancing capacity of maize farmers in the country by increasing their knowledge on improved agronomic practices on maize production, enhancing their adoption of maize production technologies and consequently impacting positively on the yield.

Based on the findings of this study, it is recommended that concerted efforts should be made to improve on the activities of REFILS in Nigeria so as consolidate on the benefits of farmers' enhancement of knowledge and adoption of improved agronomic practices on maize production. There is need for more collaboration between research and extension practitioners in Nigeria under REFILS to generate and disseminate adoptable technologies on soil management techniques which was generally low so as to update farmers' knowledge on sustainable maize production. Researchers should concentrate more on breeding disease resistant, high yielding maize varieties capable of improving farmers' yield particularly in Southwest zone where the lowest yield was recorded.

Table 6b: Distribution of farmers by Post hoc (Duncan Multiple Range Test DMRT) on yield of maize production across the zones

Zones	N	Subset for alpha = 0.05		
		1	2	3
South west	62	1204.0323		
North central	71		2176.0563	
North west	65			2813.0769

Source: Field work, 2015.

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Gender, Social Capital and Agricultural Productivity among Cassava Farmers in Oyo State, Nigeria.

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Abstract

Government efforts of to improve Nigeria's cassava productivity have been without appreciable impact. The unique social capital dimensions which specifically determine productivity for male and female farmers have not been clearly elucidated in the literature. Therefore, this study examined the effect of social capital on the gender dimensions of agricultural productivity among cassava farmers in Oyo state, Nigeria. A multi-stage sampling procedure was employed to select 180 cassava farmers using well-structured questionnaires. Data collected was analyzed using descriptive statistics, Total Factor Productivity and Ordinary Least Squares regression. The results show that 76% of the cassava farmers were male. Male farmers had a higher density of membership (56.2%) than female farmers. Cash contributions, decision making, labour contribution and heterogeneity showed similar patterns between the male and female farmers. The farmers were all productive with mean productivity of 0.189kg/? . Social capital influenced agricultural productivity of both male and female cassava farmers in different dimensions. Density of membership and cash contribution influenced the agricultural productivity of female farmers while meeting attendance and heterogeneity influenced the agricultural productivity of male farmers. Thus for increased cassava productivity, male farmers need to belong to more homogenous associations while female farmers need increased membership in more associations.

Keywords: Agricultural productivity, Cassava, Farmer, Gender, Social capital.

Introduction

Globally, cassava is an important crop for both food and feed. It is the fourth most important source of calories in the tropics, consumed by over 700 million people on a daily basis in Africa, Asia, and Latin America, and cultivated mainly on marginal lands by smallholders (FAO, 2013). In Africa, which represents roughly half of world cassava production but where 90% is used for food, cassava is an essential part of the diet for the poor. Cassava has evolved into a multipurpose crop that responds to the challenge of poverty, food security and even climate change in developing countries, particularly in sub Saharan Africa.

Annual global production stands at

about 276million metric tons (MT) (FAO, 2018). Nigeria is the world's largest producer of cassava with annual production of about 59.4 million MT (FAO, 2018) representing about 22% of global production. The total area harvested in 2017 was 6.79 million ha and average yield of 8.75 tons/ha (FAO, 2018). Cassava production in Nigeria has experienced modest increases since the early 1960s although, as evidenced from Figure 1, the increases have been due to increased land area planted to cassava rather than increased cassava yield. Cassava production has been limited due to the problem of low agricultural productivity. Yield of the crop has experienced a decline particularly once after year 2010 (see Figure 2). Several reasons have been adduced for the declining productivity

including inadequate research and development, inadequate extension services to farmers, lack of farmer education, inadequate rural infrastructures, poorly targeted government programs and inadequate credit (Ogunlela and Mukhtar 2009; Balogun *et al.* 2018; Ogunleye, 2018). The Nigerian government has made several efforts to improve the cassava yield through several interventions including; the Presidential Initiatives on Cassava, the Cassava Multiplication Programme (CMP), the Root and Tuber Expansion Programme (RTEP). Despite the several efforts to improve cassava productivity

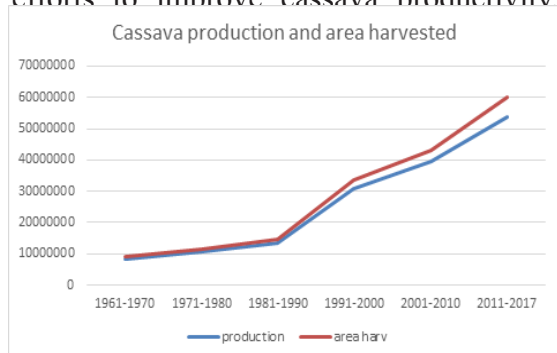


Figure 1 showing cassava production and area harvested (1961-2017)

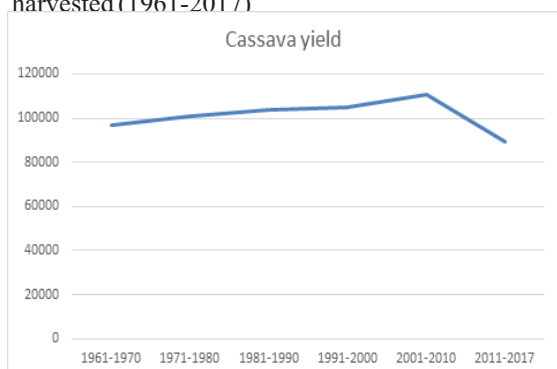


Figure 2 showing cassava yield (1961-2017) FAO (2018)

As evidenced by the cassava programmes, most efforts of government have emphasized increase in land area cultivated as the major strategy to improve productivity. An important concept which the government has not explored in solving the productivity puzzle of Nigeria's cassava sub sector is that of gender. Gender responsibilities and differences have not been clearly defined for the purpose of channeling development incentives to farmers. Gender is responsible for *segregation of roles and responsibilities between males and females in the society* (Oláh *et al.*, 2014). Such segregations result in differences in the way men and women order priorities, view concerns and ultimately make management decision regarding the use of natural resources (Oláh *et al.*, 2018; Kebede *et al.*, 2014) which in turn affect their productivity levels. For instance, men dominate the use of natural resources for agriculture and other economic activities in most regions of the world (UNEP/UN Women/PBSO/ UNDP, 2013). On the contrary, women manage smaller and less profitable businesses due primarily to their limited access to productive assets (Ajani and Igbokwe, 2013). Asset ownership is related to agricultural productivity, hence, the asset-deprived women farmers are more likely to have low agricultural productivity and consequently, be poorer than male farmers (Eboh *et al.*, 2006; Ayoola, 2009).

Access to assets, especially with respect to human, financial and natural assets, is usually out of reach for most asset-deprived women farmers. The social capital asset however, is intangible and creates the opportunity of access even for poor women

farmers. Social capital refers to the collective value of all social networks, that is, who people know and the inclinations that arise from these networks to do things for each other; otherwise called norms of reciprocity (Putnam, 2000). It refers to the people known to a person/farmer and how they do things for one another. Social capital has been found to be of great importance to agricultural development, having major impact technology adoption, improves the efficiency of rural development programmes and the outcome of activities that affect the poor (Silici, 2011; Yusuf, 2008). Social capital has been found to be positively related to agricultural productivity of the farming households (Balogun *et al.* 2018). For instance, most women farmers lack collateral to obtain credit for their agricultural activities with consequent negative effects on their productivity. By joining associations, the collateral security required by financial institutions is provided for the women farmers, credit can thus be obtained and agricultural productivity expectedly increases. Hence, association membership is social capital (Balogun *et al.* 2018).

The determinants of agricultural productivity have been explored (Balogun *et al.* 2018; Komolafe and Adeoti, 2018; Ogunleye, 2018) however, the literature is not conclusive on the factors that uniquely determine the agricultural productivity of male farmers which are expected to differ from that of female farmers (Quisimbing *et al.*, 2014). Further, the differences in roles of males and females in the society suggest that different forms of social capital may apply to either gender. Although, social capital effect on agricultural productivity has been explored (Balogun *et al.* 2018; Komolafe and Adeoti, 2018), how different

social capital dimensions uniquely affect male and female agricultural productivity levels are still limited. Given that social capital is vital for improving agricultural productivity of asset poor farmers and that different social capital dimensions can determine productivity in male and female farmers, this study investigates the gender dimensions of agricultural productivity and social capital among cassava farmers in Oyo state, Nigeria. Firstly, the socioeconomic and demographic characteristics of the cassava farmers were described. Next, the level of social capital among cassava farmers were estimated and profiled. The level of productivity of the cassava farmers were also estimated and profiled. Lastly, the effect of social capital on the agricultural productivity of male and female cassava farmers were estimated.

Materials and Methods

Study area and sampling

The study was carried out in Oyo state, a south western state of Nigeria. Oyo state covers a total land area of 28,454km² and lies on latitude 8.00° N and longitude 4.00° E. The state has an equatorial climate with dry and wet seasons with relatively high humidity. The dry season lasts from November to March while the wet season is between April and October. Average daily temperature ranges between 25°C (77.0°F) and 35°C (95.0°F), almost throughout the year. The vegetation pattern of Oyo state is mainly rainforest, in the south and guinea savannah in the north. The thick forests in the south give way to grassland interspersed with trees in the north. The climate in the state favours the cultivation of crops like maize, yam, cassava, millet, rice, plantain, cocoa tree, palm tree and cashew. The state consists of 5 geographical zones under

which the 33 local government areas. The geographical zones include: Ibadan, Okeogun, Ogbomoso, Oyo and Ibarapa.

Primary data was used for this study and collected through a multistage sampling procedure, using well-structured questionnaires. The first stage was the random selection of three out of five geographical zones of the state. The selected geographical zones were: Oyo, Ibadan and Ogbomoso. The second stage involved the random selection of one local government area from each selected agricultural zone in the state; Afijio Local Government from Oyo, Iddo Local Government from Ibadan and Ogo Oluwa Local Government from Ogbomoso. The third stage was the random selection of three wards from each local government area while the fourth stage was the random selection of one village from each selected ward. The fifth and final stage was the random selection of cassava farmers from each of the selected villages, in proportion to their size. A total of 180 cassava farmers were surveyed and used for the analyses.

Data analysis

Data were analyzed using descriptive and inferential statistics.

- The socio-economic characteristics of cassava farmers were profiled using descriptive statistics. The Total Factor Productivity (TFP) analysis was used to estimate the productivity of cassava farmers in the study area while Ordinary Least Square (OLS) regression method was used to analyze the effects of social capital on the productivity of male and female cassava farmers.
- The social capital dimensions considered included the indices of

meeting attendance, density of membership, heterogeneity, decision making, cash contribution and labour contribution. Measurement of social capital dimensions followed Grootaert (2000), Maluccio (2001), Aker (2005), Yusuf (2008) Komolafe and Adeoti (2018).

- i. Meeting attendance index was obtained by summing up attendance of farmers members at meetings and relating it to the number of scheduled meeting per annum by the associations they belonged to. The value was then multiplied by 100 to give the index.
- ii. *Density of membership* was measured by the number of active farmer membership in existing associations. A complete inventory of all associations was made at local level institutions. Each farmer was given the inventory and was asked to indicate which associations he/she belonged to. The proportion of membership of associations by individuals was calculated and rescaled to 100.
- iii. *Heterogeneity index was obtained by first identifying* the three most important associations that each farmer belonged and asking each farmer questions on whether members of each of the three associations identified lived in the same neighborhoods, had the same occupation, were of the same economic status, were of same gender

and same age group. For each of the factors, a yes/ no response was coded 1 or zero (a value of one on each criterion indicated that members of the associations were 'mostly from different' kin groups, economic status, etc.). The scores in the three associations for each farmer were then divided by the maximum score to obtain an index. This index was then multiplied by hundred (a zero value represented complete homogeneity, while 100 represented complete heterogeneity).

- iv. Decision making index: This was calculated by asking association members to subjectively evaluate whether they were “very active”, “somewhat active” or “not very active” in the group's decision making. This response was scaled from 2 to 0, and was averaged across the three most important associations and multiplied by 100 for each farmer (Grootaert, 2000).
- v. Cash contribution index was obtained from the total cash contributed to the three most important associations which the farmer belonged. The actual contribution for each farmer was rescaled by dividing the amount by the maximum fee scheduled to be contributed and multiplying the resultant fraction by 100 (Grootaert, 2000; Komolafe and Adeoti; 2018).
- vi. Labour contribution index was obtained by the number of days that farmers belonging to associations

have worked for their associations. This represents total number of days worked by members in a year divided by the total number of days they were scheduled to work for the associations. This was then rescaled to 100 (Grootaert, 2001).

- The Total Factor Productivity (TFP) estimation following Key and McBride (2003) was measured as the inverse of the average unit cost of production quantity

$$TFP \cdot \frac{Q}{AVC} \text{ or } \frac{1}{AVC} \quad (1)$$

$$TFP \cdot \frac{Q}{\sum_{i=1}^n P_x X_i} \quad (2)$$

Where:

Q = quantity of cassava in kg

AVC = Average Variable Cost in naira (N)

P_x = price of input *i*

X = input *i*

- Likert Scale was adopted to measure the social dimensions indicators for appropriate scoring in other to estimate each of the indices using Low = [1], Average = [2] and High = [3].
- The ordinary least square regression was employed to elucidate the effect of social capital on the gender dimensions of Total Factor Productivity (TFP) of cassava farmers in Oyo State, Nigeria. Three equations were run separately; to explain the effect on male farmers' productivity,

female farmers' productivity and all farmers pooled together. The explanatory variables used in the econometric model essentially follow Yusuf (2008) and Balogun *et al.* (2018).

$$Y = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \dots + \beta_n Z_n + u_i$$

Where,

Y = TFP

β_0 = Intercept

$\beta_1 - \beta_n$ = Parameters to be estimated

Z_1 = Gender (male=1, female=0; used only for the pooled data),

Z_2 = Age of farmer (Years),

Z_3 = Marital status (married=1, others=0),

Z_4 = Years of education (Years),

Z_5 = Household size (number),

Z_6 = Farmer's experience (Years),

Z_7 = Farm size (hectares),

Z_8 = Credit access (access=1, no access=0),

Z_9 = Density of Membership (%),

Z_{10} = Cash contribution index (?)

Z_{11} = Labour contribution index (%),

Z_{12} = Decision making index (%),

Z_{13} = Meeting attendance index (%),

Z_{14} = Heterogeneity index (%),

u_i = error term

Results and Discussion

The socioeconomic characteristics of farmers are presented on Table 1. The results reveal that 76.1% of the cassava farmers were male while only 23.9% were female. The mean age was about 53 years although female cassava farmers were younger than their male counterparts. This agrees with the findings of Olorunsanya and Omotesho, (2011) that male cassava household heads are older than their female counterparts. Most (81%) cassava farmers were married while the mean years of education was about 7 years, although

female cassava farmers had less years of education, about 4 years, as also found by Okoruwa *et al.*, (2006). Most (52.2%) cassava farmers had households with 6-10 persons while the mean household size was about 7 persons. The household size has implications for the quantity of family labour used in the study area. The mean years of farming experience of the farmers was about 18 years, mean farm size was 2.31 ha while the mean annual income was ₦ 89,933.30. The mean farm size (2.42 ha) and income (₦ 95,807) of male farmers were observed to be higher than that of the female farmers, 1.49 ha and ₦ 71,222.93 respectively.

The description of the social capital dimensions of the cassava farmers is presented on Table 2. Most (55%) of the cassava farmers had higher density of membership in associations although more males (56.2%) had higher density of membership than female farmers (51.2%). This means that a higher proportion of males belong to more associations than females. With respect to cash contributions, most (77.2%) cassava farmers pay about ₦ 50 or less weekly to their associations. About 62.2% of the cassava farmers contributed labour to their association more than two weeks in a year. This is in line with Komolafe and Adeoti (2018) who found mean labour contribution to be about 26 days (3.5 weeks) in a year. In terms of active membership evidenced in participation in associations' decision making, it was revealed that about 53.9% of the cassava farmers are averagely active in their associations. Furthermore, about 88.3% of the cassava farmers have low to average meeting attendance in their associations, although; male cassava farmers had the higher proportion of low meeting

Table 1: Socio-economic Characteristics of Cassava Farmers

Characteristics	Males (%)	Females (%)	All (%)
Gender	137 (76.1)	43 (23.9)	180 (100)
Age			
25-44	42(30.6)	17(39.3)	59(32.7)
45-64	61(44.6)	19(44.3)	80(44.5)
>64	43(24.8)	7(16.4)	41(22.8)
Mean	53.23	50.67	52.62
Standard Deviation	13.87	11.79	13.68
Marital Status			
Single	9(6.6)	0(0.0)	9(5.0)
Married	119(86.9)	27(62.8)	146(81.1)
Divorced	8(5.8)	3(7.0)	11(6.1)
Widow	1(0.7)	13(30.0)	14(7.8)
Years of Education			
0-6	63(45.9)	26(60.4)	89(49.3)
7-12	70(51.2)	17(39.6)	87(48.4)
>12	4(2.9)	0(0.0)	4(2.2)
Mean	8.38	7.12	5.80
Standard Deviation	7.14	3.82	6.79
Household size			
Small (1-5)	58(42.4)	18(41.8)	76(4.2)
Medium(6-10)	74(53.9)	20(46.6)	94(52.2)
>Large 10	5(3.7)	5(11.6)	10(5.6)
Mean	6.64	7.95	6.91
Standard Deviation	3.35	5.92	4.68
Farming Experience			
1-5	3(2.2)	5(11.6)	8(4.4)
6-10	11(8.0)	1(2.3)	12(6.7)
11-15	19(13.9)	1(2.3)	20(11.1)
16-20	24(17.5)	16(37.2)	40(22.30)
>20	80(58.4)	20(46.6)	100(55.5)
Mean	19.01	15.37	17.91
Standard Deviation	15.23	12.04	14.28
Farm size (ha)			
1-5	75(54.6)	30(6.9)	105(58.5)
6-10	50(36.6)	13(30.3)	63(34.9)
11-15	8(5.9)	0(0.0)	8(4.4)
>15	4(2.9)	0(0.0)	4(2.2)
Mean	2.42	1.49	2.31
Standard Deviation	3.88	2.38	3.18
Annual farm income (?)			
= 25,000	6(4.4)	8(18.6)	14(7.4)
25,500-100500	98(71.5)	33(76.7)	131(62.7)
>100,500	33(24.1)	2(4.7)	35(19.5)
Mean	95806.57	71220.93	89933.30
Standard Deviation	29827.15	33217.84	52345.11

Source: Field Survey, 2016

attendance hence, were less frequent at association meetings than female cassava farmers. Level of heterogeneity of groups to which households belong was rated according to: neighborhood, kin group, occupation, economic status, religion, political group, gender, age, education, cultural practice, belief and trust; in line with Lawal *et al.* (2009). The result revealed that there is average level of heterogeneity among cassava farmers constituting about 46.1% in all. This shows that the cassava farmers in the associations are not too different from one another and this could promote trust and information

sharing among the farmers.

The productivity levels of the cassava farmers are presented on Table 3. Productivity levels varied among the cassava farmers with about 71.1% having productivity of 0.2kg/? or less. The mean TFP was 0.189 kg/? , although; mean TFP for male farmers was 0.192kg/? while that of female farmers was 0.087kg/? . All female cassava farmers had productivity less than 0.11kg/? . Less than 30% of all the cassava farmers had productivity levels higher than 0.2 kg/? . The results are in line with Ogunsumi *et al.* (2013) who reported that majority of cassava farmers achieved productivity levels of between 0.1 and 0.5 in

Table 2: Social capital dimensions of cassava farmers

Social Capital Indicator	Male-Headed Households (%)	Female-Headed Households (%)	All Households (%)
Density of Membership			
Sparsely	60(43.3)	21(48.8)	81(45.0)
Densely	77(56.2)	22(51.2)	99(55.0)
Cash Contribution(?)			
= 50weekly	107(78.1)	32(74.4)	139(77.2)
= 50monthly	53(38.7)	8(18.6)	61(33.9)
= 50yearly	53(38.7)	8(18.6)	61(33.9)
Labour Contribution			
None	10(7.3)	2(7.3)	12(6.7)
At most two weeks per year	41(29.9)	15(34.9)	56(31.9)
More than two weeks per year	86(62.8)	26(60.4)	112(62.2)
Decision Making			
Low	54(39.4)	12(27.9)	66(36.7)
Average	69(50.4)	28(65.1)	97(53.9)
High	14(10.2)	3(7.0)	17(9.4)
Meeting Attendance			
Low	61(44.5)	15(34.9)	76(42.2)
Average	52(38.0)	21(48.8)	73(46.1)
High	24(17.5)	7(16.3)	31(17.2)
Heterogeneity			
Low	59(43.1)	12(27.9)	71(39.4)
Average	59(43.1)	24(55.8)	83(46.1)
High	19(13.8)	7(16.3)	26(14.4)

Source: Field Survey, 2016

Table 3: Productivity level of cassava farmers

TFP (kg/?)	Males (%)	Females (%)	All (%)
0.01 – 0.10	19 (13.9)	43 (100.0)	24 (13.3)
0.11 – 0.20	76 (55.5)	0 (0.0)	104 (57.8)
0.21 – 0.30	5 (10.9)	0 (0.0)	19 (10.6)
0.31 – 0.40	7 (5.1)	0 (0.0)	9 (5.0)
>0.40	20 (14.6)	0 (0.0)	24 (13.3)
Mean	0.192	0.087	0.189
Standard deviation	0.129	0.027	1.282

Percentages in parentheses

Source: Field Survey, 2016

Oyo state.

The results of social capital on the gender dimensions of agricultural productivity among cassava farmers in the study area are presented on Table 4. The F-value being statistically significant at 1% level, showing a good fit for the model. The determinants of productivity among male cassava farmers were age, years of education, farming experience, meeting attendance and heterogeneity. Farming experience and age were negative and significant in determining productivity of male farmers at 1% and 10%, respectively. This indicates that an increase in the farming experience and age of a male farmer by 1 year will decrease productivity by 0.278 and 0.57%, respectively. This result suggests that younger farmers are more productive than older farmers. This disagrees with Balogun (2018) who found that productivity increases with age. Marital status and years of education of farmers were positively related to productivity and each significant at 1%. This indicates that being married increases productivity of male farmers by 1.40% while an increase in years of education by one year, increases male cassava farmers'

productivity by 0.316%.

With respect to social capital, meeting attendance and heterogeneity index were found to be negative and each significant at 5% level in determining productivity of male farmers. Hence, a decrease in the number of association meetings by one will increase a male farmer's cassava productivity by 0.91%. Similarly, reducing the diverse nature of the association to which a male cassava farmer belongs will increase his productivity by 0.22%. This implies that male farmers are more productive when they belong to homogenous associations where members have the same occupation, have similar economic status or live in the same neighbourhood.

Similarly, productivity of female cassava farmers was determined by age, marital status and farming experience. Unlike their male counterparts, productivity of female cassava farmers was also determined by household size and farm size which were both positive and significant at 1% and 5% level, respectively. Hence, increasing a female cassava farmer's household size by 1 person will increase her productivity by 0.745%. This may be because female farmers have

Table 4: Effect of Gender and Social Capital on Agricultural Productivity

Variables	Male	Female	All
	Coefficients (S.E)	Coefficients (S.E)	Coefficients (S.E)
Gender			0.0043(0.0020)**
Age	-0.5683(0.2878)***	-0.9768(0.4946)***	-0.1045(0.2442)
Marital Status	1.4004(0.3331)*	1.0416(0.5039)***	0.6778(0.2223)*
Years of Education	0.3157(0.1182)*	0.1925(0.1998)	0.2101(0.1121)***
Household Size	0.0945(0.1369)	0.7454(0.2114)*	0.0426(0.1199)
Farming Experience	-0.2206(0.8316)*	-0.5369(0.1856)**	-0.1110(0.0712)***
Farm Size(Hectare)	-0.2781(0.7380)	6.7381(1.1128)**	0.1447(0.1609)*
Access to credit	0.0309(0.0366)	0.1624(0.1487)	0.0244(0.3504)
Density of Membership	-0.0808(0.2733)	2.5333(0.3663)**	0.49910(0.2192)**
Cash Contribution	-0.2293(0.3076)	-1.8951(0.4681)**	-0.4636(0.2645)***
Labour	0.2005(0.1594)	0.1045(0.1824)	0.1086(0.1374)
Contribution Index			
Decision Making	-0.5550(0.3350)	-0.0315(0.2339)	-0.4655(0.1901)**
Index			
Meeting Attendance	-0.9110(0.4157)**	-0.1810(0.3611)	0.6971(0.2554)**
Index			
Heterogeneity Index	-0.2193(0.2921)**	0.6740(0.3792)	-0.6971(0.2554)
Constant	-82.8690(11.0368)*	-3.9823(8.9309)*	-22.8850(6.9816)*
Prob>F	0.0000	0.0000	0.0000
R-squared	0.6297	0.9547	0.5354
Adj R-squared	0.5239	0.8889	0.4469
Root MSE	0.3252	0.1691	0.3568

Source: Author's Computation

*Significant at 1% ** Significant at 5% *** Significant at 10%

less income to spend on hired labour and thus, rely more on family labour. This result agrees with Atagher (2013) who found that large family size leads to increased agricultural output. Similarly, farm size was positive and significant at 5% in increasing productivity of female cassava farmers but had no significant effect on their male counterparts. Hence, increasing a female cassava farmer's farm size by 1 ha will increase her productivity by 6.738%.

Interestingly, the dimensions of social capital that affect male cassava farmers

differed from those that affect their female counterparts. Meeting attendance and heterogeneity index influenced productivity of male farmers whereas, density of membership and cash contribution influenced productivity among female cassava farmers. Density of membership was positive and significant at 5% level in determining productivity of female cassava farmers. Hence, increasing the number of associations that female cassava farmers belong by a unit will increase their productivity by 0.37%.

Conversely, cash contribution is negative and significant at 5% level in determining productivity of female cassava farmers. Increasing the cash contribution to an association for a female cassava farmer by ? 1 will decrease productivity by 0.47%. This result disagrees with Yusuf and Balogun (2011) that there is a positive relationship between cash contribution and productivity. This may be due to the disadvantaged position of female farmers in terms of income and assets.

In all, the pooled results show that gender was significant at 5% in determining productivity among cassava farmers. Specifically, being a male cassava farmer increases productivity by 0.004%. This finding is corroborated by Ogunleye (2018) who also found that gender improves productivity of cassava farmers. This underscores the fact that female cassava farmers are disadvantaged in terms of productivity. Other factors that significantly influenced productivity of cassava farmers in the study area were: marital status and farm size at 1%, density of membership, decision making index and meeting attendance index at 5% and years of education, farming experience, and cash contribution at 10%, with positive relationship to productivity excluding farming experience, cash contribution and decision making index. For instance, a decrease in cash contribution to the associations by ? 1 will increase productivity of cassava farmers by 0.46%.

Conclusion

It was established in this study that the socioeconomic characteristics and social capital dimensions that influences agricultural productivity of male cassava farmers differ from those that influence the

productivity of female cassava farmers. Density of membership and cash contribution in addition to household size and farm size, influence agricultural productivity of female cassava farmers whereas meeting attendance and heterogeneity in addition to years of education, influence agricultural productivity of male cassava farmers. It was concluded that gender influences the productivity of cassava farmers alongside marital status, years of education, farming experience, farm size and social capital dimensions. Therefore, to increase the productivity of female cassava farmers, government policies that favour increased land acquisition for cassava farming should be encouraged while female cassava farmers should be encouraged to increase the number of associations they belong to. Associations should also explore in-kind contributions for female farmers. To increase the productivity of male cassava farmers, it is recommended that they join associations that are more homogenous while increasing their level of formal education is also encouraged.

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Consumers' Preference for Underutilized Indigenous Vegetables in Osun State, Nigeria

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Abstract

Understanding the attributes of consumers' desire in Underutilised Indigenous Vegetables (UIVs) will ensure demand driven supply. This paper therefore, examined the preferences of consumers for UIVs consumed in Osun State. A purposive sampling technique was employed to select 150 respondents in Osun State. Data were analysed using descriptive statistics and conjoint analysis. The result of the descriptive statistics showed that 48% of the surveyed consumers were married, 78% were educated with the mean age of 44.15 ± 13.66 years and 4 ± 2.89 household members. Also, the average annual income earned by the respondents was $N736,032.00 \pm N534,270.81$. The result of the conjoint analysis showed that great preference was placed on indigenous vegetables that have bitter taste, highly medicinal with moderate price and available all year round. The study therefore recommended that scientists should develop UIVs seeds that can produce the combination of these attributes, preferred by the consumers.

Keywords: Conjoint analysis, Consumers preference, Indigenous vegetable, Underutilised vegetable

Introduction

Indigenous vegetables are vegetables whose production is confined to a particular location or have been introduced to that location for a long period of time and thus can be referred to as traditional vegetables. These traditional vegetables are area and ethnic group specific (Luchen and Mingochi, 1995; Padulosi *et al.*, 2013). For instance, indigenous vegetables in Africa continent are referred to as Africa Indigenous Vegetables. Therefore, its choice and consumption are strongly influenced by traditions (Kimiye *et al.*, 2005). In Africa, Nigeria ranked second in the production of these indigenous vegetables, producing 11,940,600 metric tonnes per year (FAOSTAT, 2012). The production of these vegetables is mostly on small-scale which often requires very little input, in rare occasions, application of organic manure and inorganic fertilizers

(Onyango *et al.*, 2009).

Over the years, indigenous vegetables were underutilised, seen as poverty crops, food for the poor and the lower class, especially with the introduction of exotic vegetables into the African continent (Abukutsa-Onyango, 2010; Oladele, 2011). In the recent times, there has been significant awareness towards the consumption of these underutilised indigenous vegetables (UIVs) for food security and income generating abilities inherent in them (Padulosi *et al.*, 2013). UIVs are chief sources of nutrients, vitamins, antioxidants, minerals, and proteins (Odhav *et al.*, 2007; Gayatri *et al.*, 2014). They also comprise some non-nutrient phytochemicals linked to protection against non-communicable diseases (Sifelani, 2015). Some are sold fresh while some are sold locally for medicinal purposes by natives (Eifediyi *et*

al., 2008), thus improving economic and health status of communities involved in their production.

In a bid to promote the future of Underutilised Indigenous Vegetables worldwide, many organisations and research institutes such as Consultative Group on International Agricultural Research (CGIAR), International Plant Genetic Resources Institute (IPGRI), Food Organisation and Agriculture, Department for International Development (DFID) among others, have carried out projects to create more awareness about the production, marketing and consumption of these vegetables. With the recently concluded MICROVEG project in Nigeria, more awareness was created in order to increase the consumption of underutilized indigenous vegetables through a regular jingle on popular FM radio station in southwestern Nigeria (Adebooye *et al.*, 2014).

Since the inception of UIVs promotion in Southwestern Nigeria, a number of researches had focused on the production (Ajekiigbe *et al.*, 2017; Ayinde *et al.*, 2016; Amujoyegbe *et al.*, 2015), marketing (Ayanwale *et al.*, 2011), demand (Ayanwale *et al.*, 2016) and gender (Deji *et al.*, 2013) analyses of UIVs. However, there is dearth of studies on the consumers' preference for these promoted UIVs in the area where they were promoted. It is therefore, necessary to evaluate and determine the consumers' preference for specific attributes of UIVs consumed in the study area. In view of this, the objectives of the study were to determine the social economic characteristics of UIVs' consumers; analyse the consumers' preference for the UIVs' attributes consumed, and also identify the levels of attributes preferred by the UIVs'

consumers. This study will help both the researchers, farmers and marketers to know the particular attributes that the consumers prefer in order to ensure demand driven supply.

Materials and Methods

The study was conducted in Osun State. Osun State is an inland state in southwestern Nigeria (NPC, 2006) on the Latitude, 7.7667, Longitude, 4.5667, Altitude 1013 fts; The State is primarily an agrarian community where UIVs' production, marketing and consumption were promoted in the recent time. All the three federal senatorial districts in Osun State (Iwo, Osogbo and Ife/Ijesa) were selected because promotion of UIVs was carried out in the whole State. Fifty consumers of indigenous vegetables from each senatorial district were purposively selected to give a total sample size of 150 respondents. Primary data were collected from the UIVs' consumers using a well-structured questionnaire administered through personal interview. The questionnaire was drawn to get information on socio-economic characteristics of the respondents, source of income and preference of consumers based on the UIVs attributes consumed (taste, availability, medicinal value and price). Data were analysed using descriptive statistics of frequency tables, mean, standard deviation and percentages, and conjoint analysis.

Conjoint analysis

The conjoint analysis was used to determine the consumers' preference for the UIVs attributes and the levels of the attributes included in the analysis. Conjoint analysis is defined as "any decomposition method that estimates the structure of a

consumer's preferences such as partworths, importance weights and ideal points given their overall evaluations of a set of alternatives that are pre-specified in terms of levels of different attributes" (Green and Srinivasan 1990, Kotri, 2006). The first step in a conjoint analysis is to define the product attributes and corresponding levels that will be used in the study. A numerical partworth utility value is then estimated for each attribute level to give the relative importance of the respondent's level. Partworths reflect the attractiveness of an attribute level, while relative importance of an attribute provides basis to draw conclusions about the role attribute plays in vegetable consumption. A larger partworth implies greater preference and from the partworths, the relative importance of different attributes can be found. The consumer's rating on their preference for each vegetable is the amount of satisfaction, or utility, that consumer gets from consuming specific vegetable.

In general agriculture, Lin *et al.* (1996) performed an opinion survey to determine important attributes; Oltman *et al.* (2014) utilized Adaptive Choice Based Conjoint to determine prominent attributes (color, firmness, size, skin, texture, interior, seed presence, flavor, and health benefits) for desiring fresh tomatoes by consumers. Also, Alberto (1999) examined apple consumers and identified five attributes that made consumers demanded for it to be crispness, size, flavor, price, and color. Harrison *et al.* (2002) tested preferences for the products' form, price, and flavour; Sy *et al.* (1997), utilized focus groups to have better understanding of the significance of attributes (purebred breeders, commercial cow-calf producers, and cattle feeders). Also, Adenegan *et al.* (2016) surveyed

buyers of organic vegetables using conjoint analysis and identified method of production, quality and price as attributes and the partworths estimate indicated high preference for good quality.

Since all influential attributes could not be included in this study, four major attributes and different levels were decided on and these were price/bunch (N20.00, N30.00, N50.00), taste (sweet, tasteless, bitter), availability (seasonal, always) and medicinal value (high, low). To estimate the partworths and relative importance of product attributes, the ordinary least squares method was chosen as estimation method and the model is specified as follows:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + E_i$$

Where Y = consumer's preference rank for vegetables

B_0 = the intercept

$B_1, B_2, B_3, \text{ and } B_4$ = parameters of independent variables showing the partworths (utility) of different vegetable attributes for a particular consumer to be estimated

X's are different levels of attributes:

X_1 = price (N20.00, N30.00, N50.00)

X_2 = taste (sweet, tasteless, bitter)

X_3 = availability (seasonal, always)

X_4 = medicinal value (high, low)

E_i = error term.

Results and Discussion

Socio-economic characteristics of the consumers are shown in Table 1. About 48% of the respondents were married with the mean age of 44.15 ± 13.66 years. Most (78%) of the respondents were literate as the respondents had secondary and tertiary education. This shows that respondents are in their middle age, have the capability to -

Table 1: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage (%)	N=180
Age (years)			
= 20	1	0.7	
21 -40	67	44.7	
41 - 60	59	39.4	
61 and above	23	15.3	
Mean Value	44.15		
Standard Deviation	13.663		
Gender of the respondents			
Male	86	57.3	
Female	64	42.7	
Marital status			
Single	43	28.6	
Married	72	48.0	
Divorced	22	14.7	
Widowed	13	8.7	
Level of education (years)			
No formal education	8	5.3	
Some primary school	3	2.0	
Primary school	9	6.0	
Some secondary school	13	8.7	
Secondary school	44	29.3	
College of education	41	27.4	
Others	32	21.3	
Household size			
1-3	47	31.3	
4-6	93	62.0	
7-9	10	6.7	
Mean	4.26		
Standard deviation	2.89		
Income (?)			
= 100000	1	0.7	
100001 - 400000	41	27.3	
400001 - 700000	44	29.3	
700001 - 1000000	34	22.7	
1000001 - 1300000	4	2.7	
1300001 - 1600000	13	8.7	
1600001 and above	13	8.7	
Mean Value	736032.66		
Standard Deviation	534270.81		

select vegetables they desire, and with their level of literacy, can perfectly rank these vegetables based on the utility derived from its consumption. More than 60% of the respondents had between 4 to 6 household members with the average of 4±2.89 members. The result also revealed that the average annual income earned by the respondents was N736,032.00 ±N534270.81. This implies that consumers (respondents) can afford vegetables provided it possesses the attributes they desire.

Consumers' preference for underutilized indigenous vegetable attributes

Table 2 presents the parthworth (utility) estimates from the conjoint analysis of the consumers' preference for underutilized indigenous vegetables attributes. The Adjusted R² of 0.723 indicates that about 72.3% of the variability in the consumers' preference for UIVs is explained by the specific independent variables included in the model. All the attributes (price, availability, medicinal value and taste)

included in the model were significant at 1% and 5% levels. Higher utility value indicates greater preference. Consumers gave higher preference to attributes level of price (₦ 20.00 and ₦ 50.00 per bunch) at 4.016 and 4.971, respectively; availability (always) at 4.632; medicinal value (highly medicinal) at 4.632 and taste (bitter) at 3.485 utility estimates. However, the price coefficients (utility estimates) at ₦ 50.00 per bunch corresponding to -4.971. This reveals an inverse relationship between price level and utility, because at higher price, little quantity can be bought and thus reduce the utility derived by the consumer. This implies that, consumers prefer UIVs that are always available with high medicinal value and bitter taste. Here, price is a major concern, since preferred attributes by consumers are not bore by one type of vegetable, higher price will prevent buying the collection of vegetables that can provide these attributes. As a result of this, consumers will prefer vegetables that are not too expensive for them to be able to - purchase more UIVs with these attributes,

Table 2: Conjoint analysis estimations of utility for underutilized indigenous vegetable

Attributes	Levels	Utility Estimate	Relative Importance (%)
Price	₦50.00	-4.971	
	₦30.00	-3.677*	25.47
	₦20.00	4.016*	
Availability	Always	4.632**	1.93
Seasonal		4.535	
Medicinal value	Highly medicinal	2.792*	36.25
	Low medicinal	4.632	
Taste	Tasty	1.639*	36.35
	Tasteless	2.786*	
	Bitter	3.485	
Constant	4.632		
Adjusted R ²	0.723		

* = significant at .01 level

** = significant at .05 level

translating to more utility.

The relative importance from the conjoint analysis revealed that taste had highest relative importance 36.35% closely followed by medicinal value (36.25%). Thus, both “taste” and “medicinal value” turned out to be the most important attributes with “availability” being the least important attribute. It appears price is not as important a factor as taste and medicinal value to the consumers. This result implies that the respondents are most concerned about the taste and medicinal value of UIVs consumed and might be willing to pay more if these attributes are found in a type of vegetable. This signifies that consumers value the health potentials in UIVs. Hence, availability, highly medicinal value and vegetables with bitter taste correspond to a higher utility by the consumers.

Conclusion and Recommendations

Based on the findings of this research, we conclude that consumers' preference is greatly placed on indigenous vegetables that are highly medicinal and have bitter taste, and that consumer will buy more of these at moderate prices. Hence, understanding consumers' preference will better inform farmers on the production systems to employ and type of vegetables to grow based on the specific attributes that consumers look out for in the vegetables they consume. This will also provide useful and important information for the seed scientists on the attributes of UIVs that consumers prefer. In addition, there is a need for food scientists to provide vital information on the nutritional values of agricultural products to encourage their consumption since many are conscious of what they consume for health reasons. Policies that will encourage demand-driven

supply of agricultural products in the country should be encouraged.

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Analysis of Sources of Agricultural Information and its Effect on Plantain Yield among Farmers in Osun State, Nigeria

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Abstract

This study examined the sources and types of agricultural information available to plantain farmers, analysed agricultural information sources and estimated its effect on plantain yield in Osun State. Multistage sampling procedure was employed to select 180 plantain farmers. Primary data were collected using well-structured questionnaires. Data were analysed using descriptive statistics of frequency tables, means and percentages and regression analysis. The results of the socioeconomic characteristics of the respondents showed that majority (90%) of the respondents were married with a mean value of 6 household members. Most (83%) of the respondents were small landholders, having less than 3 hectares with a mean value of 17 years of plantain farming experience and a mean yield value of 4.89tons/ha. The result of information sources revealed that family members were the source of information farmers frequently used while radio was the most beneficial source of information. The result further showed that respondents received information mostly on farming practices and result of regression analysis confirmed that agricultural information sources had positive effects on yield at $p < 0.05$ level of significance. Hence, there will be considerable increase in yield if agricultural information sources are increased above the present levels of use.

Keywords: Agricultural Information Sources, Plantain, Regression Analysis, Osun State.

Introduction

Plantain is a crop with a relatively high economic significance that is common to most other horticultural crops (Aina *et al.*, 2012) and presently being recognised as a cash crop (IITA, 2014). The commercial importance of plantain is enormous as it serves both food and non-food purposes. The non-food purposes include its contribution to income generation for both large and small-scale farmers (Fakayode, *et al.*, 2011) and to gross national product (GNP) (Nkendah and Akyeampong, 2003). Its fruit serves as raw materials for other businesses thus aids employment creation. Plantain flour has been endorsed to be used as a thickener (USDA, 2009; Zakpaa *et al.*, 2010) and a sweetener in the food industry as well as a drug binder in pharmaceuticals (Eleazu *et al.*, 2011). The food purposes

include contribution to food security (USDA, 2012). It is specifically important in the diet of many Nigeria families (Okoruwa *et al.*, 2014) because it contains most of the micro nutrients essential for optimum growth and body development in both children and adults (Ayanwale *et al.*, 2016). Thus it is used to solve the problem of micronutrient deficiencies (Adeniji, 2015).

The estimated annual demand for plantain in Nigeria is between 20 and 20.8 million metric tons. However, the average annual production of plantain from 2000 to 2014 was 2.6 million metric tons (FAO, 2014). This has created a deficit between demand and supply (Olumba 2014; Oso and Ayodele, 2014). This is mostly due to challenges in its production practices which result in low yield (IITA, 2014). Another

major challenge is its seasonality which makes its supply to the market highly unstable consequently affecting its price. These challenges are further compounded by the inadequate access to agricultural information on plantain production (IITA, 2014), a factor which makes it difficult for farmers to have control over their resources, manages changes in production systems as they arise and make better decisions to take advantage of market opportunities around them (Vidanapathirana, 2012).

Agricultural information remains a powerful tool by which agricultural production and yield can be improved as it acts as both an input in production and a product of an effective market (Ozcatalbas, *et al.*, 2016). However, agricultural information is not useful in itself until disseminated to its potential users (farmers). In Nigeria, agricultural information was customarily disseminated through extension services but had not been effective due to weak linkages between researchers and extension workers and between extension workers and farmers (Daudu *et al.*, 2009). This has now necessitated the use of various sources through which agricultural information can be accessed by the farmers.

Despite that intense research on plantain production have been on-going in Nigeria to increase yield (Akinyemi *et al.*, 2010; Olumba, 2014), there still exists a breach between the yield which research proves attainable {30-35 t/ha} (CARBAP, 2014) and that achieved 5.7t/ha by plantain farmers (Food and Agriculture Organization (FAO), 2014).

The objectives of this study therefore are to identify information sources used and types of information obtained from the

identified information sources, analyse agricultural information sources which can be projected from the frequency of access and use made by the farmers and the usefulness (utilisation) of the information obtained and its overall effect on the yield from plantain production of farmers.

Materials and Methods

This study was carried out in Osun State. A multistage sampling procedure was employed to select 180 respondents. The first stage involved purposive selection of six Local Government Areas (LGA) (Atakumosa East, Atakumosa West, Ayedaade, Ife East, Ife North and Oriade) based on their concentration in plantain production. The second stage involved random selection of two communities from each LGA and the final stage involved purposive selection of fifteen plantain farmers using snowball sampling technique to give a total of 180 respondents. Primary data on the socioeconomic characteristics of respondents, cost of inputs, plantain yield as well as sources and types of information, frequency of contact and usefulness of agricultural information among others, were collected with the aid of well-structured questionnaires. Data were analysed using descriptive statistics and regression analysis.

Total information score

Total information score was the summation of the product of the frequency of farmers' contact with information source and the usefulness of the information obtained from all information sources used by individual farmers. This was further used to determine the effectiveness of agriculture information sources among the respondents and explicitly specified as:

$$TIS_i = \sum_1^j FC_{ij} \times IU_{ij} \dots\dots\dots(1)$$

Implicitly specified as

$$TIS = FC_1IU_1X_1 + FC_2IU_2X_2 + FC_3IU_3X_3 + FC_4IU_4X_4 + FC_5IU_5X_5 + FC_6IU_6X_6 + FC_7IU_7X_7 + FC_8IU_8X_8 + FC_9IU_9X_9 + FC_{10}IU_{10}X_{10} + FC_{11}IU_{11}X_{11} + FC_{12}IU_{12}X_{12} \dots\dots\dots(2)$$

Where *TIS* = Total information scores,
FC is the frequency of contact with information source by the plantain farmer and

IU is the extent of usefulness of the information received from the information source by the plantain farmer,

X's are the information sources which are

- X₁ = Extension agents
- X₂ = Farmers' cooperatives
- X₃ = Agricultural institutes/Universities
- X₄ = Other government projects
- X₅ = Other farmers
- X₆ = Family members
- X₇ = Radio
- X₈ = Internet
- X₉ = Newspaper/Magazines
- X₁₀ = Input suppliers
- X₁₁ = Television
- X₁₂ = School

Results and Discussion

Socioeconomic characteristics of respondents

The results of the socioeconomic characteristics of the respondents are presented in Table 1. It showed that married people (90%) dominate plantain production. The mean household size was 6±3.4 members with 57% of the respondents having between 6 and 11 members. This indicates a large household size in the study area and this agrees with

the findings of Daudu *et al.* (2009). Large household size ensures more information sharing among household members and enhances more availability of information to farmers. Results from Table 1 also shows that 54% of the respondents had less than 16 years of experience in plantain farming. This shows that a large proportion of the respondents were new in plantain production. This is in line with reports of IITA (2014) that plantain production in Nigeria is dominated by new entrants. More so, most (71%) of the respondents had farmland ownership either by inheritance or purchase. Further examination showed that majority (82.77%) of the farmers cultivated less than 3 hectares with the average of 2±1.77 hectares of land. This indicates small scale plantain production in the study area as confirmed by Olumba (2014). The mean yield of plantain was 4.89±4.9 tons/ha. This is in contrast with the findings of FAO (2014) that the estimated annual yield is 5.7t/ha while the potential yield is between 30-35 t/ha (CARBAP, 2014). This implies existence of a yield gap in plantain production in the study area.

Sources of agricultural information available to plantain farmers

Sources are different networks through which agricultural information is disseminated to farmers and these are presented in Table 2. The following sources of information were identified: extension agents, farmers' cooperatives, agricultural institutes/universities, government projects, other farmers, family members, radio, internet, newspapers/magazines, input suppliers, television and schools. The result of the analysis revealed that family members were highly (70.56%) rated as a source of information to farmers. This

Table 1: Distribution of plantain farmers by socioeconomic characteristics

Variables	Frequency	Percentage (%)	N=180
Marital status			
Single	16	8.89	
Monogamously married	114	63.33	
Polygamously married	48	26.67	
Widowed	1	0.56	
Separated	1	0.56	
Household size			
≤5	103	57.00	
6-11	14	7.78	
≥12	6		
Mean	3.40		
Standard deviation			
Years of plantain farming			
<16	98	54.44	
16-30	62	34.44	
31-45	13	7.22	
≥46	7	3.89	
Mean	17		
Standard deviation	12.32		
Land ownership			
Inheritance	127	70.56	
Purchase	38	21.11	
Lease/Rent	15	8.33	
Plantain farm size (ha)			
<1.0	44	24.44	
1-2.9	105	58.33	
3-4.9	20	11.11	
5-10	9	5.00	
≥12	2	1.11	
Mean	2.02		
Standard deviation	1.77		
Yield (Kg/ha)			
0-5	143	79.44	
6-11	18	10.00	
12-17	7	3.89	
≥18	12	6.67	
Mean	4.89		
Standard deviation	4.90		

Table 2: Distribution of sources of agricultural information used by farmers

Sources	Frequency	Percentage	N=180
Extension agents	4	2.22	
Farmers' cooperatives	51	28.33	
Agric. institutes/Universities	13	7.22	
Other govt. projects	37	20.56	
Other farmers	59	32.78	
Family members	127	70.56	
Radio	92	51.11	
Internet	2	1.11	
Newspaper or magazines	3	1.67	
Input suppliers	15	8.33	
Television	23	12.78	
Schools	9	5.00	

Multiple responses recorded

confirms the findings of Kughur *et al.* (2015) that most farmers get agricultural information from friends and relatives. Also about 51.11% used the radio while the internet had the least usage (1.11%) followed by newspapers (1.67%). This confirms the findings of Lwoga *et al.* (2011) that farmers rely on radio more than printed materials and advanced Information and Communication Technology media such as the internet and electronic mail to access agricultural information and knowledge.

Types of agricultural information available to plantain farmers

The results presented in Table 3 show the types of agricultural information available to the respondents in the study area. These include information on improved sucker varieties, agrochemicals, market and price information, farming practices, credit facilities and land acquisition. Information on farming practices was the highest (85.56%) type of information obtained by the farmers. It was noteworthy that less than 5% of the sampled respondents obtained information on improved varieties and

credit facilities. None of the farmers obtained information on land acquisition. This result corroborates the findings of Lwoga *et al.* (2011) and Kughur *et al.* (2015) that farmers have a dearth of information on credit facilities and improved sucker varieties.

Total Information Score (TIS)

The ranking of Total Information Score (TIS) from the analysis of agricultural information sources is presented in Table 4. The radio ranked first in the study area. This means that plantain farmers mostly benefited from radio programmes. Farmers' cooperatives ranked second and this corroborates the findings of Ozcatalbas *et al.* (2016) that farmers' groups have played a significant role in increasing agricultural yield. The seventh and eleventh ranks of Agricultural Institutes/Universities and extension agents imply that plantain farmers in the study area have not maximally benefited from the different research works being carried out at various Nigeria Agricultural Research Institutes and Universities through extension agents.

Table 3: Distribution of respondents by types of agricultural information obtained

Types	Frequency	Percentage	N=180
Improved sucker varieties	8	4.44	
Agrochemicals	57	31.66	
Market and price information	26	14.45	
Farming practicies	154	85.56	
Credit facilities	2	1.67	
Land acquisition	0	0.00	

Multiple responses recorded

Table 4: Information Score (IS) for sources of information

S/N	Information source	TIS	Rank order
a	Radio	1466.06	1 st
b	Farmers' cooperatives	820.00	2nd
c	Govt. projects	653.00	3rd
d	Family members	482.80	4th
e	Other farmers	299.00	5th
f	Television	256.00	6th
g	Agric. institutes/Universities	127.00	7th
h	Input suppliers	82.50	8th
i	Schools	56.00	9th
j	Internet	27.50	10th
k	Extension agents	16.00	11th
l	Newspapers	10.00	12th

This is in line with the findings of Uganneya *et al.* (2013) that there has been no satisfactory dissemination of information from the agriculture research information sources in Nigeria.

Effect of Agricultural Information Sources on the yield of plantain

The effect of agricultural information sources was determined by regressing Total Information Score (TIS) on the yield of plantain in the study area. Of the six predictors, five (TIS, farm size, marital status, household size, cost of inputs) were statistically significant at 1% and 5% probability levels as presented in Table 5.

The coefficient of determination (R^2) of the multiple regression was 0.6284. This

implies that about 62.84% of the variations in plantain yield were explained in the model while the remaining 37.16% was not accounted for in the model. The F-statistic value of 48.76% was significant and confirmed the overall significance of the regression analysis.

TIS had a positive and significant influence at 5% level. This indicates a direct relationship with the yield and implies that a unit increase in TIS will bring about 0.14tons/ha increase in yield. This shows that agricultural information sources have positive and significant effect on plantain yield as this corroborates reports by Soyemi and Haliso (2015) and Demiryurek *et al.* (2008) that agricultural information sources have continually played a significant role in

Table 5: Estimation results for variables in the multiple regression model

Variables	Coefficient	t-statistic
Constant	-0.1850	0.07
Marital status	1.5497	2.20**
Farming experience	-0.0151	-0.44
Household size	-0.3507	-1.78**
Farm size	4.7743	13.29***
TIS	0.1443	1.99**
Cost of inputs	-0.0001	-4.11***
R ²	0.6284	
Adjusted R ²	0.6155	
F- Statistics	48.76**	

***, ** and * represent levels of significance at 1%, 5% and 10% respectively

ensuring more agricultural yield.

Using marital status as a reference point, the positive sign and statistical significance of marital status at 5% level indicates that married farmers are more productive than single farmers. The coefficient of this variable (1.54) shows that the yield of married farmers will be 1.54tons/ha higher than the yield of single farmers. This is in line with reports of Omolehin *et al.* (2007) that married farmers are more conscious of the need to get better yield to meet their family food and financial needs and hence married farmers will harness all possible yield-increasing efforts.

Cost of inputs had a negative sign and significant at 1% level. This implies an inverse relationship with yield whereby a unit increase in cost of inputs will reduce yield by 0.0001tons/ha. This agrees with the findings of Nmadu *et al.* (2015) who found that high cost of inputs constrained farmers from adopting innovations that are capable of improving yield.

Similarly, farm size, being positively significant at 1% level implies that a hectare increase in farmland size will increase yield by 4.77tons/ha. This stresses

the significance of farmland size increase coupled with greater accessibility and use of accurate agricultural information on agricultural yield (Demiryurek *et al.*, 2008; Kaine and Okoje, 2014).

Conclusion and recommendations

From the findings, it can be concluded that majority of the farmers had a dearth of yield-improving information (credit facilities, marketing and improved sucker varieties) hence low plantain yield is recorded in the study area. It was also observed that information was mostly spread to farmers by family members although farmers have mostly benefited from radio information source. Farmers in the study area have not gained so much from research information from agricultural institutes and universities in Nigeria. Lastly, the use of agricultural information sources is positive and influences plantain yield significantly. Based on the findings of this study, the following recommendations were made to increase the yield in plantain enterprise:

1. The use of radio as the disseminating source of agricultural information sources among farmers

- should be redefined since it has more usage but little impact on plantain enterprise in the study area.
2. Information on yield-improving practices should be made available to the farmers as this will encourage large scale production and also facilitate enormous yield.
 3. The use of some information sources, particularly agricultural institutions and universities in the study area was low. This study recommends that research outputs should be made accessible and farmers-friendly so as to increase plantain yield.

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Communication Strategies for Maize Dissemination among farmers in South West, Nigeria: The Problems and the Prospect.

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Abstract

This study evaluated the problems and prospects associated with communication strategies for maize dissemination among rural farmers in southwestern Nigeria. The study was carried out in Oyo and Ogun States. Multistage sampling technique was used to sample 202 maize farmers in the area. Using quasi experimental research design, maize production information were disseminated to two groups of farmers separately using different medium and data was collected on associated constraints to understanding messages from the medium utilized for dissemination. Result shows that poor interactivity was a major challenge to understanding messages from conventional media while constraints for non-conventional method was centered on the individual carrying the message. The result shows no significant difference ($t=0.114$; $p=0.910$) in the constraints identified by the two groups of farmers. Extension practitioners should make seed dropping and mobile phone use for maize dissemination more interactive. Also, radio and community leaders' forum should be strategically introduced as part of the communication strategies for effective dissemination.

Key words: Communication strategies, Maize crop, Dissemination, Seed dropping, Farmers

Introduction

Dissemination of research technologies is critical to promoting the landmark outbreak of research because no matter how brilliant an innovation appears, it remains largely elusive if not properly disseminated to the intended users. Dissemination is a key element in the research to practice continuum and it must involve consideration of target audiences and the settings in which research findings are to be received (Wilson, *et al* 2010). Dissemination is a way of communicating specific research outcome to the user/s and it is dependent on the language of the receiver/user and access to available communication media. Communication media aids information transfer and adoption process. Okwu, and Iorkaa (2011)

posits that the first step to consider in farmers use of information is their capacity to access the appropriate communication media. This makes dissemination of agricultural information to farmers through appropriate communication media crucial as the information package.

The role of communication media in agricultural technology dissemination is very significant. Communication has been used over the years to attract the attention and participation of stakeholders in the dissemination and facilitation of the adoption process. According to Akpomuvie, (2010), the majority of the populations of countries in Africa live in the rural areas and the most effective way to keep them abreast with the programmes of governments is to popularize them at the

grassroots through Information communication technologies (ICTs) and non-conventional media.

The world is developing into a global village and developmental strides are riding on available technology in communication. Communication technologies are embedded with the potential of mobilizing people for development process. Although, the Agricultural Development Programme (ADP) system has been effective in disseminating agricultural technologies in Nigeria over many years, the problem of funding which reflects in reduced extension activities has limited the impact it could make on farmers. However, this dearth of extension services does not suggest that small scale farmers are advanced to self-sufficiency in agricultural productions, hence the need for a more conventional strategy for use. The mobile phone, has gradually become a vital and indispensable tool of transmitting or exchanging information among literate and non-literate audience. The functions are not only limited to making and receiving calls but for virtually every function as performed by the computer. Disseminating maize technology information among farmers using readily available communication technologies will multiply such information and gains within a short while. However, no one communication media is sufficient on its own. Promoting necessary agronomic practices and pathological information technology will increase farmers' knowledge and accuracy on cropping pattern, reduce the incidence of pest and diseases, increase unit - output and farmer's overall income will require a more careful use of both conventional and non-conventional media Spreading the information among farmers' friends will

therefore not be a difficult task again. This is important because of the relevance of maize in promoting the economy of South West region and Nigeria at large.

Communication media use for dissemination can be in two ways: conventional or non-conventional communication media. Non-conventional media refers to the time honored, means of mass communication which mostly creates a face to face situation between the communicator and the receiver of the message such as street theatre and puppetry, involving the use of storytelling and especially communication arts that make up a distinctive culture representative of a traditional way of life (Debashi-deb, 2012). Conventional media on the other hand, are Information Communication Technologies (ICTs), the forms of communication that are new and possess a relative advantage of large coverage and acceptability amongst modern users. Conventional media address the serious problem of contemporary society and the major public issues of our time. Both non-conventional and conventional communication media could help promote improved levels of communication, and shared information that enables sustainable development on a global scale.

The two strategies assessed in this study are the

- Seed dropping method of dissemination (interpersonal) and
- Use of mobile (Mass media) phone

Seed dropping method (Non-conventional method)

Seed dropping is a non-conventional style of dissemination as it involves only interpersonal communication method, the initial coverage is limited to the original

contact. However, this method gives opportunity for farmers to ask questions and thereby clarify issues of concerns. The seed dropping method combines two major dissemination processes; it disseminates both the technology and the information in its package thus persuading the farmer to accept the new technology in a more practical way. One major justification for the use of seed dropping is explained by Ahmed *et al* (2015) that farmers need to be convinced by extension agents about the existence of the technology, how to access and use it and what to expect from it before adopting the technology.

The method of seed dropping aimed at overcoming the challenge of seed purchase and transportation. The method involved collaboration with extension personnel such as the extension staff of Agricultural Development Programme (ADP) along an identified route. This step is necessary as it guided the decision of the challenge to address.

Use of mobile phone (Conventional method)

Mediated messages play an extremely important role in how people view their world. According to Cultivation Analysis theory, most people in the modern world get much of their information in a mediated fashion rather than through direct experience. Thus, mediated sources can shape people's sense of reality. Likewise, James (2013) posited that global conversations have escalated around using social network to reach new audiences and spread philanthropic and charitable messages. In line with this, use of farmers' mobile phone for maize information dissemination was strategically carried out to present maize total information with the

use of audio and video functions in the phone. This method involved packaging all relevant information ranging from good maize variety to plant, how to plant maize for maximum economic returns, different pests and diseases of maize, harvesting and storage and possible marketing openings available to maize. This total information package was presented in a 10 minutes mp3 video and audio clip and disseminated directly to the farmers' phone. The purpose was for farmers to have a direct access to relevant information first-hand when the need arises whether at home or on the field. The total information package was to serve as the motivation to this group of farmers to consider cultivating improved maize varieties for a change. This step is in line with Bandura (1976) that learning is a cognitive process that takes place in a social context and can occur purely through observation or direct instruction, even in the absence of motor reproduction or direct reinforcement. Majority of population in Africa live in rural areas where there is obvious lack of required infrastructure to support the use of conventional media tools. Considering this gap, Akpomuvie (2010) suggested the combination of the two types of media as effective to keep the rural populace in Africa abreast with programmes.

This study was carried out to evaluate the problems and prospects associated with communication media use for maize dissemination among rural farmers in southwestern Nigeria.

The general objective is to assess the effectiveness of two dissemination strategies embarked upon by IAR&T for maize information, specifically, the study aimed to;

- identify areas of strength of the interpersonal and mobile phone strategies for up-scaling
- investigate possible constraints to interpersonal and mobile phone use strategies

Materials and Methods

Study area: The study was carried out in South Western region of Nigeria. South West Nigeria is one of the geopolitical zones of Nigeria. It has six states and the people mainly speak Yoruba, although there are other several dialects within the region. The head-quarter was formally Ibadan (now the capital of Oyo State). The study was however carried out in Oyo and Ogun States, Nigeria.

Sampling Procedure and sample size: This involved purposive selection of rural communities in the states with high record of maize production challenges. This selection is necessary to give opportunity to address specific challenges faced by farmers. Systematic sampling of 30% of households in each of the identified communities were used to select the household head. Communities selected in Ogun state include Ibese, Abule Egba, Ilaro and Ijado in Yewa North LGA and ago babalawo, igbesa and alaago in Ado-Odo LGA. While communities selected in Oyo state are Tede, Sabe, in Atisbo LGA, Iseyin Kosobo and Eruwa communities in Iseyin and Ibarapa East LGAs respectively. A total of 202 respondents were sampled in all.

Research Design: Quasi experimental research design was used for this study. This involved disseminating maize seeds variety to two groups of farmers in Oyo and Ogun States using seed dropping method and mobile phone. Thereafter, compare the

constraints encountered to understanding messages from each of the methods. The personal characteristics of the two groups were taken before the dissemination to be sure of almost similar background information then, utilising each of the strategies for the individual groups. This provided the basis employed to reduce the influence of one method on the other and to easily identify the constraints associated with each method.

Data collection: Primary data collection with the use of an interview guide was employed for the study. This process gave opportunity for farmers who could not read and write to express themselves freely on the issue raised. Questions such as personal characteristics and constraints to communication media used for dissemination were identified

Constraints faced by respondents on media use - Constraints faced by respondents with respect to the media used for dissemination was determined by asking the respondents to rate a list of possible constraints that were provided on a four-point scale of very severe constraint, severe constraint, mild constraint and not a constraint. Scores of 4, 3, 2, and 1 were awarded to the responses respectively. The mean score for each of the constraint items was computed and used to determine the order of severity of the constraints. The list of constraints provided was grouped under the following sub-headings: language barrier, poor interactivity of media, poor richness of media viz: facial expression, tone of voice, gestures etc.

Data analysis: Data were summarized and described using means and percentages while Chi-square and Pearson Product

Moment Correlation (PPMC) and independent sample T-test were used to determine the relationship between the independent variables and the constraints to appropriating messages from communication media sources.

Results and Discussion

Personal characteristics of respondent

Table 1 shows that majority (88.1%) of the respondents were married and had a mean age of 44.32 years. Also, 36.1% had no formal education while 67.3% could not read and write English language. This group of farmers can be categorized as in their mid-age therefore might not be too

young to discriminate against the use of the interpersonal method as not fashionable and also, they are not too old to criticize use of conventional media. Inability of the farmers to read and write English language would pose a hindrance to understanding messages from new conventional media tools such as the internet, twitter and others thus discouraging their use.

Constraints associated with messages from each of the media used for maize information dissemination in the study area

Table 2 presents the constraints encountered by the respondents in

Table 1: Distribution of respondents according to personal characteristics N=202

Variable	Frequency	Percentage/mean
Age		44.32±12.01
= 30	38	18.8
31- 40	47	23.3
41 – 50	59	29.2
51 – 60	44	21.8
>60	14	6.9
Marital status		
Single	3	1.5
Married	178	88.1
Divorced	2	1.0
Widowed	19	9.4
Household size		6.22±2.82
1-5	85	42.1
6-10	105	52.8
11-15	10	5.1
16-20	2	1.0
Religion		
Christianity	137	67.8
Islam	65	32.2
Ability to read and write in English		
No	136	67.3
Yes	66	32.7

Table 2: Distribution of respondents based on communication constraints to utilising messages among seed dropping and mobile phone used to disseminate maize information

S/N	Items	Mean (Use of mobile phone)	Rank	Mean (Seed dropping)	Rank
	Poor interactivity				
	Too much noise	0.4835	2 nd	0.6602	1 st
	External distractions	0.5275	1 st	0.5414	4 th
	Lack of trust in message	0.1429	3 rd	0.2707	12 th
	Lack opportunity for discussions	0.1099	4 th	0.2180	13 th
	Language barrier				
	It allowed use of difficult words	0.1099	4 th	0.5639	3 rd
	Too many use of jargons and terminologies	0.0989	8 th	0.4511	6 th
	Too many careless words by instructor	0.1099	4 th	0.3534	9 th
	Poor quality of media				
	Lack of consistency	0.1099	4 th	0.5789	2 nd
	Lack eye to eye contact	0.0879	10 th	0.4887	5 th
	Poor tone of voice	0.0769	12 th	0.4286	7 th
	Lack gestures	0.0440	13 th	0.3985	8 th
	No facial expressions	0.0330	14 th	0.3083	10 th
	Medium barriers				
	Against religious beliefs	0.0989	8 th	0.1203	14 th
	It makes messages too rigid	0.0879	10 th	0.3083	10 th

understanding the maize information disseminated to them through the two medium during the intervention. Respondents exposed to conventional media (mobile phone) ranked external distractions highest ($x = 0.53$) among other constraints. Others constraints ranked high by respondents in the conventional group include too much noise ($x = 0.48$) and lack of trust in message ($x = 0.14$). On the other hand, respondents from the non-conventional media group ranked too much noise ($x = 0.66$) and lack of consistency in message ($x = 0.58$) as first and second highest constraints.

Apart from the fact that this finding shows certain similarities in the constraints identified by both conventional and non-conventional groups of respondents, it also reveals that items relating to poor interactivity of media were mostly indicated by respondents from the conventional group as more important constraints. This is because these items attracted the first to fourth ranks. This implies that poor interactivity in the use of mobile phone audio and video application is a major barrier to clarity of message disseminated through it. On the contrary, major constraints identified by respondents

in the seed dropping group were not too centered around poor interactivity as observed among the conventional media group of respondents, but, ranged from poor interactivity to poor quality of the media used and then to language barrier. This finding suggests seed dropping strategy used as non-conventional media is constrained by factors that are more surrounded with the person(s) handling it than it occurs in conventional media. This position is corroborated by Kamba (2009) that access to information in rural communities of Africa is affected by a number of drawbacks, evident in ways in which rural information services are coordinated.

Difference in means of the Conventional and Non-conventional

Table 3 shows no significant difference in the mean of the constraints ($t=0.114$; $p = 0.910$) associated with understanding messages from the two modes of communication. This result is consistent with Table 2 that both communication media have areas of strength that enhanced understanding of listener. This is consistent with the findings of Osho (2011) that farmers use of communication media is based on availability of media and purpose of use. In line with this, constraints to use of communication media is more about the

media and disseminator and not really about the message.

Conclusion and recommendation

In conclusion, the state of the environment where communication process takes place and complexities of human behaviours handling the dissemination process are major barriers to clarity of maize information messages in the use of radio and seed dropping strategies.

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Table 3: Difference in means of the Conventional and Non-conventional media use for maize dissemination

Variable	Mode	Mean	df	T	P
Constraints	Conventional	4.20	222	0.114	0.910
	Non-conventional	4.28			

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