

ASSESSMENT OF SOCIAL MEDIA UTILIZATION BY POULTRY AND FISH FARMERS IN OYO STATE, NIGERIA

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ABSTRACT

The study attempted to assess the utilization of social media (online newspaper, Agricultural blog, Email, Facebook, Twitter and Wikipedia) by poultry and fish farmers in Oyo state. A random selection was used to select 110 respondents. Data were collected through structured questionnaire and analyzed with frequency count, percentage, and chi-square test statistics. Findings revealed that respondents are at various level of usage of social media. WhatsApp (84%) and Facebook (78%) were accessed and used social media for livestock farming purposes. Incidences of not able to access information were 43% for agricultural blogs, Emails and Twitter, 46% for online newspapers. Further analysis revealed that visiting agricultural Blogs, Wikipedia and Email and Instagram have significant relationship with the level of education of the farmers. The study posited that basic education do serve as an enhancer to the utilization of social media.

Keywords: Social media, Utilization, Fish farmers, Poultry farmers

INTRODUCTION

Mass media have the ability to reach a mass audience scattered over a wide geographic area at a very high speed. This could enhance extension coverage in areas characterized by low number of agricultural extension personnel. It could also enhance the spread of information especially in times of emergency (Ani *et al.*, 2015). Advancement in technology has brought about new communication channels popularly called social media which are either stand alone or mediated communication devices. Example of the social media include Facebook, Twitter, online newspaper, Agricultural blog, Email and Wikipedia (Olsena and Osmundsen, 2016). The key role played by social media in disseminating in the public sphere make them the most used and preferred information sources, most especially in disseminating agricultural information (Ifabiyi and Komolafe, 2016).

The social media paradigm shift in agricultural development is for appropriate information to be available in a timely and relevant format to the farmers for utilization in increasing agricultural productivity. In his report, Adejohet *al.* (2016) argued that social media could unite communities, create hypothetical small world or global village which focuses on the farmers' day-to-day concerns, making extension process easier, and helping in realizing local aspirations (Anderson-Wilk, 2009). The relative importance of the New Media stems from its similarity with the old media such as town crier, folktale, songs and poetry. Although the level of utilization of New Media depends on the awareness and credibility of media (Livondo, 2015), media richness, characteristics of the message being communicated, availability of feedback mechanism and urgency of the message (Ghanbari and Rahmati, 2010). New Media in this context refers to commonly available content through the internet, accessible on any digital device, usually containing, interactive user participation. New Media

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transmits contents through connection and conversation. It reduces the world to a global information community.

According to Memon (2014) this new media channels available to farmers are email services, social networking, specifically Facebook, online newspapers, Agricultural blogs and Twitters. It is interesting to know that Nigeria Federal Ministry of Agriculture and Rural Development (FMAD) has a twitter handle whereby the managers of Nigeria Agricultural system do disseminate relevant and timely agricultural information on agricultural development in Nigerian (Nigerian Communication Commission [NCC], 2015).

Various channels are used to disseminate agricultural knowledge to farmers but the traditional one (face to face communication) is still commonly used among farmers in developing countries (Amusat and Oyedokun, 2018). Lack of reliable platform for knowledge sharing has had detrimental roles on small farm holders' productivity. Specifically, among livestock farmers who have to cope in the recent times with the emergence of complex situations such as emergence of new diseases (bird flu), resistant livestock diseases, continuous usage of crude implement and poor-quality feeds. Also, there is an increased pressure on agricultural extension officer who has to adapt to these emerging trends despite being trained on combating traditional challenges in his bid to carry out his professional duties. With the prevalence of social media usage in recent times (Adejohet *al.*, 2016), there is need to uncover the prevalent social media usage among fish and poultry farmers, in order to recommend the media through which improved fish and poultry production practices can be effectively disseminated to reach larger population of fish and poultry farmers in Ibadan metropolis is a call for empirical study. It therefore become imperative to investigate social media usage. The general objective of the study is to assess the social media utilization by poultry and fish farmers in Oyo State, Nigeria. The specific objectives are to:

- i. Determine the socio-economic characteristics of the livestock farmers;
- ii. Examine the forms of social media used by livestock farmers;
- iii. Ascertain perceived benefits of using social media by livestock farmers; and
- iv. Determine the challenges militating against use of social media by livestock farmers.

METHODOLOGY

The study was conducted in Ibadan, Oyo State, Nigeria. Eleven (11) local government areas were utilized for the study. More importantly, the study population consisted of people engaged in poultry and fish farming in the metropolis. In each of the 11 LGAs within the metropolis, 10 registered poultry and fish farmers were randomly selected. A total one hundred and ten (110) poultry and fish farmers were therefore sampled for the study. Data for the study were collected using an interview schedule with the respondents. The independent variables are the socio-economic characteristics and the social media while the dependent variables are the perceived agricultural benefits derived from listening to agricultural news, trending issues on agriculture, dissemination of information to farmer, making use of cost effective mobile gadgets, level of awareness of the people on agricultural innovations, economic, socio-political issues affecting agricultural programs, constraints to the use of social media and preference for use of specific media. Data were analyzed using frequency count, percentages and mean. Chi-square was used in testing the hypothesis for the study.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Respondents

Results in Table 1 showed that 50% of the farmers were within the age bracket of 41-50 and 82% of the farmers were married. This implies that they are responsible adults who can make

national decisions. Majority of the respondents were male (74%), married (82%), and poultry farmers (78%). Most of the respondents have farming experience less than 5 years and 26% were between 21 to 25 years.

Table 1: Socio-Economic Characteristics of the Respondents

Variable	Frequency	Percentage (%)
Age		
30-40	30	27
41-50	55	50
51 and above	25	23
Occupation		
Farming	110	100
Type of Farming		
Poultry	86	78
Fish Farming	24	22
Sex		
Male	81	74
Female	29	26
Marital Status		
Single	20	18
Married	90	82
Level of Education		
No Formal Education	28	26
Primary education	41	37
Secondary Education	22	20
Tertiary Education	19	17
Farming Experience		
Less than 5 years	36	33
6-10 years	13	12
11-15 years	16	15
16-20 years	17	16
21-25 years	28	26
Total	110	100

Source: Field Survey, 2016

Social Media Platform Used by the Respondents

Table 2 presents livestock farmers' access to mass media for usage in the study area. The table show that WhatsApp (84%) and Facebook (78%) were accessed and used social media for livestock farming purposes. The implication of these findings is that WhatsApp and Facebook constitute a major social media platform that is utilized by the farmer through which they get information about improved agricultural practices. Therefore, agricultural success stories may be featured on WhatsApp and Facebook for patronizing farmers to watch as well as introduction of new farming methods and equipment may be broadcasted with the use of WhatsApp and Facebook media. Devesh *et al.* (2017) and Komolafe *et al.* (2018) had

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noted that WhatsApp sends real-time messages and is one of the world's most popular communication applications in the 21st century with greater potent for agricultural extension tool. Naruka *et al.* (2017) had found that farmers perceived WhatsApp as a 'convenient' communication application, problem solving with audio-visuals, on-time, and solution at the time of crisis in their agriculture activities.

The results also show that farmers have limited access to usage of Online Newspaper, Agricultural Blogs, Twitter, Email and Wikipedia (AGORA). In regards, Yagos *et al.* (2017) have observed that poor access to ICT networks and computers in most rural areas of developing countries including Nigeria is one of the reasons for limited use of web-based media in disseminating agricultural knowledge.

Table 2: Social Media Platform Used by the Respondents

Variable	Frequency	Percentage (%)
Online Newspaper		
Access	40	36
No Access	70	64
Facebook		
Access	86	78
No Access	24	22
WhatsApp		
Access	92	84
No Access	18	16
Agricultural Blogs		
Access	24	22
No Access	86	78
Twitter		
Access	20	18
No Access	90	82
Email		
Access	28	26
No Access	41	37
Wikipedia (AGORA)		
Access	36	33
No Access	13	12
Total	110	100

Source: Field Survey, 2016

Perceived Benefits of Using the Social Media

Findings from Table 3 reveal that majority of the farmers strongly agree that social media is beneficial for receiving timely information and news needed for agricultural practices. More importantly the farmers reported that social media can reach larger percentage of audience and provide adequate information about agricultural programs and activities. However, 47% of the farmers were on the opinion that social media promote level of awareness of the people about agricultural programme and expose agricultural innovation and image agricultural issues. This finding support Ifabiyi and Komolafe (2016) who earlier found that social networking through social media promote agricultural practices.

Hypothesis Testing

Ho: There is no significant relationship between socio-economic characteristic (education) and utilization of the New Media in Ibadan Metropolis. Implication of the findings reveal that utilization of Facebook has no significant relationship with the level of education of the farmers while other new media such as: Online News Papers, WhatsApp, Agricultural blogs Twitter and Email as well as Wikipedia has significant relationship with the poultry and fish farmers level of education in the study areas, for education plays a vital role in accessing this platform, manipulation and usage.

Table 3: Perceived Benefits of Using the Social Media

Variable	Frequency	Percentage (%)
Listening to Agricultural Current Affairs		
News and Current Affairs		
Strongly agree	28	26
Agree	32	29
Undecided	1	1
Disagree	40	10
Strongly disagree	10	9
Larger percentage of Audience		
Strongly agree	33	30
Agree	40	36
Undecided	0	0
Disagree	18	16
Strongly disagree	19	17
Adequate Information About Agricultural Programme		
Strongly agree	27	25
Agree	35	32
Undecided	3	3
Disagree	26	24
Strongly disagree	19	17
Cheap and Portable		
Strongly agree	21	19
Agree	26	24
Undecided	11	10
Disagree	67	61
Strongly disagree	9	8
Promote Level of Awareness		
Strongly agree	52	47
Agree	11	10
Undecided	0	0
Disagree	27	25
Strongly disagree	20	18
Total	110	100

Source: Field Survey, 2016

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Table 4: Hypothesis Testing

Variables	Chi-square	p-value	Decision
Online Newspapers	8.983	0.030	Significant
Agricultural blogs	15.011	0.002	Significant
WhatsApp	16.761	0.001	Significant
Wikipedia	12.276	0.006	Significant
Facebook	7.670	0.053	Not significant
Twitter	13.576	0.003	Significant
Email	13.680	0.031	Significant

CONCLUSION AND RECOMMENDATIONS

Majority of the farmers have heard about the social media and able to have used some. Majority of the farmers believe that the social media is beneficial as it helpful in listening to agricultural news and current affairs, reaches a large percentage of audience, and delivers adequate information about agricultural programmes. However, majority believes that the social media is not cheap and portable. This inference indicates the effectiveness of social media in disseminating agricultural and related information in the study area.

Based on the findings of this study, the following recommendations were made:

1. More efforts should be made by relevant government agencies in planning agricultural programmes and information dissemination through the social media, which farmers may utilize to improve their farming activities especially through Facebook.
2. The stakeholders (e.g., private farmers, non-governmental organizations) and government agencies should endeavor to sponsor some agricultural programmes to help improve farmers' education so that they can utilize the social media more efficiently.

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GENERAL AND SPECIFIC COMBINING ABILITY STUDIES OF YIELD AND YIELD CHARACTER OF SWEET POTATO WEEVIL IN PREDOMINANT AND NON-PREDOMINANT ENVIRONMENTS

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ABSTRACT

Combining ability for marketable sweet potato root yield were carried out using ten sweet potato varieties and their F₁ hybrids in Cylasformicarius endemic (Landmark University, Omu Aran) and free (University of Ibadan) environments during 2012 cropping season. Both general combining ability and specific combining ability play significant role on traits such as marketable root yield, non- marketable root yield, and total number of storage root/plant and marketable storage root, root size, percentage of tuber damage and weight of total roots, as well as the incidence and severity were generally low, suggesting the role of additive and dominant gene action in tolerances to Cylasformicarius. Hybrids from the parents Resisto, TIS 87/0087 displayed high performance in term of Cylasformicarius tolerance. These parents and their hybrids appeared to have gene pools for Cylasformicarius tolerance that can be manipulated for developing promising hybrids in South west, Nigeria.

Keywords: Sweet potato, Yield, Combining ability, Cylasformicarius

INTRODUCTION

Sweet potato weevil is the major insect pest constraint of sweet potato production in south west Nigeria. Pest infestation causes substantial yield losses, averaging more than 70% of sweet potato virus free environment (Thiyagu *et al.*, 2011). It causes economic damage in areas with a marked dry season or in unseasonably dry years (Mbanaso, 2011). Weevil spends its entire life cycle on the host plant, and both larval and adult stages damage the tubers and vines. Damage to tubers can reach up to 90% (Regassa and Basavaraj, 2002) and relatively minor damage can both reduce yield and render infested tubers unmarketable due to the presence of feeding marks and oviposition holes. Weevil-infested tubers emit offensive odours due to the presence of terpenes produced by the insects (Korada *et al.*, 2010) and to a rise in the level of phenolic compounds in the tubers (Zulu *et al.*, 2012), rendering them unpalatable for human or animal consumption. Tuber shrinkage also occurs due to loss of water through feeding or oviposition cavities made by the weevils. The main damage is due to larvae developing inside the edible tubers (Sutherland, 1986b; Kivuva *et al.*, 2014) Weevil is the most important biotic yield constraints of sweet potatoes, although severity varies significantly by agro-ecology. Weevils' infestation can affect the quality of the storage roots, rendering them commercially less valuable (Sutherland, 1986a). They become a problem towards the end of the season when soils are drying up and storage roots are left in the soil for too long. In some areas where weevils are endemic, damage is also recorded during the growth season and production losses reach up to 60-100% (Sutherland, 1986b). There have been mixed results regarding tolerance of sweet potato cultivars to the weevil damage.

For example, Regassa and Basavaraj (2002) found that cultivars with high foliage weight showed lower levels of damage (Nwauzor and Afuape, 2005)

also found difference in weevil damage across cultivars but found no differences. Sweet potato weevil (*Cylasformicarius*) has reached an endemic status in south west Nigeria. It constitutes a serious threat to sweet potato production and farmers are being compelled to abandoned their farmlands to *Cylasformicarius* or changed to production of less susceptible crop. The objectives of this study therefore were; (i) to asses both general and specific abilities of 18 varieties of sweet potato for tuber yield and other agronomic characters in both sweet potato virus endemic and non-endemic environments and (ii) to identify hybrids that combined tolerance to *Cylasformicarius* with tuber yield and related traits in commercial sweet potato production in *Cylasformicarius* endemic zones of south west of Nigeria.

MATERIALS AND METHODS

Experiment Site

The experiments were conducted at the Teaching and Research Farms of the Department of the Agronomy, University of Ibadan, Ibadan, Oyo State and Landmark University Omu Aran, Kwara State. The University of Ibadan is located on Latitude 3°54'E Altitude is 210m above sea level. Landmark University is located Latitude 8°36'E Altitude 945 m above sea level.

Description of Genetic Material

The genetic material used for this experiment was from the germplasm collection of the Department of Agronomy, University of Ibadan, Nigeria. This material comprised of 10 varieties of sweet potato: 5 orange-fleshed, 3 white-fleshed and 2 yellow-fleshed (Table1).

Table 1: Characteristics of the Sweet Potato Parental Materials for the Study

Variety	Source*	Flesh colour
Resisto	CIP Kenya	Orange
Ak-Wide	Akoroda	White
TIS 8250	IITA Ibadan	White
199024.2	CIP Kenya	Orange
Barth	Kaduna State	Yellow
Bleshbok	CIP Kenya	Orange
199034.1	CIP Kenya	Orange
440034	CIP Kenya	Orange
TIS87/0087	IITA Ibadan	White
W-151	CIP Kenya	Yellow

*CIP International Potato Centre, IITA, International Institute for Tropical Agriculture

Experimental Description

Planting of 25 cm long vine cuttings was done on the crest of each ridge after a light rain. Each vine was inserted at a slant, with two-thirds buried below the soil surface at a spacing of 1 m between the crest of one ridge and other. The plot size used was 3m x 1m. Weeding was done at 4, 6, and 8 weeks after planting using hoe. No fertilizer or pesticide was applied. Wooding poles of 2 m long were used for the staking. The main vines were tied and trained up to the stakes to induce flowering as described (Afolabi and Akoroda, 2015). Partial diallel crosses were made between the 10 varieties during 2011 cropping season at the teaching and

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research farm, University of Ibadan, Nigeria. The resultant 45 F₁ hybrids were harvested between 30 and 50 days after pollination between 7.00 am and 8.00 am to prevent scattering. The fruits were further air dried, shelled and kept in desiccators.

Scarification of Sweet Potato Seed and Nursery Establishment

Forty-five F₁ hybrid seeds were soaked overnight in water to break the dormancy in order to improve germination. The seeds were then placed in polythene bags filled with top soil and watered. These were transferred to the nursery after 4 weeks to improve vine production.

Field Experiments

Planting of 30 cm long vine cuttings was done on the crest of each ridge after a light rain. Each vine was inserted at a slant, with two-thirds buried below the soil surface at a spacing of 1 m between the crest of one ridge and other. The trial was laid out in a randomized complete block design with three replicates. Entries which included the hybrids and parents were made in one row of 3 x 1 m and planted at inter-row spacing of 1 m and within row spacing of 30 cm to enhance a plant population of 33,333 stands per hectare. Agronomic data were measured on plot basis, including number were collected, stand count at harvest, total root yield, marketable root yield, non-marketable root yield, and total number of storage root/plant and marketable storage root, root size, percentage of tuber damage and weight of total roots, as well as the incidence and severity (scale of 1 - 5 where 1 = 0%; 2 = 1 - 25%; 3 = 26 - 50%; 4 = 51 - 75%; and 5 = 76 - 100% root infestation according to (5) of root *Cylas*spp infestation.

Data collected were subjected to diallel analysis using Griffing approach method I (parents, crosses reciprocals together), Model I (fixed effects). Both general combining ability (GCA) and specific combining abilities (SCA) were computed using PBTools, version 1.4. 2014. Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna for the 10 parents and their F₁ hybrids with respect to *Cylasformicarius* related and sweet potato characteristics with respect to sweet potato tuber yield and other agronomic characters.

RESULTS

General and Specific Combining Ability Effects for Sweet Potato Yield and Related Traits

General combining ability (GCA) effects for *Cylasformicarius* incidence and severity was very low probably due to tolerance of the parents to *Cylasformicarius* (Table 2). Parent (Resisto) genotype had positive and highly significant GCA effect on incidence and severity of tuber Damage. TIS87/0087 genotype recorded positive and highly significant GCA effects for incidence and severity of *Cylasformicarius*. The highest GCA effects of incident and severity was 23.87 from parent 440034 and the least value (0.01) was obtained in parent Resisto. The highest GCA effects (25.50) for number of damaged tubers was recorded on the parent TIS 8250as and the least value (1.02) was recorded from the parent Resisto.

Specific Combining Ability (SCA) effects for incident and severity were generally low. However, significant effects were observed in crosses 199024.2 x barth, barth X bleshbok, barth x 199034.1, bleshbok x TIS 87/0087, and 199034.1 x TIS 87/0087 (Table 3). Similarly, SCA effects for number of damaged tubers was positive and significant for hybrid bleshbok x resisto, 440034 x Ak-wide, 440034 x barth and TIS 87/0087 x 199034.1.

General Combining Ability (GCA) effects for sweet potato agronomic character in *Cylasformicariu*- and *Cylasformicarius*-free environments differed significantly in the parents (Table 4). Parents Resisto recorded positive and significant GCA effects only for number of storage root per plant for *Cylasformicarius*-endemic environment and number of non-marketable root yield in *Cylasformicarius*-free environment. Parent Ak-wide exhibited positive and significant

GCA effects for number of storage root per plant and root weight per plant in *Cylasformicarius* free environment, and also had significant GCA effects in positive direction for both marketable yield and non-marketable yield in *Cylasformicarius* environments. TIS 8250 only showed positive and significant effects for both root number plant and marketable yield in *Cylasformicarius* free environment. Parent 199024.2 only had positive and significant GCA effects for root weight per plant and non-marketable root yield in *Cylasformicarius* free environments, and also had recorded significant effects in marketable yield and non-marketable yield in *Cylasformicarius* environments. Barth had positive and significant GCA effects for root number per plant and non-marketable yield in *Cylasformicarius* free environments. The same variety also had significant effects in root weight per plant and non-marketable yield in *Cylasformicarius* environments.

General Specific Ability (SCA) effects for marketable root yield in *Cylasformicarius* environments were generally low among some of the parents. However, parents 440034 and TIS 87/0087 exhibited high GCA effects for marketable yield and some of the agronomic characters in both *Cylasformicarius* and *Cylasformicarius* free environments. Resisto, Ak-wide and W-151 recorded high GCA effects for marketable yield in *Cylasformicarius* free environments. Hybrid Resisito × Ak-wide had positive and significant SCA effects for root weight per plant in both *Cylasformicarius* and *Cylasformicarius* free environments.

Table 2: Estimate of General Combining Ability Effects for Sweet Potato Yield in *Cylasformicarius* Endemic Environments of Omu Aran

Parents	Incidence and severity	Number of tuber damage
Resisto	0.01**	1.02**
Ak-Wide	1.50	0.22
TIS 8250	20.69	15.95
199024.2	0.05	1.27
Barth	13.94	0.23
Bleshbok	14.13	22.27
199034.1	7.56	11.05
440034	3.87	14.78
TIS87/0087	7.44**	25.50
W-151	2.05	1.25

**, * Significant at < 0.05, <0.01 levels of probability respectively

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Table 3: Estimates of SCA Effects for Incidents and Severity (Upper Diagonal) and Number of Damage Tuber (Lower Diagonal) in *Cylasformicarius* Endemic Environment

Parents	Resisto	Ak-Wide	TIS 8250	199024.2	Barth	Bleshbok	199034.1	440034	TIS87/0087	W-151
Resisto	-	0.01	0.20*	3.64	3.45	24.12	11.47	9.39	12.87	2.66
Ak-Wide	1.89	-	2.58	5.33	4.10	4.71	36.28	0.03	28.90	4.67
TIS 8250	0.28	6.94	-	4.10	1.94	1.18	41.84	9.30	21.42	3.78
199024.2	1.05	0.24	0.01	-	0.01*	2.14	54.71	32.47	7.72	8.34
Barth	8.00	3.99	29.27	1.94	-	64.39**	105.15**	9.34	36.96	5.78
Bleshbok	48.23*	23.58	4.55	0.01	34.00	-	4.16	1.30	77.67**	2.45
199034.1	3.20	1.92	0.31	34.00	8.34	0.89	-	1.31	106.38**	6.46
440034	43.03	62.90*	20.84	8.34	64.27*	7.11	3.28	-	3.63	11.62
TIS87/0087	10.04	15.01	3.41	64.27	5.32	38.72	73.39**	30.56	-	7.53
W-151	1.78	5.87	5.87	5.32	3.45	4.86	7.32	8.56	4.34	-

*, ** Significant at < 0.05 and < 0.01 levels of probability respectively

Table 4: Estimate of GCA Effects for Sweet Potato Root Yield under *Cylasformicarius*-endemic (Omu Aran) and Non-endemic (Ibadan) Environments

Parents	Root no/plant (No/pt)		Rt wt/plt (g)		Marketable root yield(t/ha)		Non-marketable root yield (t/ha)	
	E	NE	E	NE	E	NE	E	NE
Resisto	1.33*	8.2	90	230	24.2	12.83	18.6	3.1*
Ak-Wide	1.50	6.3*	98	200*	7.9*	11.92	7.9*	2.9
TIS 8250	2.5	4.2*	57	137	3.1	9.45*	6.3	2.3
199024.2	3.00	4.2	100	113*	6.8*	8.5	5.7*	2.1*
Barth	2.3	4.5*	82*	123	2.6	7.8	5.2*	1.9*
Bleshbok	2.3	3.7	45	127	1.9	5.9	3.9	1.4
199034.1	1.2	4.2*	32	133	2.8	8.6	5.7	2.1
440034	3.1	4.7	162	189	8.2	9.86	6.6	6.4
TIS87/0087	3.3	5.6	200	210	18.1	9.52	16.3*	5.3
W-151	1.50	5.5	99	213	3.8	11.5	7.7	2.8

E= endemic, NE= Non-endemic, RT wt/[t= root weight per plant,

Table 5: Estimates of SCA Effects of Selected Crosses for Sweet Potato Yield and other Agronomic Traits in *Cylasformicarius*-endemic (Omu Aran) and Non-endemic (Ibadan) Environments of the South West Nigeria

Variety	Root no/plant (No/pt)		Rt wt/plt (g)		Marketable root yield(t/ha)		Non- marketable root yield (t/ha)	
	E	NE	E	NE	E	NE	E	NE
Resisto x Ak-wide	3.00	82.94	5.14*	9.25*	1.07	2.03*	0.17	0.76
Resisto x 440034	3.53	86.54	0.14	0.47	0.76	2.35*	2.28	2.18
Resisto x TIS 87/0087	1.40	0.15	1.05	1.98	0.49	1.87*	2.05	0.27
Barth x W-151	234.44*	240.61*	0.30*	0.24	0.36	1.07*	3.48	0.05
Barth x Ak-wide	60.84*	58.90*	0.27	0.96	0.14	1.19*	2.67	1.62
TIS 87/0087 x Ak-wide	37.25	43.90	0.44	0.01	0.29	1.15*	8.18	1.26
Ak-wide x TIS 8250	62.56*	4.30*	0.02	2.06	0.09	1.72*	0.01	1.27
W-151 x 440034	5.00	0.36	0.23	3.52	0.86	2.31*	5.57	8.75
199024.2 x Bleshbok	5.76	18.50	0.41	0.46	1.83	0.01*	1.17	2.47
199024.2 x TIS 87/0087	8.70	2.12	0.04	3.22	3.67	0.71*	0.02	3.70

*,** significant at <0.05 and <0.01 levels of probability respectively, E= endemic, NE= Non-endemic, RT wt/ [t= root weight per plant,

DISCUSSION

General and Specific Combining Ability Effects for *Cylasformicarius* Parameters

Diallel crosses have been widely used in genetic research to investigate the inheritance pattern of important traits, including the one controlling yield and other agronomic traits among a set of sweet potato genotype (Thiyagu *et al.*, 2011). The diallel cross method have been devised specifically to show the combining ability of the parental lines for the purpose of identification of superior parents for use in hybrid development programme (Regassa and Basavaraj, 2002).

Combining Ability Studies of Yield and Yield Character of Sweet Potato Weevil

The presence of genetic variation among the parental genotypes and progenies across the two environments, confirmed the usefulness of diallel crosses in revealing genetic variation in the breeding populations of sweet potato (Regassa and Basavaraj, 2002). Previous studies on sweet potato reported high genetic variability resulting from diallel crosses (Griffing, 1956), indicating an extensive genetic pool for selection purposes in sweet potato breeding programmes (Thiyagu *et al.*, 2011). Significant GCA and SCA effects recorded in *Cylasformicarius*-endemic environments for marketable yield parameter such as root number plant and root weight per plant. These results revealed that both additive and non-additive gene effects played major roles in the inheritance of tolerance to the parasites both in parental line and hybrid respectively. Low GCA effects for *Cylasformicarius* incidence and severity on sweet potato suggest tolerance to *Cylasformicarius* infestations. Parents Resisto and 199024.2 with very high GCA effects for incidents and severity could be regarded as susceptible to *Cylasformicarius*. Parents 440034, Bleshbok and Barth with low GCA effects have good tolerance to *Cylasformicarius*. In this study additive gene action played a greater role in inheritance of tolerance to *Cylasformicarius* (Zulu *et al.*, 2012).

Generally, the result obtained from this study showed that some parents were tolerant to *Cylasformicarius*, but level of tolerance varied probably due to differences in genetic components among the parental population or time of planting. These results also support the findings of (Pierce, 2012) who observed that sweet potato differed significantly in their tolerance to biotic infestations. The most resistant crosses are 4440034, Bleshbok and TIS 87/0087. This supported the experiment of (Bertan *et al.*, 2007) who reported that the highest level of tolerance can be obtained from crosses involving two resistant parents, while most of the susceptible hybrids were from crosses involving susceptible parents as observed in Ak-wide and TIS 8250.

General and Specific Combining Ability Effects for Sweet Potato Yield

The magnitudes of GCA and SCA variances indicated that additive and non-additive gene action were important in determining the inheritance of tolerance to *Cylasformicarius*. There were differential responses among the parents in both *Cylasformicarius*-endemic and non-endemic environments (Regassa and Basavaraj, 2002). Low GCA effects recorded for sweet potato marketable root yield in *Cylasformicarius*-endemic environments in many of the parents indicate poor general combination in terms of marketable root yield under heavy *Cylasformicarius* infestation. However, two parents (Resisto and TIS8/0087) which exhibited high GCA effects for marketable root yield, will be suitable as parents for yield improvements in *Cylasformicarius*-endemic environments. The parents used in this study as well as the crosses generated exhibited different levels of significant GCA and SCA effects for *Cylasformicarius*. Several careful considerations ought to be placed on the role of parents when planning future crosses as cytoplasmic maternal effects are involved in the inheritance of tolerance to *Cylasformicarius*. Tolerance is influenced by the cytoplasmic maternal effect and then be used as mother parent (Tumwegamire *et al.*, 2011).

CONCLUSION

High genetic diversity exists among the sweet potato hybrids. Diallel analysis is crucial in the selection of best combiner to be used as parental lines for improvement of *Cylasformicarius*-tolerant sweet potato. Hybrids from the parents resisto, TIS 87/0087 exhibited highest tolerance

to *Cylasformicarius*. This candidate can be suggested for future study in quest for the development of *Cylasformicarius*-tolerant sweet potato.

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GENETIC ANALYSIS OF LOW-N TRAITS IN MAIZE (*Zea mays* L) USING TRIPLE TEST CROSS

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ABSTRACT

Low-N maize variety is developed for its ability to tolerate low nitrogen soil environment. This experiment was conducted to study the genetic implication of Low-N maize variety for grain yield and related traits under low nitrogen soil conditions triple test cross analysis. Inbred lines used for the study were generated from twelve low nitrogen tolerance open pollinated maize varieties after six generations of selfing. Two inbred lines along with their F₁ were used as testers for ten inbred lines in a triple test cross pattern to generate 30 crosses. The 30 crosses, their parents and the testers to State University, Ado-Ekiti during 2017 planting season. The experimental design was a Randomized Complete Block Design (RCBD). Data were collected on plant height, ear height, days to 50% anthesis, days to 50% silking, incidence of curvularia leaf spot, blight, plant aspect, ear aspect, ear rot, stay green, cob per plant, ear weight, grain moisture content and grain yield. All data were subjected to analysis of variance and complete genetic estimates. Additive and dominants were significant ($P < 0.05$) for all traits; however, epistasis estimates were not significant for all the traits tested. The degree of dominance component indicated partial dominance for all the traits. Correlation coefficients for days to 50% anthesis and 50% silking, plant height, ear height, number of cobs per plant and grain yield were positive and significant ($P < 0.05$). Since both additive and dominance gene actions were important for low-N traits, the use of reciprocal recurrent selection procedure can be adopted in incorporating the trait into elite maize varieties.

Keywords: Genetic, Dissection, Low-N, Triple test cross, Maize

INTRODUCTION

Maize is an important source of carbohydrates, proteins, vitamins and minerals comparing favourably with other starchy crops such as rice and potatoes (Amudalat, 2015). It is prepared into various products such as maize-meal pap, porridge, mixed with wheat meal to make bread and pop corns. In addition, it is fed to livestock as whole grain in the farms or can be processed into different forms. It is an important cereal crop, due to its high yielding, ease of processing, readily digested and cost less than other cereals (Jaliya *et al.*, 2008). It is cultivated worldwide on more than 160 million hectares every year and production were put at 785 million tons (Umar *et al.*, 2014). It is widely grown throughout the tropics and temperate regions as well as any place man can be found in all the continents of the world. Maize is an important crop in industrial and livestock production in the country (Vacaro *etal.*, 2002). It was reported by (Amudalat, 2015) that maize is always preferred to other crops and it is fast becoming an industrial crop in sub-Sahara African countries. The industrial uses of maize include, formulation of livestock feed, production

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of beer, industrial starch, baby foods, cornflakes, and also use in textile and pharmaceutical. Most Africans depend on maize as their staple food (Banziger and Diallo, 2001) to feed both rural and urban dwellers. Despite the economic importance of maize to the teeming populace in sub-Saharan Africa, it has not been produced to meet food and industrial needs. This could be attributed to poor genetic, biotic factors (like weeds, pests, insects, diseases), the types of varieties grown, unpredictable weather conditions, high post-harvest loss and storage losses, poor agronomic practices, abiotic stress (like drought and low soil fertility), high post-harvest, socio economic factors like market price fluctuation, or that farmers have not adopted improved technologies for maize production. Nitrogen is the most widely deficient nutrient limiting maize growth and can significantly affect yield (Fakorede *et al.*, 2001; Azevedo *et al.*, 2003; Moser *et al.*, 2006; Amanda *et al.*, 2008). Nitrogen deficiency is one of the most important stresses affecting maize production in tropical areas (Banziger *et al.*, 2000, Amanda *et al.*, 2008). It was reported that nitrogen deficiency can reduce maize yield by as much as 40% (Milander *et al.*, 2015). Nearly all cultivated maize in developed countries receives some form of N fertilizer and N use is increasing in developing countries where their impacts on raising yield from nutrient-poor soils are greatest. However, as a result of high cost of N fertilizer, poor distribution system and low purchasing power (Fakorede *et al.*, 2001), the use of N fertilizer in developing countries is hindered. The extensive use of N fertilizer not only increase crop input cost, but also can cause environmental pollution (Egli, 2011). For these reasons, reducing the amount of supplemental N used in maize production by developing low-N tolerance varieties will have significant positive economic and environmental benefits to world of agriculture. A possible approach to reduce N deficiency in soil is to lower crop demand for N through selection for low-N tolerance (Kogbe and Adediran, 2003; Shapiro *et al.*, 2008). Reports from several studies have indicated that useful genetic potential exists in maize genotypes for the improvement of nitrogen use efficiency (Ortiz-Monasterio *et al.*, 2002; Fageria and Baligar, 2005; Muurinen, 2007). Breeding programme strategy is aimed at achieving higher yield. Breeder must have sound information on the genetic behavior of yield and agronomic traits responsible for low-N in maize. Such knowledge is essential for incorporating the trait into elite maize varieties to develop improved varieties. In this study, TTC was used to estimate additive, non-additive and epistasis of low N traits in maize.

MATERIALS AND METHODS

Development of inbred lines of the genetic materials used for the experiment were done in Teaching and Research Farms of Osun State University, Ejigbo Osun State and Landmark University, Omu Aran, Kwara State from 2012 to 2016 cropping seasons. Evaluation of testcrosses was done at Teaching and Research Farms of Ekiti State University, Ado-Ekiti during the 2017 cropping season. Ado-Ekiti (7° 37'N, 5° 13'E) is located in the derived savanna zone of Nigeria. The field has been previously grown to various vegetables, cereals, root and tuber crops. Last cropping season, it was cropped to yam. The soil of the site is sandy loam, low in nitrogen and other micro elements.

Eight soil core samples were taken from each plot using soil auger before planting. Cores for each plot were combined and the composite sample was air dried. The soil was passed through a 2 mm, and 0.5 mm sieve for chemical and physical analysis. The 0.5 mm soil was used for total N and organic matter content of the soil while 2 mm soil was thoroughly mixed and subsamples taken by coning technique for the determination of organic matter, available P, pH in (H₂O, 1:1), exchangeable Ca, K, Mn, Na and Mg. the remaining soil was analyzed for particle size

distribution using Hydrometer technique. Total N and organic matter content of the soil were determined by Kjeldal (Bremner, 1965) and Walkley and Black procedures (Nelson and Sommers, 1982), respectively. Soil pH was measured using a 1:1(w/v) soil/water suspension ratio. Available P was analyzed using Bray P-1 method (Bray and Kurtz, 1945), Potassium, Ca and Mg, were first extracted using NH₄OAC. Thereafter, K was determined by flame emission in the Perkin-Elmer 5000 spectrophotometer and Mg and Ca by atomic absorption.

The materials used for this study were twelve open pollinated low-N maize obtained from International Institute of Tropical Agriculture (IITA) Ibadan (Table 1). These materials were subjected to 6 cycles of selfing to obtain inbred lines starting from cropping season of 2013. During selfing the materials were planted out in each row of 5 m length.

Table 1: Description of Experimental Materials

Names	Code
SINT MAR 20CA LARGA	L1
BR99 72L COMPI	L2
SINT MAR 20CA LARGA x BR99 72L COMPI	F1
LN TP YC7	P1
72PB PROL C4	P2
LA POSTA SEQUIA C6	P3
72L COMP IC6 LNCI	P4
DMR ESR W LN	P5
72PB PROL C3 SYN	P6
LN TP YC6 SYN	P7
DMR ESR Y LN	P8
TZPB PROL C ₃ LNSYN	P9
M ₁₃ -1881	P10

Two inbred lines from the 6th generation of selfing were used as parents. Each parent SINT MAR 20CA LARGA (L1) and BR99 72L COMPI (L2) were crossed together to generate F₁. Each of the three testers (L 1, L 2 and F₁) was used to cross the remaining 10 inbred lines to generate 30 crosses (Table 1, Fig. 1).

The 30 testcrosses, testers (L1, L2 and F1) with 10 inbred parents P1 to P10 (43 entries) were evaluated. The evaluation was carried out at Teaching and Research Farm of Ekiti State University, Ado- Ekiti with two replicates. Entries were made in a row plot of 5m long; spacing was 75cm inter-rows and 50cm intra-rows. Three seeds were initially planted per hill which were later thinned down to two in three weeks after planting to give a planting density of 53,333 plants ha⁻¹. Seed were planted on the 6th May, 2017. Weeds were controlled with a pre-emergence application of atrazine at the rate of 4kg ha⁻¹ and dragon (paraquat) at the rate of 2 liters per ha⁻¹. Chemical weed control was supplemented by manual weeding at 6 WAP in Ado-Ekiti. At 11 WAP, dragon was applied using a guarded sprayer in the two locations. Caterpillar force was applied at 5 WAP to check the attack of armyworm. Earthing-up was done to minimize lodging.

Data were collected for the following traits: Plant Height, Ear Height, Days to anthesis, Days to silking, Plant Aspect, Ear Aspect, Stay green, Ear rot, Ear weight, Grain moisture, Grain yield: Grain yield (Kg ha⁻¹) adjusted to 15% moisture and based on 80% shelling percentage (Dhilon *et al.*, 1976).

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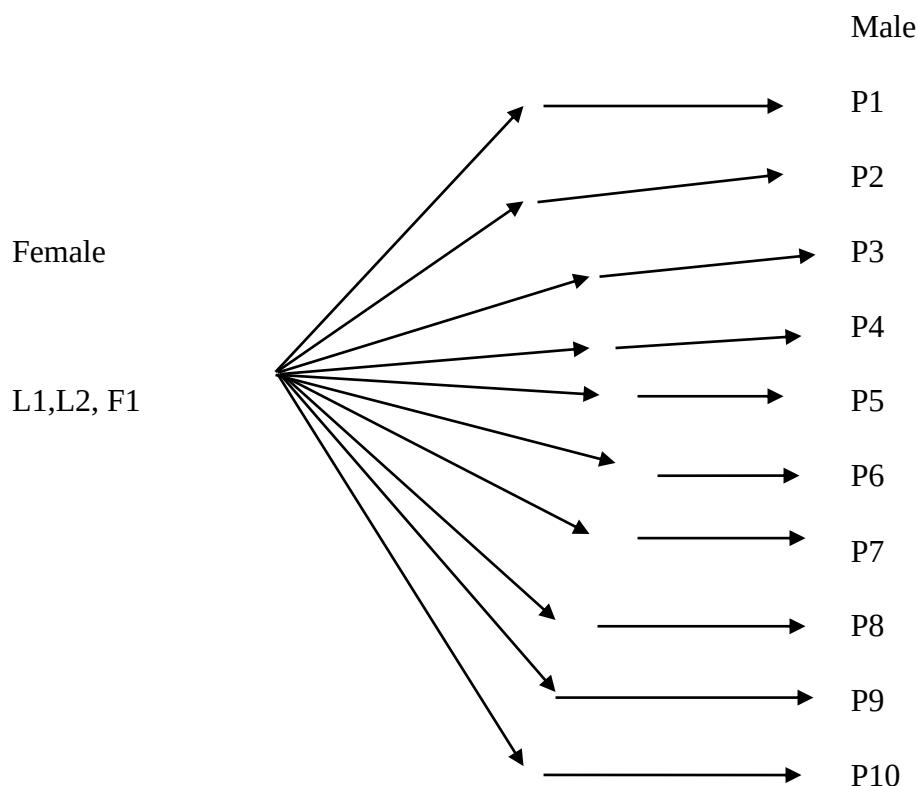


Figure: 1 Conceptual Model for Crossing of the Parents

The analysis of variance was performed following the method described by Singh and Chaudhary (1999) to determine the significance of variations among the hybrids, parents, lines, testers, L1 + L2 vs F1, P1 vs P2, lines vs testers and hybrids vs parents for each trait using TTC technique. The detection of epistasis was performed according to Singh and Chaudhary (1999). Based on the genetic model:

$$L_{ijk} = m + G_{ij} + R_k + E_{ijk}$$

Where,

L_{ijk} = Phenotypic value of cross between tester L_i and line j in K th replication

m = Overall mean of all single- and three-way crosses.

G_{ij} = Genotypic value of cross between tester L_i and line j .

R_k = Effect of K th replication.

E_{ijk} = error.

RESULTS

Analysis of Variance for Growth, Flowering, Disease, Aspect Rating, Stay Green and Yield Traits

Growth and flowering traits among entries were significantly different ($p < 0.05$) except for ASI (Table 2). Also, the differences among the hybrids showed significant differences ($p < 0.05$) for growth and flowering traits except ASI.

The differences among the lines were not significant ($p < 0.05$) except for days to 50% silking and plant height. The comparison between lines and tester showed significant differences only for plant height and ear height. The comparison between the parent and their F_1 as testers showed significant differences only for plant height and ear height. Comparing the parental lines used as tester showed no differences for all the growth and flowering traits. Anthesis-silking interval was consistently not significant for all the sources of variation.

There were no significant differences ($p < 0.05$) among entries for disease and aspect rating except blight (Table 3). The differences among hybrid for disease and aspect rating were significant for streak, plant aspect and ear aspect. However, the differences among hybrids for *curvularia*, blight and ear rot were not significant. There were no significant differences among lines for disease and aspect rating. Similarly, the differences among lines vs tester and between the parental lines used as tester were not significant for disease and aspect rating. The differences for disease and aspect rating were only significant for ear aspect in the comparison between parents and their F_1 .

Yield components and stay green traits among entries were not significantly different ($p < 0.05$) except for yield (Table 4). Also, the differences among the hybrids showed significant differences for yield but not significantly different for stay green and number of cobs per plant. The differences among lines were only significant for yield. Similarly, the comparison between the parents and their F_1 as tester showed significant difference only for yield. The differences in comparing the parental lines used as tester were not significant for all the yield components and stay green. The comparison between lines and tester showed no significant differences for stay green and number of cobs per plant. Yield was consistently significant for all the sources of variation.

Estimation of Epitasis for Growth, Flowering, Disease, Aspect Rating, Stay Green and Yield Components of Low-N Maize

The result of ANOVA for estimation of epitasis for growth, flowering, disease, aspect rating, stay green and yield components are shown in Table 5. Analysis of variances for i (additive $\times$ additive) epitasis for growth, flowering, disease, aspect rating, stay green and yield components are not significantly different ($p < 0.05$). Similarly, the differences of $j+l$ (additive $\times$ dominance) epitasis were not significant for all the traits. Interaction variances ($i \times \text{rep}$, $j+i \times \text{rep}$) was not significantly different for growth, flowering, disease, aspect rating, stay green and yield components. This is suggesting homogeneity of interaction variable.

Estimation of Degree of Dominance and Direction of Dominance for Growth, Flowering, Disease, Aspect Rating, Stay Green and Yield Components of Low-N Maize

The significant additive component (D) was consistently significant for all growth, flowering, disease, aspect rating, stay green and yield traits (Table 6). Also, dominant component (H) for days to 50% anthesis, days to 50% silking, plant height, ear height, number of cobs per plant and yield were significant. However, dominant genetic variance was not significant for ASI, *curvularia*, blight, streak, plant aspect, ear aspect and stay green.

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The magnitude of additive variance (D) was consistently higher for all the traits since the presence of common alleles in testers increases the magnitude of the additive components. The degree of dominance $(H/D)^{1/2}$ was less than one for growth, flowering, disease, aspect rating, stay green and yield components. It was highest for ear height (0.99) and lowest for ASI (0.18). The correlation coefficient (r) for ASI, curvularia, blight, streak, plant aspect, ear rot, ear aspect and stay green were not significantly different. Conversely, the correlation coefficient of days to 50% anthesis, days to 50% silking, plant height, ear height, number of cobs per plant and yield were positive and significant.

Table 2: Means Squares Arising from Analysis of Variance (ANOVA) for Growth and Flowering Traits in Maize

Source variation	of Df	Days to 50% anthesis	Days to 50% Silking	ASI	Plant height	Ear height
Entries	42	6.42**	6.26**	0.74	5202.91**	1621.74**
Hybrid	29	7.61**	7.61**	0.87	2101**	742.61**
Lines	9	3.89	3.75**	0.37	562.06**	159.74
Lines vs tester	1	0.59	0.72	0.01	11851.22**	8210.94**
P1 + P2 vs F1	1	6.75	5.33	0.08	13931.56**	12610.08**
P1 vs P2	1	4.00	0.25	2.25	2.07	36.00
Error	82	0.14	0.21	0.01	319.31	70.00

*,** Significant at $p < 0.05$ and $p < 0.01$ level of probability respectfully
ASI = Anthesis-silking intervals

Table 3: Means Squares Arising from ANOVA for Disease and Aspect Rating

Source variation	of Df	Curvularia	Blight	Streak	Plant aspect	Ear rot	Ear aspect
Entries	42	0.22	0.18*	8.67	10.11	1.19	44.25
Hybrid	29	0.17	0.17	0.42*	0.57*	0.43	0.58**
Lines	9	9.18	0.18	37.09	42.66	3.71	182.10
Lines vs tester	1	0.05	0.05	8.06	8.48	0.97	34.77
P1 + P2 vs F1	1	0.18	0.42	0.26	0.08	0.02	1.88**
P1 vs P2	1	0.02	0.02	0.39	0.06	0.06	0.14
Error	82	0.01	0.02	0.20	0.03	0.01	0.07

*,** Significant at $p < 0.05$ and $p < 0.01$ level of probability respectfully

Table 4: Means Squares Arising from ANOVA for Yield Components and Stay Green in Maize

Source variation	of Df	Cob per plant	Stay green	Yield
Entries	42	0.05	7.57	23148960.40**
Hybrid	29	0.03	0.31	8607357.50**
Lines	9	0.002	31.78	5266625.64**
Lines vs tester	1	0.16	2.59	59356791.47**
P1 + P2 vs F1	1	0.70**	3.00**	96631190.72**
P1 vs P2	1	0.01	0.06	19548377.00**
Error	82	0.01	0.02	333.42

*,** Significant at $p < 0.05$ and $p < 0.01$ level of probability respectfully

Table 5: Means Squares Arising from ANOVA for Estimation of Epistasis

	i	j + l	Total epistasis	i x rep	j + l x rep	Total epistasis x rep
Df	1	9	10	2	9	10
Days to 50% anthesis	10.30	16.21	17.47	87.33	8.31	16.24
Day to 50% silking	0.83	20.48	18.52	92.17	10.03	18.25
ASI	7.5	1.06	1.70	8.50	2.08	2.73
Plant height	33057.24	12200.39	14286.07	71430.35	8099.00	14432.32
Ear height	18963.10	3992.83	3595.44	27449.30	8664.73	10543.18
Curvularia	0.40	1.05	0.99	4.96	0.48	0.93
Blight	0.07	0.22	0.21	1.04	0.62	0.66
Streak	1.80	1.74	1.75	8.79	0.97	1.75
Plant aspect	0.03	1.87	1.68	8.41	0.82	1.58
Ear rot	0.53	0.50	0.50	2.50	0.70	0.88
Ear aspect	4.03	0.29	0.67	3.34	0.74	1.00
Cob/ plant	0.45	0.23	0.26	1.08	0.51	0.57
Stay green	3.67	0.32	0.66	3.29	0.94	1.17
Yield	9.20	6.47	5.909	2.95	1.20	1.37
Error	0.02	0.01	0.04	0.05	0.03	0.03

i= additive x additive epistasis

j + l = additive x dominance and dominance x dominance epistasis

Table 6: Estimation of Degree of Dominance and Direction of Dominance for Growth, Flowering, Disease, Aspect Rating, Stay Green and Yield Components of Low-N Maize

	D	H	(H/D)^{1/2}	R
Days to 50% anthesis	3.80**	0.53**	0.37	0.59**
Day to 50% silking	9.33**	4.68**	0.71	0.51**
ASI	4.68**	0.15	0.18	0.54
Plant height	349.64**	318.70**	0.95	0.79**
Ear height	470.64**	460.70**	0.99	0.30**
Curvularia	0.05**	0.03	0.77	0.19
Blight	0.12**	0.11	0.96	0.28
Streak	0.33**	0.07	0.46	0.41
Plant aspect	0.07**	0.05	0.84	0.58
Ear rot	0.33**	0.01	0.55	0.46
Ear aspect	1.73**	0.28	0.40	0.55
Cob/ plant	0.13**	0.04**	0.55	0.08**
Stay green	0.27**	0.15	0.75	0.04
Yield	11379572.00**	528004.97**	0.21	0.07**

*,** Significant at p<0.05 and p< 0.01 level of probability respectfully

D= Additive

H = Dominance

(H/D)^{1/2} =Degree of Dominance

r = correlation coefficient

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DISCUSSION

Triple test cross provides good estimates for genetic components of variation for quantitative traits. Some maize breeders have used triple test analysis in maize that proposed by Kearsey and Jinks (1968). Information of the type of gene action involved in the inheritance of traits is helpful in deciding the breeding procedures to be followed for plant improvement and is necessary for efficient utilization of available germplasm in a plant breeding programme. In this study, triple test cross has been helpful to provide unbiased estimates of additive and dominant components of low N traits in maize since epistasis is absent.

The highly significant differences among entries, lines and hybrids in some of the traits indicate considerable genetic variation that may exist in the lines, testers and hybrids. The significant differences reported in the yield and some traits of the two inbred parents SINT MARZOCAL LARGA and BR9972L COMP1 clearly revealed that SINT MARZOCAL LARGA, BR9972L COMP1 and SINT MARZOCAL LARGA x BR9972L COMP1 provided an estimate of additive and dominance variation with equal precision as reported by Kearsey and Jinks (1968), Lamkey *et al.* (1999), Khattak *et al.* (2002), Doerksen *et al.* (2003) and Sunil and Singh (2004).

The additive x additive, additive x dominance and dominance x dominance epistasis were not significant for all the traits in this experiment although some earlier workers (Neeraj *et al.*, 1993; Vijayakumar *et al.*, 1996) indicated evidence of epistasis for all the traits investigated. The absence of epistasis provides unbiased estimates of additive and dominance components (Singh and Yuuns, 1986; Menshway, 2008; Koumber, 2011 and Morad, 2012). Genotype × environment interactions may have some influence on the epistatic effect. Such influences have been reported elsewhere in wheat and mungbean (Ketata *et al.*, 1976; Khattak *et al.*, 2001). The cause of presence of absence of epistasis could be genetic and or environmental (Menshaw, 2008). Estimation of gene action and predicting new recombination lines in bread wheat cross using F₂ triple test cross analysis (El-Massry, 2009) and thus, it may not always be related to the inherent capacity of a genotype. Similarly, Sunil and Singh (2003), reported that components of variance changed to different degree over the environments. The environmental influences have also been reported in wheat (Pawar *et al.*, 1994).

The additive genetic variance was found to be much larger in magnitude than the Dominance variance for all traits studied. Consequently, it could be concluded that selection procedures based on accumulation of additive effects would be successful in improving all these traits studied. However, to maximize selection advance, procedures which are known to be effective in shifting gene frequency when both additive and non-additive genetic variance are involved could be preferred. This result corroborates earlier result obtained by Esmail (2007), Koumber (2011), Morad (2012) and Dawwam *et al.* (2015). The degree of dominance was less than unity for traits studied suggesting the role of partial dominance in the inheritance of these traits and as certain the fact that in cross- pollinating crops, most genes are heterozygous and the over-dominance is rare (Lamkey *et al.*, 1999; Esmail, 2007; El-Massry, 2009, Koumber, 2011; Morad, 2012 and Dawwam *et al.* 2015). Furthermore, the correlation coefficients between the sums and differences were found to be positive and significant for days to 50% anthesis, days to 50% silking, plant height, ear height, number of cobs per plant and yield. This indicates that dominance seemed to be acting in one direction. However, the correlation coefficient for the remaining traits was

insignificant indicating the genes with positive and negative effects were equally distributed among the low N genotypes including in this study. Regarding epistasis genetic correlation the results indicated positive and significant correlation in days to 50% anthesis, days to 50% silking, plant height, ear height, number of cobs per plant and yield. This indicates that most of the characters were not associated with each other and confirmed that the triple test cross mating system was useful in breaking up undesirable linkage groups to obtain new recombinant lines. In this regard, Eissa (1994), Menshawy (2008), Morad (2012) and Dawwam *et al.* (2015) reported the efficiency of triple test cross for obtaining new recombinant lines. This investigation could help to design how to use triple test cross analysis to obtained additional information about type of gene actions, genetic correlation and predicting the likely performance of new recombinants that could be derived after series of selfing generations. This also could help breeders for rightful decision about effective breeding method to be applied for improving yield and its contributing traits of low N maize.

CONCLUSION

The following conclusions can be drawn from this study:

1. The additive and dominant components were significant for all traits. This indicate that selection procedure based on accumulation of additive effects would be successful in improving these traits
2. Epistasis for growth, flowering, disease, aspect rating and yield components are not significant
3. The degree of dominance was than unity for all traits. This is suggesting partial dominance in the inheritance of these traits.

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STATUS OF ACCUMULATED HEAVY METALS IN SOILS FROM ORGANIC AND CONVENTIONAL FARMS IN AKINYELE LOCAL GOVERNMENT, IBADAN, OYO STATE, NIGERIA

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ABSTRACT

The risk associated with the presence of heavy metals in soil is their potential toxicity and ability to enter the ecosystem through the food chain. Total heavy metal content of a soil is inadequate for predicting the toxicity of heavy metals in soil. Therefore, the current study was designed to determine the various forms in which the selected heavy metals: Chromium (Cr), Lead (Pb), Nickel (Ni), and Cadmium (Cd) exist in the soil to ascertain the available forms for plant uptake. Soils samples were randomly collected from selected organic and conventional farms in Akinyele local government, Ibadan, Oyo State, Nigeria, at different depths (0-15, 15-30 and 30-45 cm) using random sampling method. Routine analysis was carried out to determine the textural classes and chemical properties of soil samples. The total heavy metals of the soil samples were determined and their fractions were analysed using sequential extraction method. Cadmium was not detected in most of the soil samples. Residual fraction was predominant in all the analysed heavy metals. In addition, Cr was more associated with the oxidizable fraction having a range of 0.1 mg/kg from Ajibode organic farm (AO) at 30-45 cm depth. Pb and Ni were both more associated with reducible fraction with Pb having a range of 2.7 mg/kg in Ajibode conventional farm (AI) at 0-15 cm depth and 0.1 mg/kg in (AI) at 30-45 cm depth. Reducible values of Ni ranges from 4.3 mg/kg in AI at 0-15 cm to 1.4 mg/kg in AO at 30-45 cm. The apparent mobility and bioavailability for these heavy metals in the studied soils were in the order: Pb>Cr>Ni. The result showed that uptake of heavy metals by the plants would be low as the concentration of the exchangeable form of the heavy metals in the analysed soil sample has the least concentration when compared with the other forms.

Keywords: Heavy metals, Bioavailability, Sequential extraction, Soil

INTRODUCTION

Speciation of heavy metals and its effects on soil's physical and chemical properties provide a basis for careful soil management that limits as far as possible, the negative impact of the heavy metals on the environment (Aydinalp and Marinova, 2003). Speciation of heavy metals is the various forms or fractions in which heavy metals may be present in the soil. These fractions can be broadly classified as exchangeable, oxidisable, reducible and residual (Agnieszka and Witold, 2004). The behaviour of these heavy metals, as well as their distribution within the soil environment is influenced by their forms (Aikpokpodion, 2010). Speciation of heavy metals in the soil is particularly important because it has been well known that mobility, bioavailability, storage, retention and toxicity of the metals in living organisms, food and the environment

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depend on their chemical forms in which they enter the ecosystems and the final forms in which they are present in the environment (Cornelis, 2002). The fractions in which heavy metals occur in the soil determine whether there will be plant uptake or not and the heavy metals present in these categories have different remobilization behaviours under changing environmental conditions (Kabala and Singh, 2001). Heavy metals with soluble fractions are biologically important (Ashmore *et al.*, 2000), because of their solubility and mobility which make them to be taken up by plants. Many researches had been carried out on the accumulation of heavy metals in soils within Akinyele local government, Ibadan, Oyo state, Nigeria. There is, however, need for determining the forms (fractions) of the accumulated heavy metals in the cultivated soils at different depths in both organic and conventional farms within Akinyele local government as this would enable us to know the extend at which these metals can be taken up by the plants.

MATERIALS AND METHODS

Research Laboratory

This study was carried out within the Agronomy Department of the University of Ibadan, Ibadan, Oyo State, Nigeria. University of Ibadan is in the tropical rainforest of south west Nigeria between latitudes 7° 15'N to 7° 30'N and longitude 3° 45'E.

Experimental Sites and Samples Procedures

Composite soil samples at different depths (0-15, 15-30 and 30-45 cm) were collected from two farms, organic and convectional farms within Akinyele local government, Ibadan, Oyo state, Nigeria. The farms where soil samples were collected are Ajibode organic farm (7° 27'23.9" N and 3° 53'30.2." E), Ajibode convectional farm (7° 27'27.1" N and 3° 53'08.4" E), while the soil samples used as control were collected from a land where no farming activities occurred around the Department of Veterinary, University of Ibadan (7° 27'17.6" N and 3° 53'41.3" E). A total of nine composite soil samples were collected with soil auger using random sampling method. Questionnaires were administered to the farmers. The essence of the questionnaires was to know the various anthropogenic activities been carried out on the farms, the type of crops grown, the cropping system used and how long the farms have been used for cultivation. Soil samples were analysed after air drying. Half of each sample was then passed through a 2-mm mesh screen. The samples were preserved in clean sealed polythene bags for analysis. The other half was sieved through a 0.5–mm mesh screen (Fritsch laboratory sieving set used) and was used to determine the total and fractional forms of Cd, Cr, Ni, and Pb in the experimental soil.

Particle Size Distribution and Chemical Analysis of Soil Samples

Particle size distribution was carried out by hydrometer method (Gee and Or, 2002). Soil pH was determined both in water and 0.01M CaCl₂ solution in ratio 1:2.5. Organic Carbon was determined by dichromate oxidation method (Nelson and Sommers, 1982). Total nitrogen was determined by the Kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus was extracted by the Bray-1-method (Bray and Kurtz, 1945). Exchangeable bases were determined by the method described by Kundsnet *al.* (1982).

Total Heavy Metal Analysis of Soil Samples

A 1.0 g of soil from each sample was taken and mixed with 1 ml sulphuric acid, 10 ml nitric acid and 4 ml perchloric acid and heated in a hot plate digestion chamber at temperature 100°C.

Evolution of white fumes indicated the completion of digestion process. Then the samples were filtered by Whatman filter paper and then transferred into appropriately labelled plastic bottles for AAS analysis (Lawrence, 2014). The total volume of the prepared samples was made up to 10 ml and Cd, Cr, Ni and Pb were analyzed by Atomic Absorption Spectrophotometer (AAS UNICAM 969 Model).

Heavy Metals Speciation Analysis of the Soil Samples

The modified three-stage sequential procedure developed by the Standards, Measurements and Testing Programme (former BCR) of the Commission of European Communities was employed. In this approach heavy metals are divided into acid-soluble/exchangeable, reducible and oxidizable fractions, which are leached with reagents (Nemati *et al.*, 2009).

Exchangeable Fraction

40 cm³ of 0.11 mol dm⁻³ CH₃COOH was added to 1 g of dry soil sample and was shaken overnight on mechanical shaker at room temperature. The mixture was filtered and the filtrate was poured in a plastic bottle.

Reducible Fraction

40 cm³ of 0.1 mol dm⁻³ NH₂OH.HCl (adjusted to pH = 2 with HNO₃) was added to the residue from the exchangeable fraction and extracted overnight at room temperature. The mixture was filtered and the filtrate kept in a plastic bottle.

Oxidizable Fraction

10 cm³ of 8.8 mol dm⁻³ H₂O₂ was added to the residue reducible fraction and digested for 1 hour at room temperature and then for 1 hr. at 85°C in a water bath with a second volume of hydrogen peroxide. Next the solution was evaporated to a few cm³. After cooling, the residue was extracted overnight with 50 cm³ of 1.0 mol dm⁻³ CH₃COONH₄ (adjusted to pH = 2 with HNO₃), at a temperature of 25°C.

Statistical Analysis

Results obtained from all samples were subjected to ANOVA statistics and P<0.05 was considered to indicate statistical significance. Correlation analyses were done using GenStat 4th edition.

Quality Assurance

All chemicals used were of reagent grade and pure deionized water was used throughout the experiment. All plastic ware soaked in 10% nitric acid, Procedural blanks preparations of standard solutions under clean laboratory environment and calibration of the Buck 210A Atomic Absorption spectrophotometer (AAS) using certified standards were ensured.

RESULTS

Textural Classes of the Experimental Soils

The soil textures at the different depths were sandy loam, clay loam, sandy clay, silt loam, and silt clay loam (Table 1).

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Chemical Properties of the Experimental Soils

The pH of the experimental soils from all the visited farms ranged from 6.1 at 15-30 cm depth in soil from Ajibode Inorganic Farm (AI) to 7.2 at 15-30 cm in soil from Ajibode Organic farm (AO) (Table 2). Soil organic carbon was high in all the soil across the depths. The soil sample used as control had the least value (7.0 g/kg) while the highest value (19.0 g/kg) was found in the soil sample from Ajibode organic farm. The total nitrogen of the soil has the least value (0.8 g/kg) at 30-45 cm in the soil sample used as control (C) while the highest value (3.8 g/kg) was found in the soil sample from Ajibode organic farm (AO) at 0-15 cm depth. The exchangeable bases of the soil samples had the least value (0.6 cmol/kg) of calcium (Ca) at the depth of 30-45 cm in C while the highest value (3.8 cmol/kg) was found in AO at 0-15 cm depth. The values of magnesium (Mg) ranged from the least value (0.6 cmol/kg) in C at 30-45 cm depth to the highest value (3.0 cmol/kg) in AO at 0-15 cm depth. The least value of Potassium (K) (0.07 cmol/kg) was found at 30-45 cm depth in C while the highest value (0.6 mol/kg) was found at 0-15 cm at AO. The available phosphorus ranged from 6.0 mg/kg at 30-45 cm in C to 17.0 mg/kg at 0-15 cm in both AI and AO.

Table 1: Particle Size Distribution of the Selected Soils in this Study

Depth (cm)	Site	Sand (g/kg)	Silt	Clay	TC
0 – 15	AI	750	130	120	Sandy Loam
	AO	372	358	270	Clay Loam
	C	850	100	50	Loamy Sand
15 – 30	AI	435	380	185	Clay Loam
	AO	658	110	232	Sandy Clay
	C	860	100	40	Loamy Sand
30 – 45	AI	450	300	250	Clay Loam
	AO	430	310	260	Clay Loam
	C	900	50	50	Loamy Sand

AI – Ajibode Conventional Farm, AO – Ajibode Organic Farm, C – Control, TC—Textural Class

Total Heavy Metals Concentrations in Experimental Soils

The soils were analyzed for the following metals: Cd, Cr, Pb and Ni as shown in Table 3. None of their concentrations was higher than the threshold limits given by Toth *et al.* (2016) and that of United Nation Environment Programme, UNEP (2013). None of the heavy metals was detected in the control soil samples at 30-45 cm depth. The lowest concentration of lead (1.3 mg/kg) was detected in the soil sample from AI at 30-45 cm depth while the highest concentration of lead (13.3 mg/kg) was detected at 0-15 cm depth in soil sample from AO. Nickel ranged from 25.2 mg/kg in soil sample from AO at 0-15 cm to 1.2 mg/kg in C at 15-30 cm. Cr had the least concentration of (1.2 mg/kg) from C at 15-30 cm and the highest concentration of (9.4 mg/kg) from AO at 0-15 cm. Cadmium was only detected at 0-15 cm in the soil samples from AI and AO. Cadmium ranged from 0.03 mg/kg in AI to 0.05 mg/kg in AO.

Fractions of Heavy Metals Concentrations (mg/kg) in Experimental Soils

The various fractions of the heavy metals were shown in Table 4. The fraction of cadmium was not analyzed because cadmium was not detected in most of the soil samples and where detected,

the concentrations were very low. The concentrations of Cr, Ni and Pb were mainly associated with the residual fraction. The exchangeable fractions of each of the heavy metals were significantly low compared with the order fractions. Cr had the highest exchangeable fraction (0.7) in the soil sample from AO at depth 15-30 cm while the lowest (0.1) in the soil sample from AO at depth 30-45 cm. The lowest exchangeable fraction (0.1) of Ni was found at depth 30-45 cm in the soil samples from C while the highest value (1.0) was found from AO at 15-30 cm depth.

The exchangeable fraction of Pb was found to be highest in soil sample from AO (1.1) at 15-30 cm depth and lowest (0.1) in the soil samples from AI at 15-45 cm depth as shown in Table 4, the reducible fraction of each of the heavy metals was significantly higher than the exchangeable fraction. Cr had the highest value (1.2) in the soil sample from AI at depth 0-15 cm and the lowest (0.2) in the soil sample from C at depth 30-45 cm. The lowest reducible fraction (0.1) of Ni was found at depth 30-45 cm in the soil samples from C while the highest fraction (1.8) was found from AI at 0-15 cm depth. Lead has highest reducible fraction (2.7) in soil sample from AI at 0-15 cm depth and lowest reducible fraction (0.1) in the soil samples from AO at 30-45 cm depth. As shown in Table 3, the oxidisable fraction of each of the heavy metals was also significantly higher than those of exchangeable fractions but varied with the reducible fractions. Cr had the highest value (1.1) in the soil sample from AO at depth 0-15 cm and the lowest (0.1) in the soil sample from AO at depth 30-45 cm. The lowest oxidisable fraction (0.2) of Ni was found at depth 30-45 cm in the soil samples from AO and C while the highest value (1.7) was found from AI at 0-15 cm depth. The oxidisable fraction of Pb was found to be highest in soil sample from AI (2.3) at 0-15 cm depth and lowest (0.2) in the soil samples from AO at 30-45 cm depth as shown in Table 4.

The residual fractions were larger than the other fractions. The least residual fraction (0.2) of Cr was detected at depth 30-45 cm in the soil sample from AO while the highest value (2.2) in the soil sample from C at 0-15 cm depth. Ni had the least value (0.2) from C at 15-30 cm and the highest value (3.0) from AI at 0-15 cm depth. Pb had the lowest residual fraction (0.3) from AO and C at 30-45 cm depth while Pb highest value (4.5) was detected from AI at 0-15 cm depth as shown in Table 4.

Relationship between Pb fraction and the soil properties

As shown in Table 6, all the Pb fractions were positively correlated with the soil properties except K and clay particles. The exchangeable Pb fraction was positively and significantly correlated with P. Also, the reducible fraction of Pb was positively correlated with the organic carbon of the soil while the oxidisable and the residual fractions were not significantly correlated with any of the soil properties. The exchangeable and reducible fractions, exchangeable and oxidisable fractions, reducible and oxidisable fractions of the Pb were all highly positively correlated.

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Table 2: Chemical Properties of the Soil Samples in the selected farms in this Study

Depth (cm)	Site	pH	EC	OC	N	P	Ca	Mg	K	Na
				(g/kg)	(mg/kg)				(cmol/kg)	
0 – 15	AI	6.3	45.6	18	3.5	17	3.6	2.3	0.4	0.3
	AO	7.2	60.5	20	3.8	17	3.8	3.0	0.6	0.2
	C	6.4	45	12	1.2	15	1.6	1.9	0.2	0.3
15 – 30	AI	6.1	40.3	15	3.0	15	2.8	1.6	0.3	0.2
	AO	6.4	42	16	3.2	14	2.7	2.4	0.4	0.1
	C	6.3	42	9	1.0	14	1.2	1.2	0.13	0.18
30 – 45	AI	6.4	41.2	9	1.4	10	1.8	1.1	0.2	0.06
	AO	6.3	60.3	10	1.6	8	1.4	1.6	0.2	0.04
	C	6.2	43	7	0.8	6	0.6	0.4	0.07	0.04

Table 3: Total Heavy Metal Concentration of the Selected Soils in this Study

Depth (cm)	Site	Pb	Ni	Cr	Cd	Threshold Limits (mg/kg) (Toth <i>et al.</i> , 2016 and UNEP, 2013)
0 – 15	AI	8.2	4.3	4.4	0.03	Pb-60
	AO	13.3	25.2	9.4	0.05	Cd-1
	C	2.3	2.4	1.3	ND	Cr-100
15 – 30	AI	4.4	2.3	1.5	ND	Ni-50
	AO	9.6	4.1	3.6	ND	
	C	1.4	1.2	1.1	ND	
30 – 45	AI	1.3	1.5	1.3	ND	
	AO	3.4	1.4	1.2	ND	
	C	ND	ND	ND	ND	

AI – Ajibode Conventional Farm, AO – Ajibode Organic Farm, C – Control soil samples, ND – Not Detected; Pb: Lead, Ni: Nickel, Cr: Chromium, Cd: Cadmium

Table 4: Fractions of Heavy Metals Concentrations (mg/kg) in Experimental Soil Samples

Depth (cm)	Site	Pb				Ni				Cr			
		Ex.	Red.	Ox.	Res.	Ex.	Red.	Ox.	Res.	Ex.	Red.	Ox.	Res.
0-15	AI	1.0	2.7	2.3	4.5	0.5	1.8	1.7	3.0	0.3	1.2	0.5	2.0
	AO	0.2	1.4	1.8	3.0	0.3	0.7	0.8	1.0	0.4	0.4	0.6	1.2
	C	1.0	1.5	1.3	1.3	0.6	1.0	1.3	1.2	0.2	0.4	1.0	2.2
15-30	AI	0.2	0.3	0.1	0.6	0.2	0.3	0.5	0.8	0.4	0.5	0.4	0.6
	AO	1.1	2.1	1.8	2.6	1.0	1.0	1.2	2.3	0.7	0.8	1.1	1.1
	C	0.3	0.5	0.4	2.0	0.3	0.4	0.5	0.7	0.4	0.6	0.4	0.6
30-45	AI	0.1	0.2	0.3	0.8	0.3	0.4	0.3	0.6	0.4	0.3	0.5	0.5
	AO	0.2	0.1	0.2	0.3	0.3	0.2	0.2	0.3	0.1	0.2	0.1	0.2
	C	0.2	0.2	0.3	0.3	0.1	0.1	0.2	0.2	ND	ND	0.3	0.8

Ex- Exchangeable Fraction, Red-Reducible Fraction, Ox-Oxidisable Fraction, Res-Residual Fraction

Table 5: Correlation Coefficient among pH, Clay, Organic Carbon, Nitrogen, Phosphorus, Potassium and Heavy Metals of the Studied Soils

	pH	O.C	N	P	K	Pb	Cr	Ni	Cd
O.C	0.490								
N	0.446	0.728*							
P	0.505	0.886**	0.705*						
K	0.328	0.721*	-0.739*	-0.586					
Pb	0.448	0.795*	0.518	0.606	-0.614				
Cr	0.399	0.746*	0.529	0.594	-0.537	0.944**			
Ni	0.396	0.718*	0.484	0.560	-0.520	0.953**	0.983**		
Cd	0.305	0.315	0.499	0.409	-0.32	0.103	-0.022	-0.024	
Clay	0.199	0.135	0.144	0.232	0.082	-0.321	-0.253	-0.296	0.166

n = 15*Significant at 5% ** Significant at 1% probability

Table 6: Correlation Coefficient among pH, Clay, Organic Carbon, Nitrogen, Phosphorus, Potassium and Pb fractions of the Studied Soils

	Ex	Red	Ox	Resi	Ph	OC	N	P	K
Red	0.9017**								
Oxi	0.9164**	0.9386**							
Res	0.2261	0.5450	0.3796						
pH	0.1963	0.3039	0.3764	0.1305					
OC	0.4060	0.6443*	0.5891	0.4592	0.5136				
N	0.4267	0.4708	0.5727	0.2960	0.0384	0.5728			
P	0.6082*	0.5193	0.5498	0.1935	-0.1376	0.3987	0.7056**		
K	-0.4491	-0.5965	-0.5872	-0.4735	-0.2069	-0.6993*	-0.7379**	-0.5866	
Clay	-0.3588	-0.4116	-0.2754	-0.3126	-0.0491	0.0154	0.1448	0.2326	0.0821

**p = 0.01, *p = 0.05

Table 7: Correlation Coefficient among pH, Clay, Organic Carbon, Nitrogen, Phosphorus, Potassium and Ni fractions of the Studied Soils

	Ex	Red	Ox	Resi	pH	OC	N	P	K
Red	0.9177**								
Oxi	0.9291**	0.9909**							
Res	0.8345**	0.9609**	0.5645						
pH	0.2565	0.2487	0.2703	0.2294					
OC	0.3820	0.5369	0.5664	0.2294	0.5136				
N	0.3984	0.4889	0.4837	0.6037*	0.0384	0.5728			
P	0.5941	0.5054	0.5274	0.4380	-0.1376	0.3987	-0.7379		
K	-0.3908	-0.5082	0.5557	0.4988	-0.2069	0.3987	0.0821	0.0154	
Clay	-0.1318	-0.3181	-0.3109	-0.5309	-0.2069	-0.6993*	0.2326	0.1448	-0.5866

**p = 0.01, *p = 0.05

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Table 8: Correlation Coefficient among pH, Clay, Organic Carbon, Nitrogen, Phosphorus, Potassium and Chromium Fractions of the Studied Soils

	Ex	Red	Ox	Resi	pH	OC	N	P	K
Red	0.9032**								
Oxi	0.9086**	0.9200**							
Res	0.8094*	0.8745**	0.889**						
pH	0.2781	0.2483	0.1850	0.1753					
OC	0.3994	0.3640	0.3558	0.4402	0.5136				
N	0.4272	0.4447	0.3232	0.5356	0.0384	0.5728			
P	0.5331	0.5604	0.5334	0.5688	-0.1376	0.3987	0.7056*		
K	-0.4231	-0.4133	-0.4823	-0.5850	-0.2069	0.6993*	-0.7379*	-0.5866	
Clay	-0.1985	-0.1374	-0.2202	-0.2753	-0.0491	0.0154	0.1448	0.2326	0.0821

** p = 0.01, * p = 0.05

Relationship between Ni fraction and the soil properties

As shown in Table 7, all the Ni fractions were positively correlated with the soil properties except K and clay particles. None of the fractions of Ni was significantly correlated with the correlated soil properties except the residual fraction and Nitrogen. The exchangeable and reducible fractions, exchangeable and oxidisable fractions, reducible and oxidisable fractions, of the Ni were all highly positively correlated.

Relationship between Cr fraction and the soil properties

As shown in Table 8, all the Cr fractions were positively correlated with the soil properties except K and clay particles. None of the fractions of Cr was significantly correlated with the correlated soil properties. The exchangeable and reducible fractions, exchangeable and oxidisable fractions, reducible and oxidisable fractions, of the Cr were all highly positively correlated.

DISCUSSION

Chemical Characteristics of the Soil

Soil pH values observed in all soil samples in this study were slightly acidic and neutral as indicated by John *et al.* (2013). The low pH values of the soil samples might be due to the decomposition of organic materials leading to the release of carbon (iv) oxide and the presence of humic acid which reacts with water to form carbonic acid which eventually increased the acidic level the soil as observed by Olayinka *et al.* (2017). The neutral pH value (7.2) observed in the soil sample from AO at 0-15 cm might therefore be due to the organic materials on the soil not been fully decomposed.

Values of the soil organic carbon content obtained were higher than that of the control soil sample probably due to the anthropogenic activities which occurred on the farms and also, the highest organic carbon (20 g/kg) obtained from the soil sample from AO at 0-15 cm, as shown in Table 2 could be the effect of the source of water used for irrigation. This observation corroborated Oyedele *et al.* (2008) who reported that polluted sites had significant higher soil organic matter and organic carbon as compared to the control site which is exposed to less anthropogenic activities. The organic carbon contents in all the analyzed soil samples were high

to moderate. This trend could be attributed to the relatively high clay fraction of soil textures as shown in Table 1 as described by Quenea *et al.* (2009) quoted by Olayinka *et al.* (2017) that clay fraction had highest level of organic carbon and nitrogen. There is decline in soil organic carbon in the control soil sample from C. This may be traced to high sand content and low clay particles, as described by Olayinka *et al.* (2017).

Fractions of Heavy Metals Concentrations (mg/kg) in Experimental Soils

As shown in Table 3, exchangeable fractions of the analyzed heavy metals (Pb, Cr and Ni) were observed to have the least value in each metal when compared with other fractions. Exchangeability of heavy metals had been shown to be determined largely by the pH of the soil, the soil organic carbon and the clay fraction of the soil among others (Mwegoha and Kihampa, 2010). The higher the soil organic carbon and clay fraction of the soil, the higher the complex formation with the heavy metals and this reduces the mobility of heavy metals. Exchangeable form of heavy metals increases as the pH of the soil become more acidic (Mwegoha and Kihampa, 2010), therefore, the low exchangeable fractions of the heavy metals analyzed in this study must have been due to the moderate and high level of the soil organic carbon, relatively high clay fraction and the slightly acidic pH of the soil samples across the depths as shown in the Table 1 and 2. Despite the high Pb concentration, in the soil sample from AO at 0 -15 cm, only small fractions were in exchangeable form even with the high organic carbon content. The most probable explanation for this is that Pb may be strongly adsorbed by the organic carbon fraction of the soil and thereby reducing its availability at the exchange complex. This view is supported by Yusuf (2007) and Adekola *et al.* (2010) who reported higher amount of Pb absorbed by organic matter than the amount found in exchangeable form.

There is no clear difference between the exchangeable, the reducible and oxidisable fractions of Cr as shown in Table 4. The most important factor that could have affected the concentration of the exchangeable fraction of Cr according to this result could be linked to the pH values of the soil. As explained by Zayed and Terry (2003) that as pH increases, the solubility of Cr tends to increase. Also, the variability of Cr solubility and exchangeability as shown in Table 4 agreed with the findings of Ogbo and Okhouya (2011) in crude oil contaminated soils remediated with mushroom plants and the theory of Basta *et al.* (2005), who found exchangeable form of Cr to increase as the pH increases. The effect of total concentration on the exchangeable form of Ni as described by Zayed and Terry (2003) could also be seen in the Table 4. The high Ni content in the soil sample from AO has reflected in its exchangeable form.

CONCLUSION AND RECOMMENDATION

Conclusion

The present study was carried out on analyses of the speciation of heavy metals (Cr, Pb, Ni) concentration at different depths in soils from different farm land where extensive agricultural activities in both organic and conventional farms were carried out in order to ascertain their available forms for plants uptake. The results showed that the soils could not be said to be polluted for now because metal content levels conformed to the world-wide background content of soil heavy metals threshold limits (UNEP, 2013; Toth *et al.*, 2016). Although selected heavy metal concentrations measured in this study do not pose a serious health risk, they can affect the quality of agricultural produce since certain fractions of these metals especially in the top soil (0-15 cm depth)

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are in exchangeable form in which they can be taken up by plants and get to human and other herbivores via food chain. The report gave emphasis on the importance of extensive investigations on the extent of heavy metal contaminated soils and their sources as well as possible control measures to reduce the associated risk due to food chain transfer of toxic heavy metals.

Recommendations

Regulations should be introduced on agrochemical applications to protect soil resources from further contamination and anthropogenic activities should be thoroughly checked on organic farms in order to maintain food safety. Organic materials should be added to the soil to improve soil organic matter which had been proved to form complexes with heavy metals thereby reducing their exchangeable form.

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PROFITABILITY ANALYSIS OF SMALL-SCALE FISHING ALONG COASTAL AREAS OF ONDO STATE, NIGERIA

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ABSTRACT

This study evaluated the profitability analysis of small-scale fishing along coastal areas of Ondo State, Nigeria. Structured questionnaire was used to collect data from 400 small-scale fishermen which were selected via multi-stage sampling procedure. Data collected was analyzed using descriptive statistics and profitability indicators. Results revealed that mean age of respondents was 39 years, among the fixed assets for fishing, outboard engine has the largest percentage cost (88.32%) while among variable assets, fuel has the largest percentage cost (67.16%). Profitability indicators such as Benefit Cost Ratio (BCR) 1.29, Gross margin ₦1,261,476.60k/fisherman/year, Return on Investment (ROI) 0.29, Net Profit Margin (NPM) 0.23 and Gross Revenue Ratio (GRR) 0.77 were used to estimate the profitability of small-scale fishing. The findings further revealed that fishing boat (1.284), outboard engine (0.352), fishing nets (1.342) and fuel (0.193) were positively and statistically significant at $p < 0.05$ level with fish output level while accessories (floats, sinks and hooks) (0.142) was positively and statistically significant at $p < 0.1$ with fish output level. The R^2 value was 72.1% showing that the independent variable was well explained by the exogenous variables. Problems encountered by small-scale fishermen include inadequate infrastructural facilities, poor road networking system and inadequate credit facilities. Based on the findings, it was recommended that small-scale fishermen should organize themselves into cooperatives in order to increase their credit accessibility. Likewise, government should embark on construction of good road network in order to ease transportation of fish harvested to the neighboring towns.

Keywords: Small-scale fishing, Profitability indicators, Fishermen, Food security

INTRODUCTION

Globally, world fisheries consist of capture fisheries and aquaculture production. In 2016, capture fisheries production worldwide was 90.9 million tonnes compared to 92.7 million tonnes in 2015 (Food and Agricultural Organization [FAO], 2018). Likewise, in 2016, 79.3 million tonnes were realized from world total marine which signifies a reduction of nearly 2 million tonnes from the previous year of 81.2 million tonnes (FAO, 2018). Despite the challenges faced in the capture fisheries, it still constitutes the most vital sub-sector based on job opportunities and largest contribution to fisheries production globally and in Nigeria (Adelaja, *et al.*, 2017). Nigeria is a maritime country with vast population of over 200 million people (National Bureau Statistics (NBS), 2018). Nigeria consists of 36 states out of which nine (9) states; Cross-Rivers, Akwa-Ibom, Delta, Bayelsa, Edo, Ogun, Lagos, Rivers and Ondo shares coastline with Atlantic Ocean. Estimate indicated that about twenty-five percent of the nation's population dwells across the

Profitability Analysis of Small-Scale Fishing Along Coastal Areas

coastal areas (Omole and Isiorho, 2011). In Nigeria, Agriculture has been the basis of the nation's economy in the years back through foreign exchange, employment opportunities, source of food and poverty eradication (Central Bank of Nigeria [CBN], 2012). As at 2017, agriculture contributes about 21% to the Nigerian economy through Gross Domestic Product (Plecher, 2019). Years back, agriculture sector was neglected due to oil discovery in the 1970s but due to present drop of oil price; Nigeria is confronted with no other choice than to broaden her horizons into agriculture and other worthwhile sectors in order to increase its economy (Tiamiyu *et al.*, 2015). In Nigeria, fisheries are a significant subsector that contributes approximately 3-5% to agriculture portion of the Gross Domestic Product (GDP) (Nigeria Fishery Statistics, 2016). The Nigeria fisheries sector comprises of three (3) sub-sectors; artisanal, industrial and aquaculture fisheries. Out of these three (3) sub-sectors, artisanal/small-scale fisheries constitute over 80% of the total fish production in the country. The Nigerian fisheries sector is a crucial device for rural growth through its high-quality protein, source of revenue and socioeconomic growth of fishing communities in Nigeria (Olaoye *et al.*, 2016).

According to Food and Agricultural Organization (2013), consumption of fish worldwide is 18.7 kilos per person while Nigeria's current fish consumption is 7.5 kilos per person which is contradictory. This simply denotes that Nigeria's current fish deficit consumption is 11.2 kilos per person and a lot of Nigerians are faced with protein malnutrition. Like many other developing countries, Nigeria is challenged with the mission of achieving food security and protein demands of its ever-growing human populace (Adelaja *et al.*, 2017; Oladimeji *et al.*, 2017). According to Eromosele (2018), Nigeria spent \$170 million (N61.2 billion) on fish importation in 2017; \$43 million, \$56 million and \$71 million from Norway, Russia and Iceland respectively. Likewise, World Trade Organization (WTO) statistics revealed that Netherlands exported fish worth of \$174 million to Nigeria. Importation of fish was embarked on in order to bridge the current supply gap of 2.1 million metric tonnes of 3.2 million metric tonnes of fish demand (Eromosele, 2018). This makes Nigeria one of the major fish importers in the developing countries. Nigeria coastal communities provide job opportunities for over 10 million people and serves as protein source to 200 million people. In most coastal communities in Nigeria, millions of people derive their livelihoods from fishing, while around 2.6 billion people acquire their protein from seafood. Despite the huge contribution to local fish supply in Nigeria, small-scale fisheries remain the most impoverished fisheries subsector (Adewumi *et al.*, 2012). Fish has been recognized as an essential source of animal protein which contribute meaningfully to the well-being and existence of a teeming inhabitant in the country.

Greater development in small-scale fisheries production can be attained with a suitable investigation that will lead to understanding of profitability level. In spite of the potentials of small-scale fisheries to the country, few researches have been carried out to determine the profitability level of the sub-sector. Small-scale fisheries profitability still remains an important factor that defines the extensive survival of the production business. The key objective of every business is to make profit. Therefore, there is need to decide whether small-scale fisheries production is worthwhile or not in order to inspire stakeholders and Federal Government to apportion funds for the growth of the sector. The objectives considered for this study were to evaluate the profitability of small-scale fisheries and determine the factors influencing output of fish level in the study area.

Ondo State coaster area is result of rich biodiversity of fin and shell fish (Akinwumi *et al.*, 2011) while the fisheries activities are largely artisanal, the artisanal nature of fisheries activities in this area contributes greatly to the country total fish production. Therefore, Ondo State coastal area significantly contributes not only to local livelihoods and economy of Ondo people but to the entire country. Being a historic fishing community, Ondo State coastal area provides a very good landing site for all types of canoes and small semi-industrial boats engaged in traditional fisheries. Fishing is the main occupation which is due to around 75% being riverine attached with open access to the sea. It is considered as one of the most important fishing areas in the coast which have rich biodiversity that contains various grouping of fish, shellfish (shrimps, crabs, lobster, gastropods and cephalopoda), reptiles and other living organisms. Some of the people also involved in local gin (ogogoro), lumbering, mat making, trading, hunting, boat building and farming (Adelaja *et al.*, 2017). Fishing communities along the coast include Aberoyo, Abereke, Igbo, Udigun-Nla, Ojumole, Ikorigho, Aiyetoro, Jinrinwo, Araromi, Ogboti, Araromi sea-side, Enuamo, Okesiri, ErunnaEro, etc.

METHODOLOGY

The study was carried out in Ilaje Local Government Area (ILGA) which is one of the coastal areas of Ondo State, Nigeria. The study area is situated in southwest of Nigeria which comprise of about 80 km coastline from northwest to southeast direction (Akinwumi *et al.*, 2011). The area consists of above 50 fishing communities along its coast as shown in Figure 1. This part is one of the most significant areas for fishing in the shore as a result of rich biodiversity of fin and shell fish. Primary data was used for data collection via structured questionnaires designed towards achieving the objectives of the study. Two stage sampling procedure was used for the choice of respondents. Purposive method was first used to select twenty (20) worthwhile fishing communities. Finally, a total 400 sampled respondents (small-scale fishermen) from the population of 1,243 fishermen were then selected using simple random sampling.

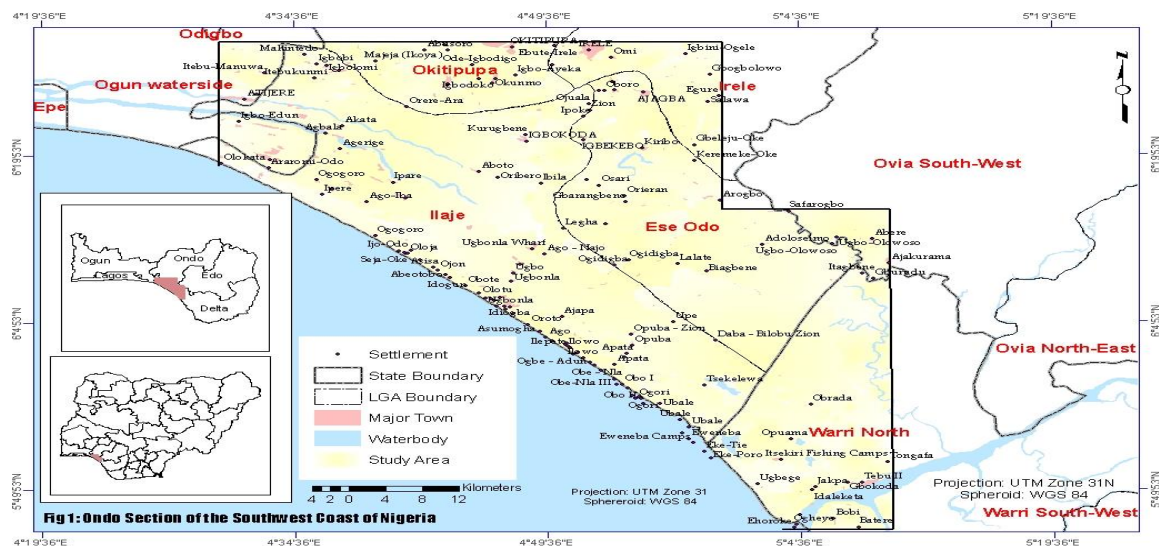


Figure 1: Map Showing the Fishing Communities along the Coastal Areas of Ondo State, Nigeria

Source: <http://pubs.sciepub.com/ajrd/2/1/1/index.html>

Profitability Analysis of Small-Scale Fishing Along Coastal Areas

Analytical Techniques

Descriptive statistics, budgetary analysis which includes gross margin, benefit cost ratio and other profitability ratios were the analytical methods used for the data collected as presented in the equations below. Multiple regression model was used to determine the influence of production cost on the level of fish output.

$$\text{Gross Margin (GM)} = \text{Total Revenue} - \text{Total Variable Cost} \dots\dots\dots(1)$$

$$\text{Net Income (NI)} = \text{Gross Margin} - \text{Total Fixed Cost} \dots\dots\dots(2)$$

$$\text{Benefit Cost Ratio (BCR)} = \text{Total Revenue/Total Cost} \dots\dots\dots(3)$$

$$\text{Returns on Investment (ROI)} = (\text{Net Income/Total Cost}) \times 100 \dots\dots\dots(4)$$

$$\text{Net Profit Margin (NPM)} = \text{Net Income/Total Revenue} \dots\dots\dots(5)$$

$$\text{Gross Revenue Ratio (GRR)} = \text{Total Cost/Total Revenue} \dots\dots\dots(6)$$

Depreciation was calculated for the fixed items in order to get their depreciated prices which was incorporated in the calculation. Straight Line Method (SLM) was used for calculation of depreciation, which anticipated salvage value of zero.

$$\text{Annual depreciation} = (\text{Original Cost} - \text{Salvage Value})/\text{Expected or useful life span (years)}$$

The regression analysis is expressed as follows:

$$Q_{i1} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e$$

Where,

$X_1 - X_5$ are the production cost

Q is the fish output value in naira

X_1 = fishing boat measured in metres

X_2 = cost outboard engine used in fish catching

X_3 = cost of fishing nets in naira

X_4 = cost of accessories in naira

X_5 = for cost of fuel in naira

β_0 = Constant

e = error term

A 4-point Likert type scale was used to elicit data on limitations faced among small-scale fishermen in the study area. The scores were weighed and the weighted average establish. The critical mean of 2.5 was used to accept or reject an item as a limitation faced by small-scale fishermen in the study area. The limitations that score equal to or more than critical means of 2.5 was accepted as limitation to small-scale fishermen in the study area or otherwise rejected.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents

Table 1 presents the descriptive statistics for socioeconomic characteristics of respondents. Result showed that on the average, a typical small-scale fisherman is 38.60 years. This implies that small-scale fishermen were in their energetic age bracket and still have the strength to undergo fishing tasks. Findings is comparable to Adewumiet *al.* (2012) and Mungai (2014) who indicated that

mean age of small-scale fishermen was 33.5 years. All (100%) the respondents were males. This is in line with Nguvava (2013), Akinbote (2016) and Olukunle (2017), who reported that fishing activities is dominated by males. Based on education, result indicated that almost 61% of the respondents had secondary education. This denotes the respondents are educated and they can accept modern techniques to improve their fishing activities. Result was in agreement with Adewumi *et al.* (2012) studies which revealed that 51% of the respondents have primary education. Mean value of respondents fishing experience is 18 years. This implies that small-scale fishermen are well experienced in the business. Almost 64% of the respondents have access to credit facilities. This signifies that some of respondents have access to credit facilities.

Table 1: Socioeconomic Characteristics of Respondents (n = 400)

Variables	Frequency	Percentage
Age (years)		
20 – 40	261	65.2
41 – 60	139	34.8
Mean $\pm$ std	38.60 $\pm$ 5.64	
Sex		
Male	400	100.0
Female	0	0.0
Educational qualification		
No formal education	13	3.3
Primary education	144	36.0
Secondary education	243	60.7
Fishing experience (Years)		
Less than 10	88	22.0
10 – 15	80	20.0
16 – 20	112	28.0
21 – 25	62	15.5
Above 25	58	14.5
Mean $\pm$ std	17.61 $\pm$ 6.82	
Access to credit facilities		
Yes	255	63.8
No	145	36.3

Source: Field survey, 2017

Profitability Ratios of Small-Scale Fishing in Ondo State, Nigeria

Table 2 shows the profitability indicators of small-scale fishing in Ondo State, Nigeria. Depreciation value of fixed items was used for this analysis. Total fixed cost used for the production cost is ₦312,163.80. From the fixed assets used, outboard engine (40hp) has the largest percentage (88.32%), followed by fishing boat (3.95%), fishing nets (3.94%) and accessories (3.80%), respectively. This finding is in line with Inioni and Oyaide (2007) studies who discovered that outboard engine and boat/canoe are the vital fixed assets to improve production of fish. Variable assets used depend on the effort applied by small scale fishermen during fishing activities. Variable cost is determined by the capacity of production. The total variable cost is ₦2,869,665.00. Among the variable assets used, fuel has the largest percentage

Profitability Analysis of Small-Scale Fishing Along Coastal Areas

(67.16%) in the variable cost followed by oil (12.56%) and lubricant (5.80%). These three variable assets are considered as vital in small scale fishing. According to Inioni and Oyiade (2007), fuel contributes within 60 to 71% of variable costs. Gross margin was calculated which gives ₦1,261,476.60/fishermen/annual. Similarly, profitability ratios such as Benefit Cost Ratio (BCR) was used as one of the techniques of project evaluation. BCR value is 1.29 which implies that small-scale fishing is profitable based on the rule of thumb according to Olagunjuet *al.* (2007) which says that once a business has BCR value which is more than one, it shows that the business is profitable. The finding is in accordance with Adewumi *et al.* (2012) and Ashley-Dejo *et al.* (2017) who perceived that small-scale fishing is a worthwhile business. Also, Return on Investment (ROI) value is 0.29, Gross Revenue Ratio (GRR) value is 0.77 and Net Profit Margin (NPM) value is 0.23 respectively. This result is in agreement with Ashley-Dejo *et al.* (2017) and Olukunle (2017) studies which revealed that each phase of the fishery value series was profitable based on profitability analysis. However, based on the profitability ratio results, small-scale fishing is a worthwhile business in the study area.

Table 2: Profitability Ratios of Small-Scale Fishing in Ondo State

Items	Amount in Naira (₦)	% Total Cost
Fixed cost		
Fishing boat	12,333.75	3.95
Outboard engine (40 horse power)	275,700.00	88.32
Fishing nets	12,327.50	3.94
Accessories (floats, sinks and hooks)	11,892.50	3.80
Total fixed cost	312,163.80	100
Variable cost		
Fuel	1,927,125.00	67.16
Oil	360,360.00	12.56
Lubricant	166,500.00	5.80
Food (For crew)	118,080.00	4.11
Repair and Maintenance	156,000.00	5.44
Miscellaneous expenses	141,600.00	4.93
Total variable cost	2,869,665.00	100
Total cost	3,181,828.80	
Total revenue	4,131,142.00	
Gross margin	1,261,476.60	
Net income	949,312.80	
Benefit cost ratio (BCR)	1.29	
Rate of revenue on investment (RORI)	0.29	
Gross revenue ratio (GRR)	0.77	
Net profit margin (NPM)	0.23	
Expense structure ratio (ESR)	0.11	

USD\$1 = ₦360 (Nigerian Naira) by 2017 exchange rate. **Source: Field survey, 2017

Multiple Regression Model

Multiple regression analysis was used to determine the influence of production cost on the level of fish output in the study area. Fish output was regressed against production parameters which include size of fishing boat, outboard engine, fishing nets, fishing accessories and cost of fuel which form part of the fixed and variable cost of production. The linear functional form was chosen of

the three forms fitted for the analysis. The significant t-values, magnitude of the coefficient of determination (R^2) and the significant values of the estimators were the criteria used in the selection. Result in Table 3 presents the regression result of factors influencing fish output level. Result revealed that all the estimated coefficient of the variables has a positive association with the level of fish output. Variables such as fishing boat (1.284), outboard engine (0.352), fishing nets (1.342) and fuel (0.193) were statistically significant at $p < 0.05$ level with fish output level. Similarly, accessories (floats, sinks and hooks) (0.142) was statistically significant at $p < 0.1$ with fish output level. This denotes that an additional unit increase in number of fishing boats for fishing activities will increase the level of fish output by 100% all other dependent variables remain constant. Also, increase in the efficiency of outboard engine and number of fishing nets used for fishing, increases the level of fish output. This will make the small-scale fishermen to put in more efforts to increase their fish catch. Likewise, increase in fuel consumption based on fishing cycle increases the level of fish output. This finding is in accordance with Adewumiet *al.* (2012) studies which stated that if the small-scale fishermen acquire more fishing equipment, it will increase their fish output level and at the long run increase their revenue. In this result, null hypothesis is rejected while alternative hypothesis is accepted. The R^2 value indicates that 72.1% of the output level of fish is determined by the independent variables.

Table 3: Regression Result of the Factors Influencing Output of Fish Level in the Study Area

Variable	Coefficient	Standard error	T-stat	Significant
Constant	4.236	1.183	3.582	0.000
Fishing boat	1.284	0.547	2.347	0.003**
Outboard engine	0.352	0.178	1.972	0.001**
Fishing nets	1.342	0.627	2.142	0.023**
Accessories (floats, sinks and hooks)	0.142	0.082	1.723	0.540*
Fuel	0.193	0.086	2.243	0.000**
R^2	0.721			
F stat	6.062			

Source: Field survey, 2017

Limitations Faced among Small-Scale Fishermen in Ondo State, Nigeria

Table 4 presents the limitations faced by small-scale fishermen in the study area. From the results, the greatest critical limitations faced by the small-scale fishermen were lack of electricity (3.99), lack of storage facilities (3.98), lack of good roads (3.96), inadequate and high fuel price (3.96), oil spillage (3.96), lack of spare parts for their outboard engines (3.91), high cost of outboard engines (3.86), lack of health centers, inadequate provision of good schools (secondary), lack of good water and high cost of lubricant. All these elements reduce fish production output and also increase cost of production incurred in the study area. As a result of this, crucial involvement is required to provide small-scale fishermen with the necessary basic amenities at a cheap price to boost their production level. This is in accordance with Adewumiet *al.* (2012) that provision of storage system and other facilities are vital in small-scale fishing. Oil spillage is also ranked as one of the key limitations faced by small-scale fishermen. There is need

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for the Federal Government and Federal Department of Fisheries (FDF) to guide against oil spillage which is caused by oil companies by setting down guidelines and principles governing natural resources usage.

Table 4: Percentage Distribution of the Constraints Faced by Small-Scale Fishermen

Constraints	Mean value
Lack of electricity	3.99**
Lack of storage facilities	3.98**
Lack of good roads	3.96**
Inadequate and high fuel price	3.96**
Oil spillage	3.96**
Lack of spare parts for their outboard engines	3.91**
High cost of outboard engines	3.86**
Lack of good drink water	3.75**
Lack of health centers	3.70**
Inadequate provision of good schools (secondary)	3.64**
Lack of access to credit facilities	3.64**
High cost of lubricant	2.75**
Recreational facilities	2.25*

Source: Author's computation

CONCLUSION

Findings of this study revealed that small-scale fishing is dominated by economically active males and small-scale fishing is profitable based on the benefit cost ratio (BCR) which was greater than 1 and other profitability indicators measured. Findings revealed that there is a significant relationship between fishing boat, outboard engine, fishing nets and fuel at $p < 0.05$ level with the level of fish output while accessories (floats, sinks and hooks) were significantly related with level of fish output at $p < 0.1$ level. The major problem faced by the small-scale fishermen is lack of electricity and storage facilities. The study recommends that small scale fishermen should be inspired to form themselves into cooperatives in order to have easy access to credit facilities and fishing equipment at a subsidized rate. Also, there is need for lay down principles for proper management of the fisheries resources and urgent implementation by Government.

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STOCHASTIC DOMINANCE RANKINGS OF CONSUMPTION EXPENDITURE AMONGST ARABLE CROP FARMING HOUSEHOLDS IN DELTA STATE, NIGERIA

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ABSTRACT

Finessing the question on household settlement choice is to enquire the income/consumption expenditure distribution that either makes her better-off or worse-off. Using 430 household-level micro-data from a three-stage sampling procedure, the study ranked consumption expenditure by household attributes in Delta state, Nigeria on axiomatic poverty measure. Results showed that household heads in the widowed and $0 < age \leq 20$ years categories in Delta-North first-order stochastically dominated Delta-South ($N \succ_{s=1} S$), $20 < age \leq 40$ years household heads in $S \succ_{s=1} C$ and $N \succ_{s=1} C$, household heads in the widowed, vocational education holder and $0 < age \leq 20$ years, $20 < age \leq 40$ years and $age > 60$ years categories in $N \succ_{s=1} C$, while household heads in the vocational education holder, $0 < age \leq 20$ years, $20 < age \leq 40$ years and $age > 60$ years categories in $S \succ_{s=1} C$. Household heads in the female, single, medium household-size, tertiary education holder and $0 < age \leq 20$ years categories in $N \succ_{s=2} S$ and $N \succ_{s=3} S$. Household heads in the single, medium-size, $20 < age \leq 40$ years and tertiary education holder categories in $N \succ_{s=2} C$ and $N \succ_{s=3} C$. Household heads in the separated spouse and small household-size categories in $C \succ_{s=2} N$ and $C \succ_{s=3} N$ while household heads that are in the single category in $C \succ_{s=2} S$ and $C \succ_{s=3} S$. There is, generally, no stochastic dominance between pairwise comparisons by district in the state, in terms of consumption expenditure, except by other household attributes.

Keywords: Household, Expenditure, Poverty, Dominance, Ranking

INTRODUCTION

Consumption inequality exerts various effects on a country's well-being, poverty inclusive. Poverty, just as inequality, retards economic growth (Banerjee and Duflo, 2003; Castello-Climent, 2010; Herzer and Vollmer, 2012) with a negative two-way relationship between it and institutional quality (Chong and Gradstein, 2007). It is a strong predictor of life satisfaction, happiness, and psychological well-being (Cummins, 2000; McBride, 2001; Clark *et al.*, 2008; Kahneman and Deaton, 2010). Poverty in terms of consumption expenditure deprivation is, moreover, found to be associated with lower self-rated health condition (Subramanyam *et al.*, 2009). Ojogho and Ojo (2017) reports that household consumption expenditure structure is a reflection of the socio-economic variables of commodities consuming households in Nigeria, but leaves open the differentials in consumption expenditure by household attributes. Moreover, a household has to choose, under uncertainty, among districts having different consumption expenditure distribution for settlement. Typically, a household in Delta state will choose the

Consumption Expenditure Ranking of Farming Households

senatorial district where consumption expenditure dispersion is lower to minimize her risk. A district with more inequality gives her either more opportunities of relatively getting richer or the risk of being poorer.

The question of consumption expenditure differentials in Delta state is yet a question for empirical resolve. The National Bureau of Statistics only reports that in 2019, the state had 5.38% of consumption expenditure of the total household expenditure, poverty head-count rate, poverty depth and poverty severity of 60.20%, 0.94 and 0.21 respectively, and a Gini coefficient inequality of 29.84 (National Bureau of Statistics [NBS], 2019).

The existing literatures on poverty in Nigeria have used several indices to measure poverty (Ojoghoet *al.*, 2008; Ike and Uzokwe, 2015). Such studies not only used income data for poverty study rather than consumption expenditure but tend overwhelmingly to focus on the poverty headcount which is the same crude aggregation methodology used by the Unsatisfied Basic Needs approach. Current household income contains not only relevant information about a household's long-run status but also a transitory variance component, making it an imperfect indicator. This leads to disrupting the equality between consumption and income. It is well-known that consumption inequality is usually observed to track income inequality (Krueger and Perri, 2006; DomeijandFloden, 2010; Heathcote *et al.*, 2010; JapelliandPistaferri, 2010, 2011). All poverty measure, so far analysed, used a specification of poverty line. That creates disagreement both about the right location of the poverty line and about the proper poverty measure. To use singular poverty index to rank different consumption expenditure distributions in terms of poverty typically presents results for a variety of poverty measures that are sensitive to the means of identifying the poor and the measure obtained in aggregating below the poverty line. Potentially, different results can be obtained by the choice of a different poverty index. To overcome such issues, a number of dominance criteria have been developed that enables poverty comparisons while at the same time allows for different ways of identifying the poor and for different ways of measuring poverty. No meaningful conclusions can be drawn if poverty differs substantially when different poverty measures are applied or the position of the poverty line is changed.

To draw robust conclusion about ordinal pairwise comparison, the study ranked consumption expenditure by household attributes in Delta state, Nigeria using a measure that is not based on a pre-determined functional form, rather on some desirable axioms that the corresponding class of indices should obey. It specifically aimed to ascertain whether poverty is unambiguously lower or higher between groups regardless of parameters and poverty measures. The results provide an up-to-date picture of consumption expenditure differentials between different population sub-groups across Delta state that will help targeting, particularly, vulnerable groups among farming population. By using consumption expenditure as the variable of analysis, the study moves one step closer towards evaluating households' actual welfare in the State.

METHODS AND DATA

The study was conducted in Delta state, Nigeria. The state lies approximately between Longitude 5°00' and 6°45' East and Latitude 5°00' and 6°30' North. It is bounded in the North and West

by Edo State, in the East by Anambra, Imo, and Rivers States, in the South-east by Bayelsa State, and in the Southern flank by the Blight of Bénin. The majority of the people in the state are in the civil service, farming, hunting, fishing and oil exploration occupations. The study focused on consumption expenditure of households in the state for the period between May-November 2018 to avoid the influence of festivals on consumption expenditure.

A three-stage sampling procedure was used to select households in the state. The first stage used a simple random sampling of two Local Government Areas (LGAs) from each senatorial district of the State. The LGAs were Ndokwa-East and Oshimili-South in Delta-North senatorial district, Warri-North and Bomadi in Delta-South senatorial district, and Ethiope-West and Sapele in Delta-Central senatorial district. The second stage involved a simple random sampling of three communities in each LGA from a sampling frame of communities in the respective LGAs. The communities were Aboh, Ibrede and Okapi-Oluchi in Ndokwa-East LGA, Asaba, Omeligbona and Ugbolu in Oshimili-South LGA of Delta-North senatorial district, Akugbene, Bomadi and Esanma in Bomadi LGA, Ogheye, Opuama and Tebu in Warri-North LGA of Delta-South senatorial district, and Irobe, Mosaga and Oghara in Ethiope-West LGA, Elume, Ikeransan and Oboba in Sapele LGA of Delta-Central senatorial district of the state. The sample size for the study in each community was determined using the small sample-size estimator of Krejcie and Morgan (1970). The sample-size estimator is given as:

$$s_i = \frac{\chi^2 N_i P(1-P)}{d^2(N_i-1) + \chi^2 P(1-P)} \quad [1]$$

Where s_i is the sample size of the i^{th} community, $P = 0.50$, N_i is the target population of the i^{th} community, $\chi^2_{0.05,1} = 3,841$ for one degree of freedom at 95% confidence level, and $d = 0.05$.

A simple random sample of households in each community was then taken from the list of the target population in the state developed from a pilot survey. The sample size were respectively 24 from Aboh, 28 from Ibrede and 19 from Okapi-Oluchi in Ndokwa-East LGA, 24 from Asaba, 28 from Omeligbona and 10 from Ugbolu in Oshimili-South LGA of Delta-North senatorial district, 52 from Akugbene, 36 from Bomadi and 28 from Esanma in Bomadi LGA, 32 from Ogheye, 48 from Opuama and 28 from Tebu in Warri-North LGA of Delta-South senatorial district, and 31 from Irobe, 26 from Mosaga and 23 from Oghara in Ethiope-West LGA, 31 from Elume, 39 from Ikeransan and 32 from Oboba in Sapele LGA of Delta-Central senatorial district of the state. That amounted to 133 households from Delta-North, 224 households from Delta-South, and 182 households from Delta-Central senatorial district of the state making a total sample size of 539 households for the study out of a target population of 588 as presented in Table 1. Only 459 copies of questionnaire were retrieved from the households making a response rate of 85%. However, 430 copies of questionnaire were valid for analysis. A household was identified by its household head. Household consumption expenditure measures were on purchased food, value of home-grown food consumed, housing, clothing, education, health and medical fees, transportation, communication, and other utilities, excluding irregular one-time expenses arising from special occasions, repayments of loans, savings and taxes. Household consumption

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expenditure was scaled to take account of differing household size and composition, using a scale used by Callan *et al.* (1996) and O'Neill and Sweetman (1998). The weights were 1 for the first adult in the household, 0.7 for additional people aged over 14 and 0.5 for people aged less than 14.

Model Specification

The study argued that the decision-making process on the demand-side is done by the household head. The study further assumed the existence of uniform weak orders among welfare outcomes measured by household consumption expenditures in the state. On the above assumptions, the study followed stochastic dominance approach to rank consumption expenditure distribution using the Foster, Greer, and Thorbecke (1984) poverty indexes, for poverty head-count ratio, poverty depth and poverty severity:

$$P_{\alpha} = \int_0^z (1 - x/z)^{\alpha} f(x) dx, \forall \alpha \in [0, 2] \quad [2]$$

Table 1: Sampling Frame and Sample Size

Senatorial Districts/LGAs	Communities	Sample Frame	Sample Size
Delta-North senatorial district:			
Ndokwa-East LGA	Aboh	25	24
	Ibrede	30	28
	Okapi-Oluchi	20	19
Oshimili-South LGA	Asaba	25	24
	Omeligbona	30	28
	Ugbolu	10	10
Sub-total		140	133
Delta-South senatorial district:			
Bomadi LGA	Akugbene	60	52
	Bomadi	40	36
	Esanma	30	28
Warri-North LGA	Ogheye	35	32
	Opuama	55	48
	Tebu	30	28
Sub-total		250	224
Delta-Central senatorial district:			
Ethiope-West LGA	Irobe	34	31
	Mosaga	28	26
	Oghara	24	23
Sapele LGA	Elume	34	31
	Ikeransan	43	39
	Oboba	35	32
Sub-total		198	182
Total		588	539

Source: Field Survey, 2018

However, for the notion of stochastic dominance curve, the study used a monotonic transformation of the Foster, Greer, and Thorbecke (FGT) curve model:

$$F_s(x) = \int_0^x F_{s-1}(t)dt = \frac{1}{(s-1)!} \int_0^x (x-t)^{s-1} f(t)dt, \forall x \in [0, \infty) \quad [3]$$

Since the FGT indices are strictly equivalent, up to a scale factor, to the dominance curves when the poverty-line, z , vary, the poverty stochastic dominance curve was expressed as:

$$F_s(x) = cP(\alpha = s - 1, z) \quad [4]$$

Where x is the consumption expenditure of the i^{th} household, $c = 1/(s-1)!$ is a constant term, and dominance was taken as the consumption expenditure distribution that generates less poverty. Following Davidson and Duclos (2000), the study then compares stochastic dominance poverty curves at order s or FGT curves at $\alpha = s - 1$, to check for s -order stochastic dominance in poverty of the expenditure distribution for one group, A over the expenditure distribution of the other group, B ($A \succ_{s \in [0,3]} B$) for the order $s = \alpha + 1$ over the range $[z^-, z^+]$, if and only if:

$$P_1(\zeta; \alpha) < P_2(\zeta; \alpha) \forall \zeta \in [z^-, z^+] \quad [5]$$

Providing the values of ζ and $P_1(\zeta; \alpha)$ for which $P_1(\zeta; \alpha) = P_2(\zeta; \alpha)$ when $sign(P_1(\zeta - \eta; \alpha) - P_2(\zeta - \eta; \alpha)) = sign(P_1(\zeta + \eta; \alpha) - P_2(\zeta + \eta; \alpha))$ for small η where the crossing points ζ are the “critical poverty lines” and $P(\zeta; z)$ is the FGT index, and s is the order of stochastic dominance of poverty comparison. However, at any of the s^{th} -order stochastic dominance of poverty comparison, if the cumulative distribution functions do not cross, then the poverty rankings for all measures were considered robust to the choice of poverty line at that order. The analysis was done using STATA 14.1

RESULTS AND DISCUSSION

The socio-economic characteristics descriptive statistics of households in the State are presented in Table 2. The results that the modal age in the state was the $40 < age < 60$ category across the state representing 54.88%, 62.63%, 47.58% and 54.59% in the state in general and Delta-north, Delta-central and Delta-south respectively but average age that ranged from about 40 years to 46 years.

The typical education level in the state was the primary (30.00%) and secondary education (31.40%), secondary (27.42%) and tertiary (52.42%) education in Delta-central, primary (33.33%) and secondary (28.59%) in Delta-south, but a bi-modal education level distribution in Delta-north, consisting of primary (42.42%) and secondary (42.42%) education levels. The state had majority of male-headed household heads which is more in Delta-north (83.84%) and Delta-central (81.45%). The results also showed that majority of the household heads were married with greater proportion of married household heads in Delta-north. With an average household size ranging from six to eight, the modal household size in the state was the medium category. The results suggest middle age-cohorts with male-headed decision maker whose education level are more of primary and secondary education.

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Table 2: Socio-economic Characteristics Distribution of Households in Delta State

Variable	Pooled Frequency (Percentage)	Delta North Frequency (Percentage)	Delta Frequency (Percentage)	Delta South Frequency (Percentage)
Age (years)				
0 < age ≤ 20				
20 < age ≤ 40	2 (0.47) 154 (35.81)	7 (0.07) 20 (20.20)	6 (0.05) 58 (46.68)	2 (0.97) 65 (31.40)
40 < age ≤ 60	236 (54.88) 38 (8.84)	62 (62.63) 10 (10.10)	59 (47.58) 1 (0.81)	113 (54.59) 27 (13.04)
> 60	43.37	45.54	39.77	44.49
Mean				
Education Level				
Non-formal	45 (10.47)	1 (1.01)	7 ((5.65)	37 (17.87)
Primary	129 (30.00)	42 (42.42)	18 (14.52)	69 (33.33)
Secondary	135 (31.40)	42 (42.42)	34 (27.42)	59 (28.50)
Vocational	19 (4.42)	7 (7.07)	-	12 (5.80)
Tertiary	102 (23.72)	7 (7.07)	65 (52.42)	30 (14.49)
Sex				
Male	323 (75.12)	83 (83.84)	101 (81.45)	139 (67.15)
Female	107 (24.88)	16 (16.16)	23 (18.55)	68 (32.85)
Marital Status				
Single	57 (13.26)	1 (1.01)	30 (24.19)	26 (12.56)
Married	335 (77.91)	96 (96.97)	92 (74.19)	146 (70.52)
Separated	20 (4.65)	1 (1.01)	1 (0.81)	18 (8.70)
Widowed	18 (4.19)	1 (1.01)	1 (0.81)	17 (8.21)
Household Size				
Small (1 – 5)	131 (30.47)	23 (23.23)	52 (41.94)	56 (27.05)
Medium (6 – 10)	189 (43.95)	51 (51.52)	53 (42.73)	85 (1.06)
Large (> 10)	110 (25.58)	25 (25.25)	19 (15.32)	66 (31.88)
Mean	7	8	6	8

Source: Computed from Field Survey, 2018; values in parentheses are corresponding percentages

Table 3 presents the results of consumption expenditure distributions ranking by senatorial districts in the state. The results showed two poverty-line critical points between Delta-North and Delta-South for first (N2650 and N5600) and second (N2816 and N12856) stochastic dominance but one point of intersection for the third (N3137) stochastic dominance. There were seven, three and one (N3314) point of intersection for first, second and third stochastic dominance respectively between Delta-North and Delta-Central in the state. Between Delta-South and Delta-Central, there were 16 points of intersection for first stochastic dominance and two each for the second and third stochastic dominance. These imply that the dominance condition is not satisfied for the first-, second- and third-order stochastic dominance. A robust conclusion is, therefore, not

possible, since intersections are encountered. Hence, none of the three senatorial district of Delta state has higher social welfare, on average, than the other for all additively separable social welfare functions that respect anonymity. The results also imply that poverty ranking by senatorial district in the state depends on the poverty-line and poverty threshold.

Table 4 presents the results of consumption expenditure distributions ranking by sex in the state. The results of pairwise ranking showed that there were two poverty-line critical points between males in Delta-North and Delta-South for first- (N2650 and N5600), second- (N2860.24 and N8828.29) and third-order (N3224.32 and N13910.19) stochastic dominance respectively. There were five, one (N3026.73) and one (N3311.67) point of intersection for first-, second- and third-order stochastic dominance respectively between males in Delta-North and Delta-Central in the state. Between males in Delta-South and Delta-Central, there were ten points of intersection for first-order stochastic dominance and two each for the second- (N2840.73 and N3331.43) and third-order (N3052.67 and N3569.14) stochastic dominance. These imply that none of three senatorial district of Delta state has higher social welfare, on average, than any other among the male-headed household for all additively separable social welfare functions that respect anonymity. The result of rankings also suggests that poverty ranking among male-headed household in the state depends on the poverty-line and poverty threshold.

Also presented in Table 4 are the results of consumption expenditure distributions ranking for the female-headed household in the state. The results showed that there were two poverty-line critical points between females in Delta-North and Delta-Central for first- (N3050.00 and N3970.00), second- (N3268.14 and N4352.03) and third-order (N3436.41 and N4943.13) stochastic dominance respectively. There were five, and one each at the first-, second- (N6267.42) and third-order (N9883.25) stochastic dominance respectively between female-headed households in Delta-South and Delta-Central of the state.

Consumption Expenditure Ranking of Farming Households

Table 3: Stochastic Dominance Comparison between FGT Curves by Senatorial Districts in Delta State

North = 1; South = 2			North = 1; Central = 2			South =1; central = 2		
Critical values, (z^*)			Critical values, (z^*)			Critical values, (z^*)		
$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$
2650.00**	2815.92**	3137.58**	2600.00**	2896.36**	3314.39**	2700.00*	2782.55*	2967.95*
5600.00*	12856.47*		2770.00*	2912.36*		3230.00**	5492.20**	6617.60**
			2780.00**	3004.69**		3430.00*		
			2900.00*			4000.00**		
			2990.00**			4020.00*		
			3670.00*			4070.00**		
			3740.00*			4150.00*		
						4170.00**		
						4180.00*		
						4190.00**		
						4200.00*		
						4220.00**		
						4720.00*		
						4750.00**		
						4880.00*		
						4900.00**		

Source: Computed from Field Survey, 2018; *Case A: Before this intersection, distribution 2 dominates distribution 1; **Case B: Before this intersection, distribution 1 dominates distribution 2.

Table 4: Stochastic Dominance Comparison between FGT Curves by Sex in Delta State

Sex	North = 1; South = 2			North = 1; Central = 2			South =1; central = 2		
	Critical values, (z^*)			Critical values, (z^*)			Critical values, (z^*)		
	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$
Male	2650.00**	2860.24**	3224.32**	2550.00**	3026.73**	3311.67**	2700.00*	2840.73*	3052.67 *
	5600.00*	8828.29*	13910.19*	2900.00*			3150.00**	3331.43**	3569.14**
				2990.00**			3200.00*		
				3670.00*			3210.00**		
				3730.00**			3600.00*		
							3820.00**		
							4200.00*		
							4220.00**		
							4880.00*		
							4900.00**		
Female	3280.00*	$N >_{s=2} S$	$N >_{s=3} S$	3050.00*	3268.14*	3436.41*	3980.00**	6267.42**	9883.25**
	3300.00**			3970.00**	4352.03**	4943.13**	4030.00*		
	3370.00*						4050.00**		
	3400.00**						4700.00*		
	5360.00*						4730.00**		

Source: Computed from Field Survey, 2018; *Case A: Before this intersection, distribution 2 dominates distribution 1; **Case B: Before this intersection, distribution 1 dominates distribution 2.

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These suggests that the dominance condition is not satisfied for the first-, second-, and third-order dominance of poverty between pairwise comparison ordinal poverty ranking in Delta-North and Delta-South, and Delta-South and Delta-Central. Thus, a robust conclusion is not possible between female-headed household in Delta-North and Delta-South at first-order stochastic dominance, and between Delta-South and Delta-Central at any of first-, second- and third-order stochastic dominance, but and their ranking in terms of poverty changes depends on where the poverty line is drawn. However, there is a robust conclusion between female-headed household in Delta-North and Delta-South at second- and third-order stochastic dominance.

The consumption expenditure distributions ranking for female-headed households between Delta-North and Delta-South showed that Delta-North second-order $N \succ_{s=2} S$ and third-order $N \succ_{s=3} S$ stochastically dominates consumption expenditure distribution for female-headed households in Delta-South. Thus, the average poverty gap is greater in Delta-South than in Delta-North for all poverty lines. This means that Delta-North has higher social welfare, on average, than Delta-South. It also implies that depth of poverty in consumption expenditure gap ratio and severity, but not the head-count ratio, shows a rise in poverty over the female-headed households in Delta-South than in Delta-North in terms of consumption expenditure among the poor female-headed households in Delta state. This implies that poverty is worse for female-headed households in Delta-South than in Delta-North. There is, thus, a unanimous ranking of the respective pairwise female-headed household populations in the state for progressively more and more restricted classes of poverty indices.

The results of consumption expenditure distributions ranking by marital status in the state are presented in Table 5. The results showed that there was one poverty-line critical point (N4700) between household heads in the single category in Delta-north and Delta-south (N4700), Delta-North and Delta-Central (N4700), and Delta-South and Delta-Central (N4840) at the first-order stochastic dominance. However, there was stochastic dominance at the second- and third-order among household heads in the single category with Delta-North second- $N \succ_{s=2} S$ and third-order $N \succ_{s=3} S$ stochastically dominating Delta-South, Delta-North over Delta-Central ($N \succ_{s=2} C$ and $N \succ_{s=3} C$), and Delta-Central over Delta-South ($C \succ_{s=2} S$ and $C \succ_{s=3} S$) respectively. It implies that depth of poverty in consumption expenditure gap ratio and severity, but not the head-count ratio, shows a rise in poverty over the households of the single marital status category in Delta-South and Delta-Central than in Delta-North in terms of consumption expenditure among the poor households of single marital status category in Delta state.

In Table 5, are also results for household heads in the separated and widow/widower marital status categories. For a restricted range of poverty line between N1700 and N3180, intersections are not encountered for household heads in the separated spouse marital status category poverty rankings. Thus, poverty for all measures will be robust to the choice of poverty line. There was dominance in the state at the second- and third-order stochastic dominance between household heads in the separated marital status category in Delta-Central over Delta-North ($C \succ_{s=2} N$ and $C \succ_{s=3} N$). Hence depth of poverty in terms of consumption expenditure gap ratio and severity, but not the head-count ratio, shows a rise in poverty over the household heads with households in separated spouse marital status category in Delta-North than in Delta-central in terms of consumption expenditure among the poor household heads with separated spouse marital status category in Delta

state. In households with widow/widower as household heads, there was poverty stochastic dominance at the first-order in Delta-North over Delta-South ($N \succ_{s=1} S$), and Delta-North over Delta-Central ($N \succ_{s=1} C$). This implies that poverty is worse for household with widow/widower as household heads in Delta-South and Delta-Central than in Delta-North. Thus, for all poverty indices, there is more poverty in Delta-South and Delta-Central than in Delta-North, suggesting that Delta-North has higher social welfare than Delta-South and Delta-Central for all additively separable social welfare functions that respect anonymity.

The results of consumption expenditure distributions ranking by household size in the state are presented in Table 6. The results showed that there were six poverty-line critical points for small-size households between Delta-North and Delta-South for first-order stochastic dominance, and four poverty-line critical points between Delta-South and Delta-Central at first-order stochastic dominance, and one poverty line critical point each for small-size households between Delta-South and Delta-Central at the second-order (N2768.79) and third-order (N3061.45) stochastic dominance respectively. These suggest that the dominance condition is not satisfied for small-size households between Delta-North and Delta-South, Delta-North and Delta-Central, and Delta-South and Delta-Central at the first-order stochastic dominance, thus, a robust pairwise ordinal ranking conclusion is not possible for small-size households between Delta-North and Delta-South, Delta-North and Delta-Central, and Delta-South and Delta-Central of the state. However, there was poverty stochastic dominance for small-size households in Delta-Central over Delta-North at the second- and third-order ($C \succ_{s=2} N$ and $C \succ_{s=3} N$) stochastic dominance respectively. This implies that poverty depth and severity are worse for small-size households in Delta-North than in Delta-Central.

For the medium-size households, there was one poverty line critical point between Delta-North and Delta-South for first (N6830), two poverty line critical points (N2770 and N3000) between Delta-North and Delta-Central at first-order stochastic dominance. These suggest that the dominance condition is not satisfied for medium-size households between Delta-North and Delta-South at the first-order stochastic dominance, thus, a robust conclusion is not possible. There was, however, poverty stochastic dominance of medium-size households in Delta-North over Delta-South at the second-order ($N \succ_{s=2} S$) and third-order ($N \succ_{s=3} S$) stochastic dominance respectively, while Delta-North second- and third-order stochastically dominated Delta-Central ($N \succ_{s=2} C$ and $N \succ_{s=3} C$). The implication is that, among the medium-size households, poverty depth and severity are worse in Delta-South and Delta-Central than in Delta-North. Also, depth of poverty in consumption expenditure gap ratio, but not the head-count ratio, shows a rise in poverty over medium-size households in Delta-South and Delta-Central than in Delta-North in terms of consumption expenditure among medium-size poor households in Delta state.

Table 7 shows the results of consumption expenditure distributions ranking by age in the state. The results showed that, in households with age of household head, $0 < age \leq 20$, years, there was poverty stochastic dominance at the first-order in Delta-North over Delta-South ($N \succ_{s=1} S$), Delta-North over Delta-Central ($N \succ_{s=1} C$) and Delta-South over Delta-Central ($S \succ_{s=1} C$). This implies that poverty-ratio, poverty-depth and poverty severity are worse for household heads with age, $0 < age \leq 20$, years, in Delta-South and Delta-Central than in Delta-North such that

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for all poverty indices, there is more poverty in Delta-South and Delta-Central than in Delta-North.

Hence, Delta-North has higher social welfare than Delta-South Delta-Central for all additively separable social welfare functions that respect anonymity. However, poverty is worse for household heads with age, $0 < age \leq 20$, in Delta-Central than in Delta-South such that, for all poverty indices, there is more poverty in Delta-Central than in Delta-South, suggesting that Delta-South has higher social welfare than Delta-Central for all additively separable social welfare functions that respect anonymity. The trend is the same for age bracket, $20 < age \leq 40$, except for ranking between Delta-North and Delta-South where Delta-South first-order stochastically dominates Delta-North ($S \succ_{s=1} N$).

Among households with age of household head, > 60 years, there was poverty stochastic dominance at the first-order in Delta-North over Delta-Central ($N \succ_{s=1} C$), and Delta-South over Delta-Central ($N \succ_{s=1} C$). This implies that poverty is worse for household heads with age, > 60 years, in Delta-Central than in Delta-North and Delta-South such that, for all poverty indices, there is more poverty in Delta-Central than in Delta-North, suggesting that Delta-North has higher social welfare than Delta-Central for all additively separable social welfare functions that respect anonymity. Similarly, poverty-depth is worse for household heads with age bracket, > 60 years, in Delta-North than in Delta-South for all poverty indices. There is, however, no unanimous ranking of the two populations for household heads in age bracket, > 60 , between Delta-North and Delta-South at the first-, and third-order stochastic dominance and for progressively more and more restricted classes of poverty indices. For a restricted range of poverty line between N1700 and N2650, intersections are not encountered at first-order stochastic dominance for household heads in age bracket, $20 < age \leq 40$ years.

The results of consumption expenditure distributions ranking by education status in the state are presented in Table 8. The results showed one poverty line critical points each between Delta-North and Delta-South at the first-, second- and third-order stochastic dominance (N4070, 6020 and N10966), and between Delta-North and Delta-Central (N4070, N4838 and N6617) respectively for household heads with non-formal education.

There was greater number of poverty line critical points for some other categories of education status in the state. These suggest that the dominance condition is not satisfied and that the two dominance curves cross where the most of the poverty-line critical points. Hence, a robust conclusion is not possible, since intersections are encountered. Hence, none of the categories of education status in the state has higher social welfare, on average, than the other for all additively separable social welfare functions that respect anonymity. Poverty ranking would depend on the poverty line and poverty threshold.

Table 5: Stochastic Dominance Comparison between FGT Curves by Marital Status in Delta State

Marital Status	North = 1; South = 2			North = 1; Central = 2			South = 1; central = 2		
	Critical values, (z^*)			Critical values, (z^*)			Critical values, (z^*)		
	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$
Single	4700.00*	$N \succ_{s=2} S$	$N \succ_{s=3} S$	4700.00*	$N \succ_{s=2} C$	$N \succ_{s=3} C$	4840.00**	$C \succ_{s=2} S$	$C \succ_{s=3} S$
Married	2700.00**	3000.32**	3361.33**	2600.00**	2855.08**	3350.10**	2730.00*	3009.13*	3494.16*
	5600.00*	8929.38*		2900.00*			3250.00**	5537.54**	6604.92**
				2990.00**			3400.00*		
				3650.00*			4110.00**		
				3800.00**			4150.00*		
							4280.00**		
							4320.00*		
							4330.00**		
							4720.00*		
							4750.00**		
							4850.00*		
							4900.00*		
Separated	3180.00*	3222.96*	3364.45	[1700,3180] ¹	$C \succ_{s=2} N$	$C \succ_{s=3} N$	3730.00**	4015.80**	4621.33**
Widowed	$N \succ_{s=1} S$			$N \succ_{s=1} C$			3150.00**	3234.66**	3448.66**

Source: Computed from Field Survey, 2018; *Case A: Before this intersection, distribution 2 dominates distribution 1, **Case B: Before this intersection, distribution 1 dominates distribution 2, ¹ Case C: No dominance before this intersection.

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Table 6: Stochastic Dominance Comparison between FGT curves by Household Size in Delta State

Household Size	North = 1; South = 2			North = 1; Central = 2			South = 1; central = 2		
	Critical values, (z^*)			Critical values, (z^*)			Critical values, (z^*)		
	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$
Small:									
(1 – 5)	2700.00**	3226.13**	3815.43**	2780.00**	$C >_{s=2} N$	$C >_{s=3} N$	2620.00*	2768.79*	3061.45*
	4390.00*			3480.00*			4930.00**		
	4420.00**			4930.00**			5150.00*		
	4850.00*			4950.00*			5200.00**		
	6540.00**			5335.00**					
	6600.00*								
Medium:									
(6 – 10)	6830.00*	$N >_{s=2} S$	$N >_{s=3} S$	2770.00*	$N >_{s=2} C$	$N >_{s=3} C$	2650.00*	2722.84*	2787.40*
				3000.00**			3100.00**	6253.40**	8563.04*
							3130.00*		
							3250.00**		
							3320.00*		
							3330.00**		
							3500.00*		
							3880.00**		
							4500.00*		
							4920.00**		
							4990.00*		
							5130.00**		
							5150.00*		
							5450.00**		
Large: (> 10)									
	3500.00*	7164.65*	9929.28	3150.00**	3196.20**	3243.12**	3150.00**	5325.93**	6694.16**
	3520.00**			3500.00*	3832.58*		3180.00*		
	3690.00*			3970.00**	4275.26**		3210.00**		
	3970.00**			5700.00*			3400.00*		
	4500.00*			6140.00**			4380.00**		
	4520.00**						4950.00*		
	5250.00*						5020.00**		
	5300.00**								
	5600.00*								

Source: Computed from Field Survey, 2018; *Case A: Before this intersection, distribution 2 dominates distribution 1, **Case B: Before this intersection, distribution 1 dominates distribution 2

Table 7: Stochastic Dominance Comparison between FGT curves by Age of Household Head in Delta State

Age (years)	North = 1; South = 2			North = 1; Central = 2			South =1; central = 2		
	Critical values, (z^*)			Critical values, (z^*)			Critical values, (z^*)		
	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$
$0 < age \leq 20$	$N \succ_{s=1} S$			$N \succ_{s=1} C$			$S \succ_{s=1} C$		
$20 < age \leq 40$	$S \succ_{s=1} N$			$N \succ_{s=1} C$			$S \succ_{s=1} C$		
$40 < age \leq 60$	[1700,2650] ^l $N \succ_{s=2} S$ $N \succ_{s=3} S$			3280.00*	$N \succ_{s=2} C$	$N \succ_{s=3} C$	3770.00**	4468.71 **	5565.79**
> 60				3480.00**					
	2900.00*	$S \succ_{s=2} N$	3069.53*	$N \succ_{s=1} C$			$S \succ_{s=1} C$		
	4030.00**								
	4900.00*								
	5010.00**								
	5030.00*								

Source: Computed from Field Survey, 2018; *Case A: Before this intersection, distribution 2 dominates distribution 1, **Case B: Before this intersection, distribution 1 dominates distribution 2

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Table 8: Stochastic Dominance Comparison between FGT curves by Education Level of Household Head in Delta State

Education Level	North = 1; South = 2			North = 1; Central = 2			South =1; central = 2		
	Critical values, (z^*)			Critical values, (z^*)			Critical values, (z^*)		
	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$	$s = 1$	$s = 2$	$s = 3$
Non-formal	4070.00*	6020.00*	10965.87*	4070.00*	4837.73*	6616.69*	3150.00** 3900.00*	3333.16* 4282.29*	3767.65** 4730.63*
Primary							5800.00**		
	2700.00**	2789.57**	3038.35**	2300.00**	$N \succ_{s=2} C$	2490.79 **	2730.00*	3025.95*	3333.07*
	3880.00*	5567.15*	7177.20*	2900.00*			3500.00**	4010.37**	4420.59**
	4150.00**			3200.00**			3580.00*		
	4170.00*			3690.00*			3720.00**		
	4370.00**			3700.00**					
	4390.00*								
Secondary									
	2620.00**	2857.90**	3193.04**	3000.00**	3266.78**	$N \succ_{s=3} C$	3210.00**	4572.20**	5448.37**
	3670.00*	7639.40*	10913.44*	3100.00*			3500.00*		
	3700.00**			3210.00**			3900.00**		
	5130.00*			3580.00*			3970.00*		
	5220.00**			3850.00**			3980.00**		
	5250.00*			5800.00*					
	5300.00**			6140.00**					
	5500.00*								
Vocational									
	2770.00*	4703.24**	2840.64*	$N \succ_{s=1} C$			$S \succ_{s=1} C$		
	3700.00**		5881.58**						
Tertiary									
	[1700,3080] ¹	$N \succ_{s=2} S$	$N \succ_{s=3} S$	4500.00* 4600.00**	$N \succ_{s=2} C$	$N \succ_{s=3} C$	3490.00* 5770.00**	3761.63*	4271.56*

Source: Computed from Field Survey, 2018; *Case A: Before this intersection, distribution 2 dominates distribution 1, **Case B: Before this intersection, distribution 1 dominates distribution 2, ***Case C: No dominance before this intersection.

CONCLUSION

This study ranked consumption expenditure by household attributes in Delta state, Nigeria using axiomatic poverty measure on household-level data from a three-stage sampling procedure. Household expenditure measures were on food, value of home-grown food consumed, housing, clothing, education, health and medical fees, transportation, communication, and other utilities, excluding irregular, one-time expenses arising from special occasions, repayments of loans other than house purchase mortgages, savings and taxes. Household expenditure was scaled to take account of differing household size and composition, using a scale which has been widely used in poverty studies in the European Union. It is the same as scale “C” used by Callan *et al.* (1996) and is also used by O’Neill and Sweetman (1998). The weights are 1 for the first adult in the household, 0.7 for additional people aged over 14 and 0.5 for people aged less than 14. The study assumed the existence of uniform weak orders among welfare outcomes measured by household consumption expenditures in Delta state from the stochastic dominance approach to rank consumption expenditure distribution using the Foster, Greer, and Thorbecke (1984) poverty indexes, for poverty head-count ratio, poverty depth and poverty severity. The results suggest that, although the sample of households studied is small, some clear patterns of economic well-being is observed across household sub-groups. In addition, while first order dominance seems very rare, second order dominance holds in many cases. There is, generally, no stochastic dominance between pairwise comparisons by district in the state, in terms of consumption expenditure, except in poverty decomposition by other household attributes. Redistribution policies can be effective measures in reducing inequality in disposable income and consumption expenditures. Efforts to raise the welfare of specific groups such as elderly farming households, those with less educational level, and those headed by separated, divorced, or widowed females should be in the center of an effective Delta State welfare scheme system. An extension of the sample to incorporate larger and more specific groups of farming households targeted for various public transfer policy measures would shed additional light on the state of welfare of households in the state and the impact of such policies implemented.

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EFFECTS OF GENDER-BASED ROLES ON FARM HOUSEHOLDS' FOOD SECURITY STATUS IN RURAL AREAS OF KOGI STATE, NIGERIA

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ABSTRACT

Gender is one of the key issues of discourse among policy experts, research scholars and government as part of the sustainable development goals. In this paper, we examined gender roles in food security among farming households in Kogi state, Nigeria. First, we assessed the food security status of the farm households. Second, the contributions of gender in household security status were identified. A three-stage sampling technique was used to select 120 farm households and data were collected using a well-structured questionnaire. In the study we employed the use of food security index, chi square test and logistic regression analysis. The results revealed that only about 35% of the households are food secure (>2470 kcal/AE/day). The logistic regression model shows that fitted model is statistically significant with the log likelihood of 118.691 and Chi-square of 59.19 (P value < 0.05) with the R² of 0.61. Household size, access to credit and membership of social groups are significant factors influencing households' food security status. Therefore, the study recommends that women empowerments should be inculcated into the mainstream of any government policy targeted at ensuring food security of rural households.

Keywords: Gender, Sustainable development, Food security, Rural household

INTRODUCTION

Globally, an estimate of 820 million people did not have enough to eat in 2018. In the previous years, the value was up from 811 million (WHO, 2020). In Africa, the number of hungry people was 256.1 million (WHO, 2020). This underscores the immense challenge of achieving the Sustainable Development Goal of Zero Hunger by 2030 (FAO, 2019). However, the basic causes of hunger are attributed to society structures and processes, such as access to resources, socio-economic and political contexts (Lancet, 2013). Generally, in food security studies, there is the macro and micro level of measuring food insecurity. The macro or national level mostly aims at the food availability and the micro level focuses on household or individual food requirement and utilization. The need to provide adequate and nutritious food for the population given persistence of hunger mostly in the developing countries remain the principal challenge facing policy makers and this will continue for many years to come (Stamouliset *al.*, 2004). Thus, the issue of food insecurity in Africa and particularly in Nigeria are no exception to this. In fact, both men and women are differently affected by the problem of food insecurity owing to their roles and differential access to resources (Botreau and Cohen, 2019). The poor macroeconomic conditions and high levels of conflict in northern Nigeria are the key drivers of acute food insecurity.

This is compounded by widespread flooding in 2020 and below-average income, which drove low access to agricultural inputs, resulting in a below-average 2020/21 harvest (FEWSNET, 2021). Furthermore, all these impacts on household acute food insecurity coupled with the longer-term indirect impacts of the COVID-19 pandemic. The Nigerian macro economy dependence on oil exports (accounting for more than 70 percent of government revenue) and low levels of cross-border trade, conflict, and the limited movement of goods from surplus to deficit-producing areas of the country culminate in affecting the food security of the nation (FEWSNET, 2021).

The long-lasting view of food security as a problem of food availability has been partly re-visited within a more macro-economic approach. The focus on the food sector – initially only agricultural production, but also food trading later on – has been criticized by economists for being too concentrated on one single economic sector. Recognizing that the economy is composed of many interdependent sectors, food insecurity cannot be viewed as a problem that is exclusive to the agricultural/food sector. That is why the first attempt to broaden the discipline was actually an attempt to shift the analysis towards national economies as a whole. In a market-economy, a stronger economic system can allow the import of goods such as food. This macro-economic framework was also more consistent with old and very influential economic theories such as Ricardo’s comparative advantages, according to which each country has to specialize in the sector in which it has an advantage, given by the abundance of a specific productive asset or by lower costs of production. This whole approach might be considered a way to include the national means of increasing aggregate food availability within the food security framework (Burchi and De Muro, 2016). The approach is very similar to the one traditionally used to assess poverty. While poverty was conceived as a lack of sufficient income needed to buy a bundle of goods to guarantee the survival (or minimum standard of living) of a person, food insecurity is implicitly assumed to be a sub-category of poverty (often referred to as “food poverty”), i.e., lack of sufficient income needed to buy the amount of food required for survival at the given conditions (Sibrianet *al.*, 2007; Sibrian, 2008). In particular, different foods are converted into calories: If people’s calorie availability is lower than a threshold identified by international nutritionists, they are considered to be food insecure. Through household surveys providing information on income, it is theoretically possible to estimate the amount of food consumed, given the assumption that poorer households use a larger proportion of their income to buy food. Food is, then, converted into calories: if household calorie availability is lower than the “required” minimum, some or all the members of that household are food insecure. The specific problem related to this method consists in the assumption of a given income-calorie elasticity.

According to the World Bank (2014) and Diirroet *al.* (2018), women constitute a significant proportion of Sub-Sahara African farmers and contribute most of the agricultural labour. However, the slow progress towards gender equality in the region implies that women face challenges in access to land, productive assets, credit, extension services, and input and output markets, which constrain agricultural productivity (World Bank, 2014; Debela, 2017; Mukasa *et al.*, 2017). In addition, women are adversely affected and vulnerable to conflicts and poverty (Botreau and Cohen, 2019). These challenges prevent women from exploring the existing and emerging agricultural and non-agricultural opportunities. These affect households and communities by exacerbating poverty, food insecurity, vulnerability, and gender inequality. Food and Agricultural Organization (FAO) echoes the importance of improvements in the agricultural sector in accelerating the momentum for food insecurity reduction in SSA. Nevertheless, this would remain elusive if the persistent gender inequality in the region is not addressed (Lutomia *et al.*, 2019).

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Doss (2017) also posited that in general, the arguments for targeting women can be grouped into two main strands. One strand focuses on the productive potential of women farmers. The claim is that women are heavily involved in agricultural production in the developing world—and especially in Africa—and that they have been left out of many development efforts. Thus, there are very high returns to targeting current investments to women—with these returns showing up as increased aggregate agricultural production and higher incomes for women. A second (and not mutually exclusive) line of argument posits that women represent an important class of beneficiaries of agricultural development efforts—and that their needs have frequently been neglected by programmes that focus on productivity increases.

New data has allowed us to challenge some myths about women in agriculture. Evidence for Africa (Doss *et al.*, 2015) and Asia (Kieran *et al.*, 2016) is inconsistent with a widely cited figure that women own only between 1% and 2% of the world's land, although they do own considerably less land than men. In the six African countries for which there is data, women provide 40% of the labour for crop agriculture, a lower figure than the 60% to 80% that is often cited (Palacios-Lopez *et al.*, 2015). Finally, no evidence supports the claim that women produce 60% to 80% of the world's food (Doss, 2017). Given women's responsibilities for household work, it would be surprising if they produced most of the food.

Gender differentials play dynamic roles in enhancing agricultural productivity and ensuring food security and their activities contribute substantially to poverty alleviation (Ayinde *et al.*, 2016). Rural women are key actors in food production, reducing food losses, increasing agricultural productivity, enhancing dietary diversity and the marketing of produce along agri-food value chains. In doing so, however, they continue to face significant social and economic discrimination as they all too often lack secure access to productive resources, finance, advisory services, markets, social protection, agricultural inputs and technological know-how. In addition, many rural women are the primary caretakers of their households, with significant consequences for their workloads and thus, for their productive capacity and overall well-being (FAO, 2020).

However, most of the past studies on food security focused on the macro level of food security (Quisumbing *et al.*, 1995; Delpeuchet *al.*, 1999; Smith and Haddad, 2000; Cogill, 2003; Olumakaiye and Ajayi, 2006; Doocy and Burnham, 2006). Only few micro level studies which analyzes household level food consumption exist (Guneseckara, 1999; Ekanayake *et al.*, 2003; Rathnayake and Weerahewa, 2003; Babatunde *et al.*, 2008; Kassie *et al.*, 2012), and very few studies have been designed to investigate the women's role (Adepojuet *al.*, 2015). There is paucity of data on gender role in food security in Kogi state with its different socio-cultural characteristics. Against this backdrop, this study aims to access the effects of gender-based roles on food security status of farm household in Kogi state. The specific objectives are to: analyze the food security status of farm households; identify gender-based roles in food security status of farm households; determine the effects of gender-based roles on food security status of farm households.

METHODOLOGY

Study Area

The study area chosen for this study is Kogi State. The State is in the north central geo-political zone of Nigeria. It is situated between latitudes 6°33'N and 8°44'N and longitudes 3°22'E and 7°49'E and has its capital in Lokoja. Kogi State has a total land mass of 28,313.53 sq. km and a

population of 3,278,487. It has about 172,000 farm families, 70% of this population lives in the rural areas and they are engaged in crop production and animal rearing (Kogi State Government, 2010). Kogi State is made up of 21 Local Government Areas. Its low land areas are extensively plain, alluvial and swampy. The main ethnic groups are Igala, Ebira, and Okun. Agriculture is the mainstay of the economy. There are many farm produce from the state notably coffee, cocoa, palm oil, cashews, groundnuts, maize, cassava, yam, rice and melon. Mineral resources include coal, limestone, iron, petroleum and tin. The state is home to the largest iron and steel industry in Nigeria known as Ajaokuta Steel Company Limited and one of the largest cement factories in Africa, the Obajana Cement Factory. The map of the state is shown on Figure 1.

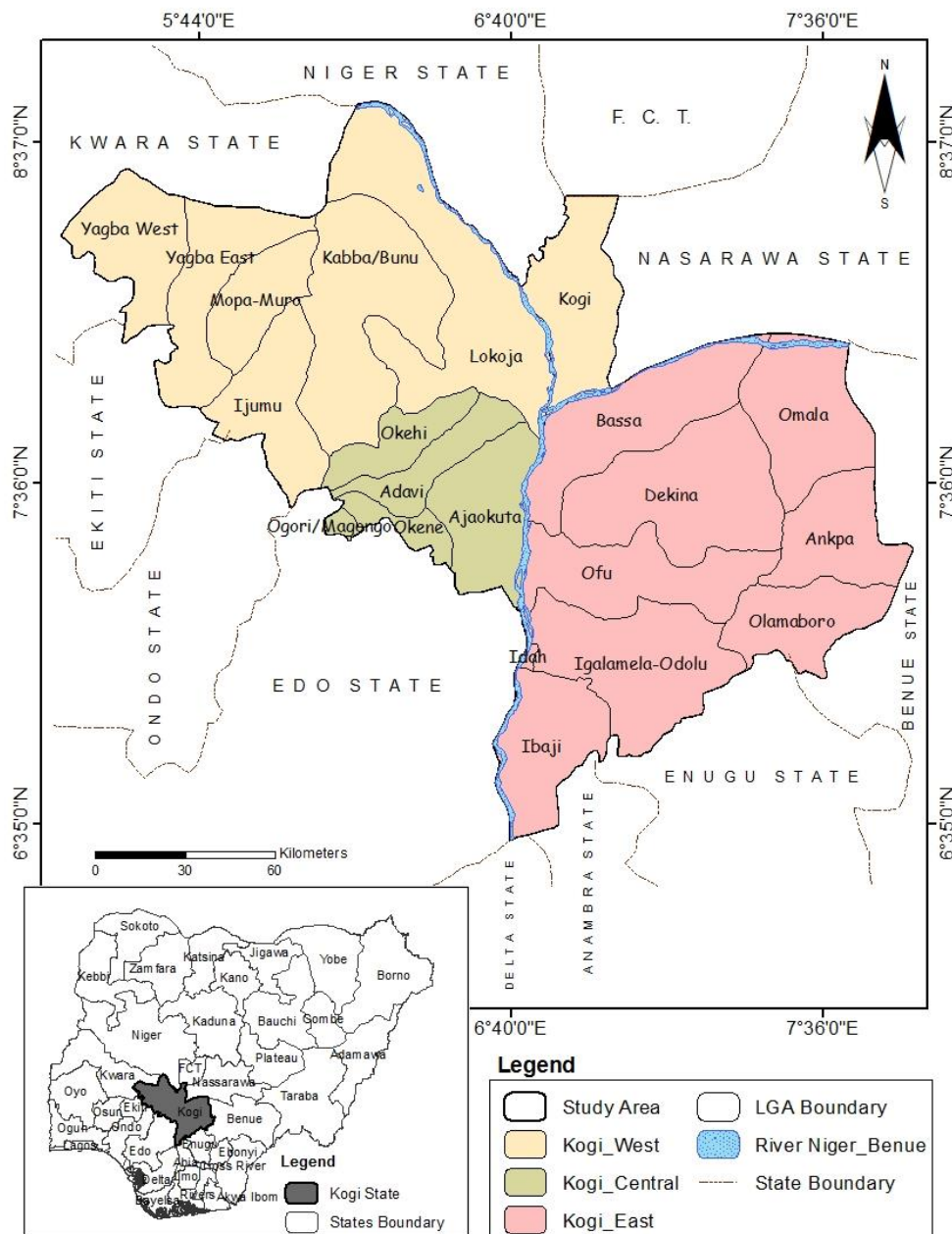


Figure 1: Map of Kogi State Showing the Senatorial Districts and the Local Government Areas (Adapted from Sadiq *et al.*, 2013)

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Sampling Procedure

A three-stage sampling technique was employed for this study. The first stage involved the random selection of five local government areas (LGAs) from the state. The second stage involves the random selection of two villages from each of the five selected LGAs to make a total of ten villages, while the final stage involved the selection of twelve households using simple random sampling technique from each of the ten villages selected, giving a total of 120 households. The instrument for data collection used in this study is questionnaire.

Analytical Tools

Food Security Index

To measure household food security, a food security index was constructed. These involved two steps: recommendation and aggregation. The recommendation stage involved defining the minimum level of nutrition necessary to maintain healthy living – (the food security line) for the population understudy, below which households are classified as food insecure. The calorie availability for the farm households was derived from the nutrient content of self-produced and purchased food items. A daily recommendation level of 2470 kcal per capital per day was adopted as the food security line for the study (Food and Agriculture Organization/World Agriculture Organization, 2019), below which households were classified as food-insecure and equal or above which households were classified as food secure. Aggregation, on the other hand, involved derivation of food security statistics for the households. Daily per capita calorie consumption was estimated by dividing the estimated daily calorie supply to the household by size. Availability was estimated using food nutrient composition. The food security line is used in this study after converting all household members into adult equivalent unit. The formula for converting all household members into adult equivalent is as follows:

$$ADEQ = (A + 0.5C)^{0.9} \dots\dots\dots(1)$$

Where, ADEQ = Adult equivalent unit,

A = Number of adults above the age of 15 years,

C = Number of children below the age of 15 years in a household.

For the purpose of this study, a household is defined as a group of people living together and eating from the same pot for six months or more.

Foster-Greer-Thorbecke (FGT) procedure was used to know the depth, incidence, and severity of food insecurity of selected households.

$$P_{\alpha} = \frac{1}{N} \sum_{i=1}^Q \left(\frac{Z - Y_i}{Z} \right)^{\alpha} \dots\dots\dots(2)$$

Where,

P_{α} Measures the depth, incidence, and severity of food insecurity

N = Total number of households

Q = the number of food-insecure households

Z = recommended daily calorie representing a food poverty line

Y_i = the actual daily calorie intake of household

The Headcount ratio (H) is a measure of food security status and it is defined as:

$$H = \frac{M}{N} \dots\dots\dots(3)$$

Where, M = the number of the food-insecure

N = Total number of households

Food Insecurity Gap: this is a measure of the depth of food insecurity and it is expressed as:

$$FIG_i = \frac{TCR_n - TCC_n}{TCR_n} \dots\dots\dots(4)$$

Where, FIG_i= Food insecurity gap of ith food insecure household

TCC_i= Total calorie consumption by ith food insecure household

TCR_i= Total calorie requirement for ith food insecure household

The total food insecurity gap or shortfall index is expressed as:

$$TFIG = \sum \frac{TCR_n - TCC_n}{\frac{TCR_n}{FIH}} \dots\dots\dots(5)$$

Square food insecure Gap: this indicate the severity of food insecurity among the food insecure household and it is given as:

$$SFIG = \sum \frac{(FIG_n)^2}{FIH} \dots\dots\dots(6)$$

Logistic Regression Analysis

In statistics, regression analysis consists of techniques for modeling the relationship between a dependent variable (also called response variable) and one or more independent variables (also known as explanatory variables or predictors). It is more suitable to apply when the relationship between the variables is linear. The general model is given below

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + U_i \dots\dots\dots(7)$$

Where,

Z_i = Food security status (1, for food secure households; 0, otherwise)

X₁ = Amount of credit accessed (Naira)

X₂ = Per capita income (Naira)

X₃ = Membership of cooperative society (Dummy: 1 = yes; 0, otherwise)

X₄ = Farm size (hectare)

X₅ = Household size (Adult Equivalent)

X₆ = Gender of household head (Dummy: 1 = male; 0, otherwise)

X₇ = Number of years household head spent in school (Numbers)

U_i= Error term

RESULTS AND DISCUSSION

This section presents the result and discussion of the major findings in the study.

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Socio-Economic Characteristics of the Respondents

The socio-economic status of the households revealed that 78.3% of the household heads are still in their prime age of less than 60 years of age. 39.2% of the households are female headed with the remaining being headed by males. 56.7% are married while others are single or widowed. The household size distribution shows a 57.5% of the households had less than 10 members (Table 1).

Table 1: Socio-Economic Characteristics of the Respondent

Age group	Frequency	Percent
<20	1	.8
21 – 25	42	35.0
26 – 30	52	43.3
31 – 35	16	13.3
36 – 40	1	.8
41 above	8	6.7
Total	120	100.0
Gender of Household head	Frequency	Percent
Female	47	39.2
Male	73	60.8
Total	120	100.0
Marital Status	Frequency	Percent
Single	2	1.6
Married	68	56.7
Widow	50	41.7
Total	120	100.0
Household Size	Frequency	Percent
1-5	23	19.2
6-10	46	38.3
11-15	30	25.0
16-20	20	16.7
21-25	1	.8
Total	120	100.0
Farming Experience	Frequency	Percent
0-5	93	77.5
6-10	24	20.0
11-15	3	2.5
Total	120	100.0
Educational Status	Frequency	Percent
No formal education	3	2.5
Primary	4	3.3
Secondary	8	6.7
Tertiary	105	87.5
Total	120	100.0
Membership of Agricultural Association	Frequency	Percent
Yes	56	46.7
No	64	53.3
Total	120	100.0

The educational status of the respondents revealed that only 12.5% of household heads have been in school up to secondary level. While 46.7% of the heads are registered members of cooperative or agricultural association, others are not. This might have implication on their access to information, among others.

Food Security Status of the Household Respondents

Table 2 shows the calorie intake per adult equivalent per day in the study area. Given the household food security daily recommendation of 2470 kcal/AE/day (FAO, 2006), about 65% of the households in the study area were food insecure and about 35% of the household were food secure.

Table 2: Calorie Intake Distribution of Rural Households

Calorie intake (kcal/AE/day)	Frequency	Percentage
1000-1734	65	54.17
1735-2469	13	10.83
>2470	42	35.0
Total	120	100

Source: Author's Computations, 2019

Determinant of Food Security Status among the Households.

The result of the logistic regression model shows that fitted model is statically significant with the log likelihood factor of 118.691 and Chi-square of 59.19 ($p < 0.05$). The R^2 of 0.61 implies that 61% of the variable is explained by the independent variables. From the result presented in Table 3, access to credit, cooperative membership, and household size are statically significant variables that influence rural household food security in the study area at 10%, 5%, and 1% value respectively. Household size has a negative relationship with food security while access to credit and cooperative membership have positive effect on rural household food security. This result is in consonance with findings of (Babatunde *et al.*, 2008; Kassie *et al.*, 2012).

Table 3: Determinant of Food Security Status among the Households.

Variables	B	S.E	Wald	Sig.	Exp (B)
Constant	0.988	1.497	0.603	0.453	2.453
Access to credit	0.616*	0.340	2.223	0.068	0.541
Total per capital income	0.000	0.000	1.673	0.163	1.000
Cooperative membership	0.219**	0.470	3.435	0.0071	1.167
Farm size	0.156	0.492	30.392	0.056	0.615
Household size in AE	-0.079***	0.092	0.311	0.000	1.056
Gender of household head	-0.073	0.029	0.108	0.931	0.963
Education of Hh (years)	0.012	0.022	2.81	0.651	0.326

Disaggregated Effect of Gender-Based Roles on Farming Household Food Security Status

Table 4 present the results of disaggregation of gender-based roles on farming households' food security status. The women's contribution to income and age of household head are significant, having p-values less than 10%. The result is in consonance with the report that gender have a

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significant relationship with household food security (Levin *et al.*, 1999; Ekanayake *et al.*, 2003; Olumokaiye and Ajayi, 2006; Babatunde *et al.*, 2008; Kassie *et al.*, 2012).

Table 4: Effects of Gender-Based Roles on Farm Households' Food Security Status

	B	Std. Error	Beta	T	Sig.
(Constant)	1.872	.515		3.633	.000
Man's income contribution	.265	.130	.184	2.035	.064
Woman's income contribution	-.102	.114	-.083	-.896	.002
Gender of household head	.433	.155	.268	2.789	.061
Age of household head	-.003	.068	-.004	-.040	.008
Household size	.038	.071	.049	.538	.592

Source: Authors' Computation, 2019

CONCLUSION AND RECOMMENDATIONS

This paper examines gender role on food security among rural farm households in Kogi state, Nigeria, given the importance placed on gender issue in the sustainable development goals globally and as a nation. In this paper, we specifically assessed the food security status of the farm households, identified the key determinants of food security status, then we went further to identify the gender roles in food security and we examined the effect of gender roles on food security status of the respondents. The data were collected from 120 sampled households using a well-structured questionnaire, while both descriptive and inferential statistics were used to analyze the data. The results obtained shows that about 65.0% of the households consumed less than 2470 kcal/AE/day, while 35.0% consumed at least 2470 kcal/AE/day. Access to credit, cooperative membership, and household size are statistically significant variables that are likely to influence rural households' food security status. Therefore, the study concludes that gender-based roles have effect on farm households' food security status. Hence, it was recommended that gender should be given priority when food policies are formulated and should be mainstreamed into all government policies targeted at ensuring food security among rural households.

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COMPARATIVE MORPHOLOGY AND pH OF THE ALIMENTARY TRACT IN *Archachatina marginata* AND *Achatina achatina*

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ABSTRACT

A study was carried out to investigate the comparative morphology and pH of the gut in the Giant African Land Snails, in *Archachatina marginata* and *Achatina achatina* respectively. The crop is long, distended and less fleshy with reddish brown coloured juice (5.8 ml volume) in *A. marginata*, while it is short, compact and fleshy with greenish brown coloured juice (3.2 ml volume) in *A. achatina*. The digestive gland was heavier (17.36 vs. 15.74 g) in the latter than the former. The absolute weight of the crop in *A. marginata* was significantly ($p < 0.05$) higher than in *A. Achatina*, however, the absolute and relative weights of the digestive gland in *A. achatina* was significantly ($p < 0.05$) higher than in *A. marginata*. There were significant ($p < 0.05$) differences in linear measurements of the salivary gland and crop for absolute values and the salivary gland, crop, stomach and digestive gland for relative values. *Archachatina marginata* had significantly ($p < 0.05$) longer salivary gland and crop than *Achatina achatina* for absolute length values and significantly ($p < 0.05$) longer salivary gland, crop and digestive gland for relative length values. However, the relative stomach length in *A. achatina* was significantly ($p < 0.05$) longer than in *A. marginata*. The gut pH was more acidic in the crop (5.38 and 4.83) than in the mouth (6.93 and 6.82) where it tended towards neutrality in *A. marginata* and *A. achatina* respectively. The pH profiles in the two species, decreased by 1.65 and 1.99 from the mouth to the crop while it increased by 1.46 and 1.97 from the crop to the distal digestive gland in *A. marginata* and *A. achatina* respectively. In the herbivorous snails, the pH along the gut regions remained acidic all through (5.38 – 6.93 and 4.83 – 6.82) in *A. marginata* and *A. achatina* respectively, confirming the herbivorous habits in these snail species. The longer gut and distended crop with higher volume of crop juice in *A. marginata*, implies its ability to store, utilize and digest more food materials than *A. achatina*. These results provide the basis for a better understanding of the physiology of the digestive processes in these snails.

Keywords: pH profile, Morphology, Gut length, Gut weight, *A. marginata*, *A. achatina*

INTRODUCTION

Snail farming is fast gaining popularity all around the globe including the continent of Africa. Snail species are many with new species being discovered and others being rediscovered (Thach, 2015 and Schilthuizen, 2017). In West Africa, the commonly farmed snails are the giant African land snails. Captive rearing of the giant African land snails is profitable agri-business due to the low capital inputs and numerous benefits of the snails. Snails are known for their production of high-quality meat, health benefits, medicinal and cosmetic use of the haemolymph and mucin, use of the shell and offal, with profitable income from sale of snail meat and its products. In Nigeria, unlike what obtains for conventional and other mini livestock, there is yet to be any standard nutrient requirements to guide snail farmers in ration formulation for the giant African

land snails. To achieve this, many studies had been carried out using different feed materials to feed snails but no standard has been set. It is however imperative to first have a detailed understanding of the anatomy and physiology of digestion in the gastrointestinal tract of the giant African land snail.

The snail gut, like that of most animals, consists of an oesophagus leading from the mouth to the stomach followed by a long intestine ending in an anus (Martin *et al.*, 2011). Therefore, as is generally found in stylommatophorans the digestion process starts in the mouth and ends in the anus. The snail gut regions are involved in food reception, storage, digestion, nutrient absorption and faeces formation (Dimitriadis, 2001). Earlier studies showed that food is gathered into the mouth by movement of the radula over the tip of the Odontophore and by movement of the Odontophore itself (Mackenstedt and Markel, 1987). The function of the salivary gland is believed to be lubrication, thus assisting with the removal of food from the radula and its passage into the oesophagus. The digestive gland or the hepatopancreas of gastropod molluscs is the key organ for metabolism. It is the main source of production of digestive enzymes, and it is involved in absorption of nutrients, food storage and excretion (Baker, 2002). Hepatopancreas is also implicated in storage and excretion of inorganic reserves, lipids and carbohydrate metabolites (Zaraiet *al.*, 2011). Intestine length is determined by diet type in some animals and as such they balance nutritional needs to meet energy requirements through phenotype adjustment (Karasov and Douglas, 2013). Determination of morphological characteristic for the exploration of the spatial and trophic niche (Pagotto *et al.*, 2011) is necessary in identifying adaptive ecomorphological patterns due to selection. Giant land snails are well equipped with a wide range of digestive enzymes (Ademoluet *al.*, 2013) with earlier studies showing that land snails often eat plants high in protein and calcium nutrients (Omole *et al.*, 2011), and they also partake in leaf litter decomposition just like other invertebrates living on the soil (De Oliveira *et al.*, 2010).

As part of studies carried out to investigate the physiology of digestion in the giant African land snails, the morpho-anatomy and pH profile of alimentary tract in *A. marginata* and *A. achatina* were studied and compared. Little work of this kind has been carried out in the giant African land snails and in this study the gut anatomical structures and pH profile in the two species of giant African land snails were investigated.

MATERIALS AND METHODS

Experimental Animal

Adult snails (150-170 kg weight) of *A. marginata* species (20 snails) and *A. achatina* (20 snails) used in this study were obtained from local snail market. The snails were kept in clean, basket units of 45 x 20 x 21 cm, each containing 5 snails per basket for adequate spacing. Each snail was given adequate feed (Pawpaw leaves and fruits) and water (*ad libbitum*) and allowed to acclimate for 2 weeks prior to its use.

Morphoanatomy

Snails were aseptically dissected following the methods of Segun (1975) and identification of the gut regions was carried out. The organs of the alimentary tract were extracted to identify the regions of the gut, namely mouth, radula, buccal mass, anterior oesophagus, posterior oesophagus, crop, salivary gland, Stomach, small intestine, rectum, hepatopancreas and anus. Pictures of the overall view and pictures of individual digestive tract organ of the snail were taken using a digital camera.

Comparative Morphology and pH of *A. marginata* & *A. Achatina* Gut

Morphometric Data Collection

The measurements of the organs of the alimentary tract extracted were taken, length and width of the organs were measured by means of meter ruler, cotton thread, and vernier calliper, while the weights of each of the parts was determined using a sensitive scale (Ohaus Adventurer - 0.001 g sensitivity).

Determination of pH

The measurements of the gut pH were carried out using pH meter. The digestive tract of *A. marginata* and *A. achatina* were excised and cut into the gut regions after dissection. Individual gut regions were homogenized with the gastro-intestinal tract contents and an equal volume of phosphate buffer in a Potter homogenizer (Potter and Elvehjem, 1936) which was fitted with a Perspex pestle and surrounded by ice. The homogenate pH of the snail gut was determined using the pH meter.

Statistical analysis

Morphometric data were subjected to the pooled variance 't' test (Systat Inc., 2004) for comparison between species. pH data were subjected to analysis of variance (ANOVA) using the Systat Analytical Computer Package version 5.02 (Systat Inc., 2004) in a 2 x 11 factorial arrangement (2 snail specie x 11 gut regions) in 3 replicates. Significant means were separated using Turkey's highest significant difference (HSD).

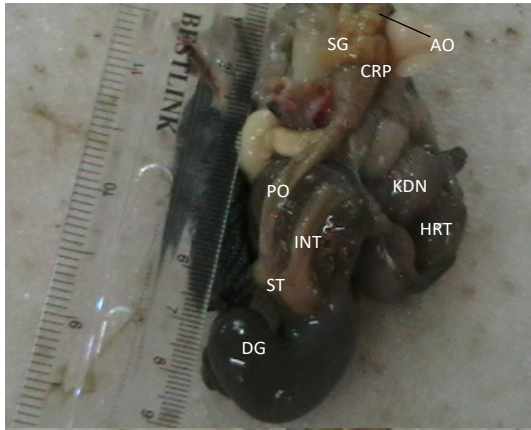
RESULTS

A general overview of the digestive tract (Plates 1A and 1B), a schematic diagram (Plate 2) representing the two species of GALS and specific views of individual digestive organs (Plate 3) showed that the digestive system of GALS consists of a mouth, a buccal mass, an anterior portion of the oesophagus, a pair of salivary glands with a pair of salivary ducts connecting the anterior portion of the gland to the dorsoposterior surface of the buccal mass, a crop, on the surface of which the pair of salivary glands are located, a posterior portion of the oesophagus, a stomach, an intestine, a digestive gland which connects to the stomach via a short duct and to the posterior portion of the oesophagus via a longer duct, and finally a rectum leading to an anus.

The Foregut: mouth, buccal mass, anterior oesophagus, crop and posterior oesophagus

It was observed that the mouth is located at the middle of the snail head and opens into the buccal mass. It is circular (anterior and ventral) when fully extended and surrounded by lips and a jaw which facilitates the extension of the snail's mouth when eating. The radula shape is a concave bend and inside the mouth on the anterior of the buccal mass. It is yellowish brown in *A. marginata* but reddish brown in *A. achatina*. It consists of rows of teeth which is sharp and scratchy to touch. The buccal mass (BM) follows immediately after, with its upper surface connected to the salivary glands by thin salivary ducts, and opens into the anterior oesophagus. The anterior oesophagus is a short tubular structure protruding from the posterior of the BM and on its posterior and ventral surfaces laid the elongated tubular salivary ducts linking the buccal cavity. The crop is thin walled, bulbous, highly distended and filled with reddish brown crop juice in *A. marginata* but in *A. achatina* the crop juice is dark greenish brown and the crop is less distended and thick walled. The mean volume of the crop juice (Figure 1) differs being 3.5ml and 5.8ml in *A. Achatina* and *A. marginata*. respectively. In *A. marginata* the crop is large and contains a higher crop juice volume compare to *A. achatina*.

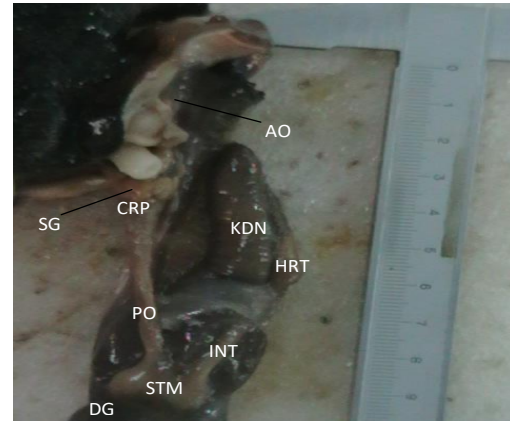
The crop, in the two snail species, connects the short anterior oesophagus to the long posterior oesophagus. The posterior oesophagus is a long tubular structure linking the posterior end of the crop to the stomach. It occupies about the middle of the snail body passing directly into the stomach, it connects to the digestive gland via digestive gland duct.



A. An overview of the digestive system of *A. marginata*

SG= Salivary gland, CRP= Crop, PO= posterior oesophagus, INT = Intestine, STM= stomach, KDN= Kidney, HRT= Heart, AO= Anterior Oesophagus, DG= Digestive gland.

Plate 1A: Overview of the Digestive System in *Archachatina marginata*



B. An overview of the digestive system of *A. achatina*

SG= Salivary gland, CRP= Crop, PO= posterior oesophagus, INT = Intestine, STM= stomach, KDN= Kidney, HRT= Heart, AO= Anterior Oesophagus, DG= Digestive gland.

Plate 1B: Overview of the Digestive System in *Achatina achatina*

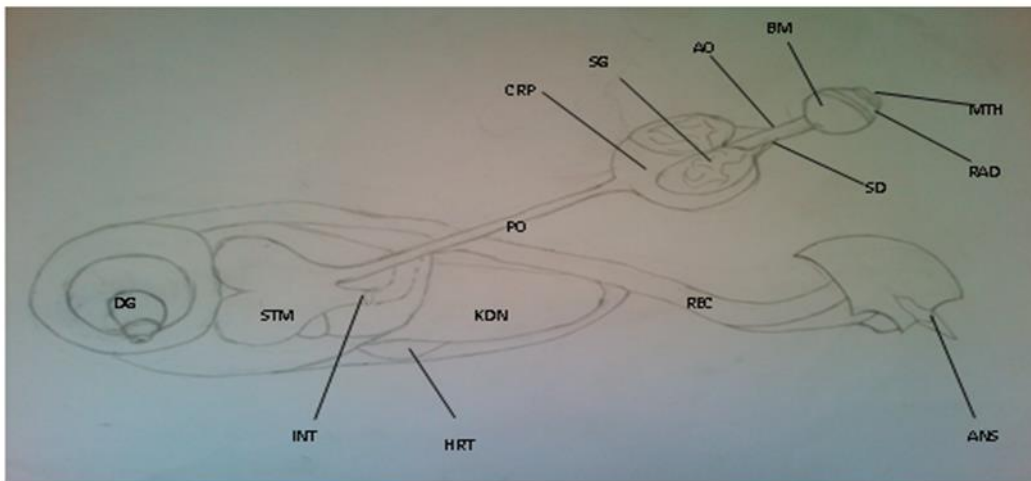


Plate 2: The schematic diagram of the alimentary tract of the Giant African Land Snails (GALS). Mouth = MTH, Radula = RAD, Buccal mass = BM, Anterior Oesophagus = AO, Crop covered with salivary gland = CRP, Paired salivary glands = SG, Salivary ducts = SD, Posterior Oesophagus = PO, Stomach = STM, Digestive gland = DG, Rectum = REC, Heart = HRT, Kidney= KDN, Anus = ANS. Scale= x0.25

Comparative Morphology and pH of *A. marginata* & *A. Achatina* Gut

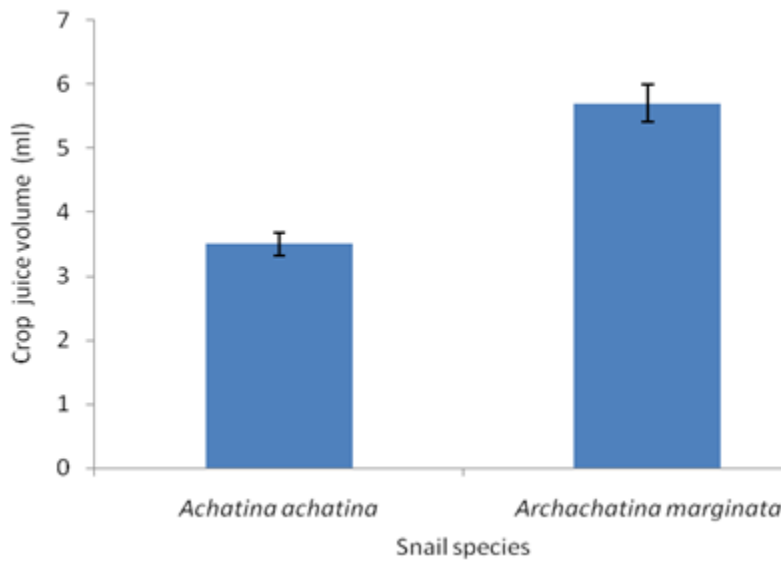


Figure 1: Crop juice volume in *Archachatina marginata* and *Achatina achatina*

The Midgut: stomach and intestine

The stomach is a muscular, bi-lobed and u-shaped structure located in the posterior of the snail body. It is slightly embedded on the anterior portion of the digestive gland, facing the kidney and links both the posterior oesophagus anteriorly and the intestine posteriorly. The stomach connects to the digestive gland via a very short digestive gland duct in the mid portion of the gastric sac. The intestine is a thin long tube elongating from the stomach to the rectum. The intestine follows a path toward the left side of the stomach penetrating the digestive gland to form a c-shaped boundary between the digestive gland and the kidney before linking the thick cartilaginous rectum. The intestine is deeply embedded in the tissues of the digestive gland in *A. marginata* while the depth is shallower in *A. achatina*.

The Hindgut: rectum and anus

The rectum is located in the right mid-section of the snail's body cavity. The diameter is wider than the intestine and continues to widen slightly as it moves to open into the anus. The hepatopancreas is linked by a short duct to the stomach and a longer duct to the posterior oesophagus. It is the largest organ of the digestive system. It forms spiral curves that is widest at the anterior end and thins at the posterior end. The anus is located at the right mid ventral part of the snail body. The rectum opens into the anus and it contains an anal sphincter and a wide anal opening.

The Appendages: salivary and digestive glands

The salivary glands are a flat paired structure consisting of lobes. It is leaf-shaped and irregular, yellowish and with thick lobes. The salivary glands lace the entire surface of the crop; covering the ventral and dorsal surfaces and sides of the crop. The entire lobed structure is connected by short tubes linking the entire gland structure and also penetrating the crop. The salivary gland is also linked to the buccal mass by the elongated salivary ducts. The digestive gland / hepatopancreas is linked by a short duct to the stomach and a longer duct to the posterior oesophagus. It is the largest organ of the digestive system and even the entire snail body. It forms

spiral curves that is widest at the anterior end and thins at the posterior end. The summary of the features of the digestive system in *A. marginata* and *A. achatina* are as outlined in Table 1.

Morphometry

The absolute and relative weights of the different digestive tract organ of the GALS are presented in Table 2. There were similarities ($p>0.05$) in the weights of the different organs of the snail species, except that of the buccal mass, crop (absolute weight) and digestive gland, which showed differences ($p<0.05$) in weights. The absolute weight of the crop in *A. marginata* was higher ($p<0.05$) than in *A. achatina*, while the absolute and relative weights of the digestive gland in *A. achatina* was higher ($p<0.05$) than in *A. marginata*.

Tables 3 showed linear measurements (absolute and relative linear measurements, respectively) of the snail digestive tract organs. There were differences ($p<0.05$) in linear measurements of the salivary gland and crop for absolute values and the salivary gland, crop, stomach and digestive gland for relative values. *A. marginata* had longer ($p<0.05$) salivary gland and crop than *A. achatina* for absolute length values and longer ($p<0.05$) salivary gland, crop and digestive gland for relative length values. However, the relative stomach length in *A. achatina* was longer ($P<0.05$) than in *A. marginata*. The lengths (absolute and relative) of all other organs of the digestive tract were not affected ($p>0.05$) by species differences of GALS.

Table 4 shows the mean values of width measurements of the organs of the snail digestive tract. There were no differences ($p>0.05$) between snail species in width of organs of the digestive tract, with the exception of the buccal mass and crop. *A. marginata* had higher ($p<0.05$) width than *A. achatina*. The width of all other organs of the digestive tract were not affected ($p>0.05$) by gut region in both species of GALS.

Table 2: Mean Absolute (g) and Relative Weights (%) of Digestive Tract Organ of *Archachartina marginata* (AM) and *Achatina achatina* (AA)

Gut region	Absolute weight (g)		Relative weight (%)	
	AA	AM	AM	AA
Mouth	0.33 ± 0.06	0.66 ± 0.29	0.14 ± 0.03	0.40 ± 0.17
Radula	0.02 ± 0.00	0.02 ± 0.01	0.01 ± 0.00	0.01 ± 0.00
Buccal mass	1.22 ± 0.25 ^a	0.71 ± 0.06 ^b	0.52 ± 0.09	0.43 ± 0.03
Anterior oesophagus	0.13 ± 0.02	0.10 ± 0.03	0.05 ± 0.01	0.06 ± 0.02
Salivary gland	0.64 ± 0.14	0.45 ± 0.02	0.27 ± 0.05	0.27 ± 0.01
Crop	1.44 ± 0.39 ^a	0.69 ± 0.04 ^b	0.62 ± 0.18	0.42 ± 0.03
Posterior oesophagus	0.59 ± 0.30	0.32 ± 0.06	0.25 ± 0.12	0.19 ± 0.03
Stomach	1.30 ± 0.22	1.18 ± 0.30	0.56 ± 0.11	0.71 ± 0.19
Intestine	0.40 ± 0.02	0.34 ± 0.11	0.17 ± 0.01	0.21 ± 0.065
Digestive gland	15.74 ± 0.02 ^b	17.36 ± 2.11 ^a	6.73 ± 0.25 ^b	10.46 ± 1.43 ^a
Rectum	2.78 ± 0.49	2.06 ± 0.72	1.19 ± 0.20	1.25 ± 0.45
Anus	2.10 ± 0.83	1.7 ± 0.72	0.90 ± 0.38	1.05 ± 0.16
Whole gut	31.32 ± 1.19	25.59 ± 1.74	13.39 ± 0.95	15.43 ± 0.84
Live weight	233.89 ± 5.18 ^a	166.23 ± 2.57 ^b		

^{a, b}Means with different superscripts in the same row differ significantly ($p<0.05$) for absolute and relative weights independently. Values are given as mean ± SEM

Comparative Morphology and pH of *A. marginata* & *A. Achatina* Gut



Plate 3: The Organs of the Alimentary Tract in *A. marginata* (1 A-D) and *A. achatina* (2 A-D).

Radula = RAD, Mouth = M, Buccal mass = BM, Anterior Oesophagus = AO, Crop covered with salivary gland = CRP, Paired salivary glands = SG, Posterior Oesophagus = PO, A-D: Scale= x0.25



Plate 4: The Organs of the Alimentary Tract in *A. marginata* (1A-C) and *A. achatina* (2A-C).

Paired salivary glands = SG, Paired salivary ducts = SD, Posterior Oesophagus = PO, Stomach = STM, Intestine = INT, Hepatopancreas/Digestive gland = DG, Rectum = REC, Anus = ANS. A-C: Scale= x0.25

Comparative Morphology and pH of *A. marginata* & *A. Achatina* Gut

Table 1: Summary of the Features of the Digestive System of *A. marginata* (AM) and *A. achatina* (AA)

Organ	Position in snail body	Colour and shape
Mouth	Anteriorly ventral on the head with lips and radula	Dark brown sometimes with a patch of light brown in AM. Circular when fully Protruded.
Radula	Inside the mouth and anteriorly on the BM	Concave shape. Yellowish brown in AM while Reddish brown in AA
Buccal (BM)	Anterior body portion.	Cream and Pear -shaped
Anterior Oesophagus	Arises from dorso posterior surface of the buccal mass. It is short with the salivary duct wrapped round it	Light brown, Elongated and tubular
Crop	Posterior body part, between anterior and posterior oesophagus. It is slightly distended and thick walled in AM but thin walled in AA	Spherical, Reddish brown when filled with crop juice in AM while Brown even when filled with crop juice
Posterior oesophagus	Dorsal mid-body section. It is a long tube linking the crop to the stomach	Light brown Elongated and tubular
Stomach	Posterior body portion and embedded on the surface of the anterior portion of the DG. It is tough, thick and muscular	Cream Bi-lobed and thick walled
intestine	Anterior portion is embedded in DG (slightly in AM but deeply in AA), forms a c-shaped curve along the boundary between the kidney and DG. It is thin walled and long	Cream, elongated and tube
Digestive gland (DG)	Dorsal body portion. It contains tubules and connecting ducts linked to the posterior oesophagus and stomach.	Spiral shape. Dark in AM while Dark brown in AA
Salivary glands	Covers the entire width and $\frac{3}{4}$ length of the bulbous crop. Contains several lobes connected by thin ducts to the buccal mass and crop.	Thin, irregular, flat and leaf-shaped. Cream in AM while Yellow in AA
Rectum	Right mid body section, with a wider diameter than the intestine	White, elongated and thick cartilaginous tube
Anus	Right middle ventral body section. The opening is wide	Slightly curved. Dark in AM while Reddish brown in AA

Table 3: Mean absolute (cm) and relative linear measurements (%) of digestive tract organ of *Archachartina marginata*(AM) and *Achatina achatina* (AA)

Gut region	Absolute measurements (cm)		Relative measurements (%)	
	AA	AM	AM	AA
Mouth	0.58 ± 0.45	0.41 ± 0.25	2.08 ± 1.34	1.85 ± 1.08
Radula	0.90 ± 0.10	0.60 ± 0.44	3.44 ± 0.77	2.65 ± 1.89
Buccal mass	1.13 ± 0.31	0.85 ± 0.15	4.21 ± 0.75	3.84 ± 0.82
Anterior oesophagus	0.80 ± 0.00	0.85 ± 0.25	3.03 ± 0.36	3.85 ± 1.28
Salivary gland	5.60 ± 1.00 ^a	2.50 ± 0.20 ^b	20.94 ± 1.47 ^a	11.27 ± 1.33 ^b
Crop	5.35 ± 0.75 ^a	2.70 ± 0.36 ^b	20.07 ± 0.79 ^a	12.18 ± 2.01 ^b
Posterior oesophagus	3.50 ± 0.40	3.18 ± 0.48	13.15 ± 0.41	14.32 ± 2.15
Stomach	1.10 ± 0.10	1.15 ± 0.13	4.14 ± 0.16 ^b	5.16 ± 0.39 ^a
Intestine	5.60 ± 0.50	5.08 ± 1.03	21.09 ± 0.86	22.89 ± 4.68
Digestive gland	14.30 ± 1.70	10.38 ± 2.09	54.72 ± 12.71 ^a	46.72 ± 9.29 ^b
Rectum	7.02 ± 1.37	7.28 ± 1.79	26.21 ± 2.05	32.65 ± 7.22
Anus	0.65 ± 0.35	0.42 ± 0.20	2.57 ± 1.60	1.86 ± 0.85
Whole gut length	26.63 ± 3.30 ^a	22.25 ± 0.91 ^b		

^{a,b} Means with different superscripts in the same row differ significantly (P<0.05) for absolute and relative linear measurements independently. Values are given as mean ± SEM

Table 4: Mean Width (cm) of Digestive tract organs of *A. marginata* and *A. achatina*

Gut region	AM	AA
Mouth	0.95 ± 0.21	0.58 ± 0.45
Radula	0.10 ± 0.00	0.23 ± 0.23
Buccal mass	1.00 ± 0.10 ^a	0.70 ± 0.10 ^b
Anterior oesophagus	0.20 ± 0.00	0.20 ± 0.17
Salivary gland	4.40 ± 0.90	1.80 ± 0.00
Crop	1.75 ± 0.15 ^a	0.80 ± 0.10 ^b
Posterior oesophagus	0.20 ± 0.00	0.13 ± 0.06
Stomach	1.10 ± 0.10	1.05 ± 0.13
Intestine	0.17 ± 0.05	0.17 ± 0.06
Digestive gland	2.67 ± 0.12	2.55 ± 0.22
Rectum	0.40 ± 0.10	0.43 ± 0.06
Anus	2.10 ± 0.20	1.87 ± 0.25

^{a,b} Means with different superscripts in the same row differ significantly (P<0.05) Values are given as mean ± SEM

pH of the Alimentary Tract in GALS

The pH measurement of the different regions of the digestive tract of GALS is shown in Table 5 and Table 6. The highest pH level was recorded in the mouth, foregut region, (6.93 and 6.82 for *A. marginata* and *A. achatina* respectively). *A. marginata* mouth is however less acidic than *A. Achatina* mouth, with the mouth pH tending towards neutrality in both species. The most acidic region of the foregut is the salivary gland in *A. Achatina* while it is the buccal mass in *A. marginata*. The lowest pH was found in the crop for the mid gut (4.83 and 5.38 for *A. achatina* and *A. marginata* respectively). *A. achatina* crop juice is more acidic than *A. marginata* crop juice. pH was higher (p<0.05) for *A. marginata* than *A. achatina* in all regions of the mid gut. Within both species anterior oesophagus had a higher (p<0.05) pH than other regions of the mid gut except the crop.

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The pH profiles in the two species, decreased by 1.65 and 1.99 from the mouth to the crop while it increased by 1.46 and 1.97 from the crop to the digestive gland in *A. marginata* and *A. achatina* respectively. The pH along the gut regions remained acidic all through (5.38 – 6.93 and 4.83 – 6.82) in *A. marginata* and *A. achatina* respectively. There was a higher ($p < 0.05$) intestinal pH in *A. marginata* than in *A. achatina*. In both species digestive gland had a higher ($p < 0.05$) pH than other regions of the hindgut. The pH measurements of the whole gut for the two species of GALS (*A. marginata* and *A. achatina*) were different ($p < 0.05$) from each other, gut pH for *A. marginata* species, was higher ($p < 0.05$) than that of *A. achatina*. However, on the basis of gut region division there were no differences ($p > 0.05$) in the pH values of *A. marginata* and *A. achatina* species based on gut regions i.e., the pH of the fore- mid- and hind-gut regions were not significantly different.

Table 5: Effect of Snail Species and Gut Region on pH Profile of the Alimentary Tract of GALS

Gut region	AM	AA
Anterior/Foregut		
Mouth	6.93 ± 0.02^a	6.82 ± 0.00^b
Buccal mass	6.34 ± 0.02	6.46 ± 0.01
Anterior oesophagus	6.67 ± 0.01^a	6.24 ± 0.22^b
Crop	6.51 ± 0.18^a	5.84 ± 0.12^b
Crop juice	5.38 ± 0.17^a	4.83 ± 0.08^b
Posterior oesophagus	6.00 ± 0.19^a	5.85 ± 0.01^b
Middle/Midgut		
Stomach	6.03 ± 0.28^a	5.98 ± 0.10^b
Intestine	6.75 ± 0.23^a	6.16 ± 0.04^b
Posterior/Hindgut		
Rectum	6.53 ± 0.04^a	6.54 ± 0.17^b
Appendages		
Salivary gland	6.53 ± 0.04^a	6.23 ± 0.08^b
Digestive gland	6.84 ± 0.09	6.80 ± 0.10

Table 6: Effect of Snail Species on pH Profile of the Major Parts of the Alimentary Tract of GALS

Gut region	AM	AA
Whole gut	6.41 ± 0.09^a	6.16 ± 0.10^b
Anterior/Foregut	6.60 ± 0.095	6.50 ± 0.095
Middle/Midgut	6.12 ± 0.095	5.75 ± 0.095
Posterior/Hindgut	6.70 ± 0.095	6.50 ± 0.095

DISCUSSION

In this study, the structural division of the snail's digestive tract into three major sections namely: foregut, midgut and hindgut, were similar to those reported in other studies (Nation, 2004; Lobo-da-Cunha et al., 2010a and 2010b; Martinez-Pereira *et al* 2013; De Oliveira and Cônsoli, 2020). The salivary and digestive glands are considered to be appendages of the snail digestive tract in agreement with earlier authors (Lobo-da-Cunha et al., 2010a and 2010b). The mouth in the two species is round, extensible thick lipped organ for picking up food materials; Authors have described snail mouth as crescentic slit (Sreenivasan, 1995) or a round opening Segun (1975). In this study it was observed that the radula helps GALS to hold, tear and cut food materials to smaller pieces corroborating the findings of Hanson (2020) that the radula can be used to cut food of larger size, however carnivorous species use it on their prey (Kantor and Puillandre, 2012). The number of the row of teeth were not ascertained in this study, it was however reported in earlier studies that the number of teeth in one transverse row as well as the number of rows is variable based on snail species Rumi *et al.* (2017), and Krings *et al.* (2019). In the two species of study, buccal mass is structurally similar in form and size and it has a number of protractor and retractor muscles which helps to move the radula, thereby enhancing the mechanism of feeding. An earlier study (Neustadter *et al.*, 2007) revealed that in species like *Aplysia californica*, the buccal mass is suspended within the head by thin extrinsic muscles that facilitate rotation of the entire buccal mass during feeding thereby combining protraction and retraction with opening and closing in order to carry out the action of biting, swallowing and rejection.

The structure of the anterior oesophagus in GALS is similar to that of other snails possessing this structure. Sreenivasan (1995) reported that the anterior oesophagus is a short, thick-walled tube found in most gastropods. The crop seems to be the largest part of the foregut which stores and initially digests food materials. The larger and more distended structure of the crop with a higher crop juice volume in *A. marginata* species compared to *A. achatina* may be an adaptation for uncertain food supply, and when the food is available, a larger amount can be consumed and effectively digested per time. Charrier and Brune (2003) described the crop in terrestrial snails as enlarged, ectodermal sac surrounded by a pair of salivary glands. The posterior oesophagus tube opens unto the stomach, functioning to conduct and digest food materials in the two species of GALS. The u-shaped, thick-walled, muscular and bi-lobed stomach in both species of GALS is similar to earlier reports describing the stomach as thick-walled and muscular in euthyneuran mollusks, cylindrical in Cymbulia, bilobed in Lanx (Ghose, 1963), two plates in Onchidella (Fretter, 1943), and globular projections in Limnaea (Carriker, 1946). This study revealed that the intestine lies deeply imbedded in the anterior portion of the digestive gland in *A. marginata* but slightly imbedded in the anterior portion of the digestive gland in *A. achatina* in contrast to reports by Ghose, (1963) that the intestine is fully embedded in the digestive gland in *A. achatina*. In this study the tube-like rectum is thick walled in both species of GALS contrasting the report of Ghose, (1963) that the rectum is thin walled in *A. achatina*. The rectum links the exterior through the anus which opens beside the pneumostome, just behind the head in GALS as was also by Segun, (1975).

In this study the anterior lobe of the digestive gland opens into the crop and stomach in *Archachatina* and *Achatina* species via two digestive gland ducts. The longer duct opens into the

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posterior oesophagus linking the crop while the shorter duct opens into the stomach. This study corroborates the report of Ghose (1961), Charrier (1990) and Dar *et al.* (2017), that in land snail's digestive gland ducts open into two different sections of the gut, one opens in the stomach and the other in the crop. The discharge of the secretion of the digestive gland in the crop possibly accelerates the process of digestion, since the food is partly digested before it reaches the stomach. Also, saliva is mixed with the food in the buccal cavity, so digestion actually starts from there as reported by Dar *et al.* (2017). The digestive gland is heavier in *A. achatina* than in *A. marginata*. The reason for the heavier but shorter digestive gland in *A. achatina* is not well understood. However, the less heavy but longer digestive gland in *A. marginata* is indicative of its capacity for production of more crop juice, digestion and absorption of food materials and nutrients. The digestive gland in snails is very large and its secretion is conveyed to the stomach either by one or more digestive ducts, where the final stages of digestion take place (Carriker, 1946; Creek, 1953; Ghose, 1963; Lobo-da-Cunha, 2000). The digestive gland is involved in the extracellular and intracellular digestion of food. It serves other functions such as storage of lipids, glycogen and minerals; it is also the main site of nutrient absorption and plays a major role in detoxification (Nelson and Morton, 1979; Morton, 1983; Beeby and Richmond, 1988; Henry *et al.*, 1991). Moreover, in some animal species it also stores secondary metabolites sequestered from algae, which may be involved in the chemical defense system of these animals (Pennings, 1994).

Gut Morphometric

The gut represents the functional link between foraging (energy intake) and the energy available for survival, growth, and reproduction (Karasov, 1990; Secor, 2001). In this study, in terms of organ weight and length, the digestive gland had a higher value for both species of snails with *A. achatina* having a significantly heavier weight but shorter length than *A. marginata* in absolute and relative measures. The longer gut length of *A. marginata* may be indicative of the snail's ability to adapt to seasonal fluctuations in quantity and quality of food supplies. Earlier report showed that there is a strong relationship between intestinal tube length and diets in fish, such that they balance nutritional requirements against energetic cost by adjusting their phenotype (Wagner *et al.*, 2009). Also, many animal species change their gut size seasonally as a consequence of fluctuating resource quantity and quality (Stark, 1999; Naya *et al.*, 2009) for example, Eurasian perch developed longer guts when exposed to poorer quality food types both in the lab and in the wild (Olsson *et al.*, 2007). Animals cannot maintain a unique digestive system that is simultaneously adapted for every type of diet because different food types are absorbed through different biochemical pathways and have different processing times (Karasov and Martinez, 2007; Karasov *et al.*, 2011). Organisms need longer guts to digest lower quality food (e.g., fiber-rich) than higher quality food (e.g., protein-rich) (German and Horn, 2006; Wagner *et al.*, 2009). Buddington *et al.* (1997) proposed that herbivores may have adapted to having absorptive tissues distributed along long, thin intestinal tubes, in order to enhance diffusion and absorption. The digesta would encounter more gut surface and spend less time at each position in the gut thus maintaining a higher diffusion gradient between nutrients in the bolus and those being absorbed across the mucosa. Longer gut tube may ensure that membrane-bound transport molecules operate at maximal rates when their target molecules are available in high concentration. In addition, longer guts have higher surface area and allow a longer retention time of the food, consequently enhancing nutrient absorption (Sibly, 1981). The wider and longer

crop of *A. marginata* also suggests the ability to retain more crop juice produced by the digestive gland thus enhancing the digestive process within the snail.

Gut pH

Results of the present study showed that for the two species of herbivorous snails, the pH of the crop was the most acidic while the mouth pH is the least acidic, in the mouth the pH tended towards neutrality in both species. In general, *A. achatina* had a more acidic alimentary tract than *A. marginata* except at the buccal mass region of the gut. The pH profile gradient in the two species, decreased from the mouth to the crop but there after rises up unto to the distal digestive gland. In the herbivorous snails, the pH along the gut regions remained acidic all through, which may be due to the feeding habits of the snails and the type of gut micro flora present. The gut pH has implications on the bacteria flora type but not on the bacterial population within the gut microbial community (O'May *et al.*, 2005; Dar *et al.*, 2017). Oyeleke *et al.* (2012) reported that bacteria can also change the pH of the gut through fermentative reactions end products that affect the acid-base balance of the digestive tract. This study agrees with an earlier report (Walker *et al.*, 1996; Charrier *et al.*, 2006), that the pH of the crop is more acidic than the pH of the digestive gland. The lower crop pH may be attributed to the secretion of gut digestive enzymes and presence of food materials in the crop. Charrier and Brune (2003) documented a lower pH in the crop than in the distal intestine in gut pH of helicid snails. The gut of both snail species revealed an increase in pH along the gastrointestinal tract as found in reports of Charrier and Brune (2003).

CONCLUSION

The physiology of the digestive tract in the giant land snail is such that food material passes through the crop to the stomach while fine particles and soluble materials pass into the digestive gland; no food passes into the salivary glands, therefore the changes in pH that occurred in these organs were consistent with an effect of food material. The gastrointestinal tract is structurally similar in the two species of snail, starting in the mouth and ending in an anus. The longer and more distended crop in *A. marginata*, compared to *A. achatina*, implies its ability to, ingest, store, digest and utilize more food materials than *A. achatina*. These results provide the basis for a better understanding of the physiology of the digestive processes in these snails.

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ECONOMIC ANALYSIS OF IMPROVED VARIETY OF GROUNDNUT PRODUCTION IN NORTH-WESTERN NIGERIA

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ABSTRACT

This research was conducted to analyse the economics of improved groundnut seeds' production in North-Western, Nigeria. A multi-stage sampling technique was employed for this study. Data were collected from 125 producers of improved variety of groundnut seeds in Bunkure Local Government Area (LGA) of Kano State using well-structured questionnaire. The data collected were analysed using both descriptive and inferential statistics. The descriptive statistics result revealed that respondents were active, mostly males and that they were mostly literate. The result revealed that the marketing of improved variety of groundnut seeds was efficient and that the enterprise was considered viable. Age, household size, farm size and access to credit were the factors that influenced the net marketing margin to producers of improved groundnut seeds. The study recommends that adequate credit facilities should be made available and improved variety of groundnut seeds should be subsidized so that producers can be motivated to use and adopt them.

Keywords: Improved seeds, Groundnut, Marketing, Budgetary technique, Factors, Kano State

INTRODUCTION

Seed is a fundamental input in crop production (Chijioke and Uteh, 2018). They are first and foremost, the source of most food, at least of plant origin, and therefore have the greatest socio-economic benefit to human welfare of any known biological device. Seeds are very important because they carry the genetic information that controls the maximum attainable crop productivity, resistance to diseases, and tolerance to environmental stress factors such as drought (Bishaw, 2004; Cavatassiet *al.*, 2010). Though there are different seeds available worldwide, legume seeds such as groundnut (*Arachis hypogaea* L.) serve multiple functions in the rural economies of developing countries such as Nigeria, and are also valued by smallholders as source of income as well as sources of feed and protein rich fodder for livestock (John *et al.*, 2004; Okello *et al.*, 2010; Chinma *et al.*, 2014). Groundnuts in Nigeria is cultivated in different States of the country with Niger, Kano, Jigawa, Zamfara as the top producing States (Yusuf, 2008; National Agricultural Extension and Research Liaison Services [NAERLS], 2011), with the entire country producing an estimated 2,420,000 tonnes of groundnut in 2017 (Proshare, 2020). According to Idama (2000) and Hamidu *et al.* (2006), in Nigeria, many different products of commercial value (such as, paste, cake, oil, candy, soup, etc.) can be produced from groundnut seeds while there are several employment opportunities from enhanced groundnut production. Moreover, there has recently been an increased awareness in the cultivation of groundnut and other food legumes, not only as food but as soil fertilizer which reduces the farmers' demand for

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inorganic fertilizer. Regardless of the essential role of groundnut in eliminating or reducing poverty, food security and financial development, inappropriate production efficiencies and absence of mechanical change have frequently confined producers into producing only for survival and has also resulted to the stagnation of the sector, particularly in developing countries, Nigeria inclusive (Kassie *et al.*, 2011; Shiferaw *et al.*, 2011; Asfaw *et al.*, 2012; Thuo *et al.*, 2014; Ghosh and Mandal, 2015).

Similarly, Mutegi and Zingore (2014) and International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) (2001) also noted that the average yields of legumes such as groundnuts are on the decline resulting into increased food insecurity. Several reasons have been adduced to these, which include: unreliable rains, policies that do not support small scale producers, low productivity associated with farmers' production systems as well as the types of varieties cultivated (Coulibaly and Lowenberg-Debbier, 2000; Ondoma, 2006). Most smallholder farmers in most Sub-Saharan African (SSA) countries, including Nigeria still grow recycled traditional varieties which, though, have most of the desired attributes, are low yielding, late maturing and susceptible to diseases compared to genetically improved varieties (Minde *et al.*, 2008). This situation has however led to producers having very little output (or insufficient supply) which are sold for meagre amount. Thus, in a bid to curb this situation and for both producers and the economy to enjoy increased production and enhanced foreign exchange earnings, the Nigerian government in conjunction with different research institutes embarked on strategies to overcome the challenges of grain-legumes production to impact on the livelihoods of the producers. They made significant improvement in this area with the most significant being the introduction of short-duration strains. In addition, literature has shown that improved varieties with high yield potentials have been developed to increase agricultural output and improve farmers' income (Ajeigbe *et al.*, 2009). However, the use and adoption of these improved cultivars have rather been disappointing because farmers still mostly use traditional cultivars, despite their limitations. Several studies have adduced the non-use or rejection of these improved varieties to farmers' socioeconomic characteristics such as: small farm size, low education, lack of experience, inaccessibility to capital and unavailability of labour amongst others (Ondoma, 2006; Andrew, 2014). Hence, farmers' use of indigenous and archaic knowledge in the production of legumes for immediate economic returns and continuous revenue generation calls for critical evaluation (Toluwase and Abdu-raheem, 2013). This evaluation could only be achieved if the profitability of the improved seeds sector is well understood; this is because using improved seeds for profitable farming is considered as a significant strategy in boosting agricultural production and achieving food security (Ruma, 2008). This is due to the fact that improved seeds are fundamental in raising the efficiency of other inputs (Shobowale, 1994; Chijioke and Uteh, 2018). Improved groundnut seeds thus have the ability to enhance yield, income and productivity of producers. It is against this backdrop that this study investigated the marketing margin and factors influencing the marketing margin of producers of improved groundnut seeds in North-Western Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out in North-Western Nigeria. A multi-stage sampling procedure was employed for the study. The first stage involved a purposive selection of Kano State from the seven North-Western States because of the then International Institute of tropical Agriculture (IITA) improved seeds projects. In the second stage, Bunkure LGA was purposively selected because it was one of the project cities in Kano State. Thereafter, a purposive selection of five communities was made from the LGA. This is because these areas were known for groundnut seed production in the State. Finally, 25 producers of improved variety of groundnut seeds were purposively selected from each of the communities using the services of some enumerators provided by IITA, Kano. Thus, a total of 125 producers were sampled. Information was collected from respondents on their socio-economic characteristics, prices of improved variety of groundnut seed and expenditures.

The data collected were analysed using descriptive statistics, budgetary technique and Ordinary Least Square regression. Descriptive statistics such as percentages, frequencies and means were employed to describe the socio-economic characteristics of the respondents; budgetary technique was used to estimate the marketing margin of improved variety of groundnut seeds' enterprise while regression analysis was used to determine the factors influencing the value accruing to the producers of improved variety of groundnut seeds.

Budgetary Technique

Budgetary technique was employed to estimate the marketing margin of improved variety of groundnut seeds' enterprise. The various types of seeds, input used and their costs were identified. Gross marketing margin measures the difference between selling price and purchased price. The selling price was obtained by multiplying the unit price of each seed by the quantity sold while the purchase price was obtained by multiplying the cost of seed by the quantity used in production. The variable costs used for this study include the cost on land clearing, weeding, fertilizer, pesticides, harvesting/transportation. Using the straight-line method, the depreciation expenses were calculated on the fixed items (such as: hoe, axe, cutlass, and wheel barrow which were assumed for a lifespan of 3 years), which were then used in the analysis. The addition of total variable costs and total fixed costs gives the overall costs incurred in production.

The equations are:

$$SP = P_i \times Q_i \quad (1)$$

$$PP = C_i \times Q_j \quad (2)$$

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

$$GMM = SP - PP \quad (4)$$

$$NMM = GMM - MC \quad (5)$$

Where;

NMM is net marketing margin, GMM is gross marketing margin, TMC is the total marketing cost, TVC is total variable cost, TFC is the total fixed cost, SP is the selling price, PP is the

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purchase price, C_i is the cost of seed, Q_i is the quantity of improved variety of groundnut produced, P_i is the price of improved variety of groundnut and Q_j is the quantity of improved variety of groundnut bought.

Marketing efficiency can be defined as the maximization of the ratio of output to input in Marketing (Olukosiet *al.*, 2004). Efficiency can be expressed in physical or monetary terms, if monetary terms are used, efficiency concept becomes a ratio of benefits to cost or if in physical, it becomes a ratio of output to input used. In an attempt to examine the marketing efficiency of improved groundnut seed in Kano State, the following formula was adopted:

$$\text{Marketing efficiency} = \frac{\text{Value added by marketing service}}{\text{Marketing Cost}} \times 100 \quad (6)$$

$$\text{Marketing efficiency} = \frac{\text{Selling price} - \text{Purchased price}}{\text{Marketing Cost}} \times 100 \quad (7)$$

Value added by an average producer was calculated as the difference between the selling price and the purchased price; when marketing efficiency = 100%, it implies that the producer just recovered the cost incurred in carrying out the marketing services. This is break-even point for the respondent. If marketing efficiency > 100%, it implies that the respondent covered the cost of marketing and made a margin above 100%. This is point of the market being efficient. If marketing efficiency < 100%, it implies that the market is inefficient.

Regression Model

To determine the factors influencing the marketing margin to the producers of improved variety of groundnut seeds, a multiple regression analytical technique was used. The dependent variable was the computed net marketing margin for each producer. A number of explanatory variables were identified and included in the model. The implicit function is given as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, e)$$

Where;

Y = Net Marketing Margin;

X_1 = Age of improved groundnut seeds' producer (Years);

X_2 = Years of education (Years);

X_3 = Household size (Number);

X_4 = Farm experience (Years);

X_5 = Farm size (Ha);

X_6 = Gender (1 = male, 0 = female);

X_7 = Extension visit (1 = yes, 0 = no);

X_8 = Member of social organization (1 = yes, 0 = no);

X_9 = Access to credit (1 = yes, 0 = no);

X_{10} = Access to input (1 = yes, 0 = no);

e = Error term.

Different regression functions like linear, exponential, semi-log and Cobb Douglas were used to analyse the factors influencing the marketing margin to the producers of improved variety of groundnut seeds. Out of the regression functions used, the Cobb-Douglas regression function was

adopted as the main equation based on the highest coefficient of determination (R^2), with the highest F-statistics, number of significant variables and the signs of the estimated coefficients.

RESULTS AND DISCUSSION

The result from Table 1 revealed that the mean age of producers was 41 ± 12.17 years. This shows that an average producer in the study area was active and more likely to demand for improved seed technology. This result is similar to the findings of Abdullahi and Tsowa (2014), who reported that farmers in their study are still in their economically active age and their participation could promote legume production as they would be willing to take risks in expectation of higher profit. Improved groundnut seed production is seen to be gender biased as majority (96.0%) of the respondents were male. This also could be ascribed to the land tenure system being practiced in the area. Generally, majority (76.0%) of producers could either read or write, which is very important as it could increase their chances of accessing readily available modern farming technologies and improved farm practices, such as improved groundnut seeds. This result agrees with Abdullahi (2011), who reported that western education facilitates the adoption of modern technologies and use of improved farm practices. The farming experience of most (78.4%) of the producers span more than 10 years with majority (73.6%) of them cultivating an average farm size of 4 hectares. It is believed that farmers with long years of experience would have acquired enough expertise that would enable them overcome constraints faced in production, and this could be a signal for achievement of high farm productivity (Abdullahi and Tsowa, 2014). It was also revealed that majority (62.4%) of the producers purchased their seeds from the market. Also, 97.6% of the producers had access to modern farm inputs, 60.0% are members of different cooperative societies while 80.0% of the producers had access to extension agents. The access to extension agents is important as it makes farmers better informed about farm management planning and new technologies, thus improving their efficiency in farm production (Oseni *et al.*, 2015).

Marketing Margin of the Farm Enterprise

The items of cost were classified into fixed and variable cost while the return or revenue was realized from the sales of improved variety of groundnut seeds by individual producers. The fixed cost items were depreciated over time while the variable cost items were determined by each producer based on the quantity used for improved variety of groundnut seeds' production at a particular price. The marketing margin to improved variety of groundnut seeds' enterprise was examined for producers and is presented in Table 2. The result as shown in Table 2 revealed that though producers from the study area incurred cost in the cultivation of improved variety of groundnut seeds, they still have higher revenues. In addition, the result showed that the average value added which was calculated as the difference between the selling price and the purchased price, was ₦112,830. The marketing efficiency of improved variety of groundnut seeds calculated as the ratio of the value added to marketing cost was 129.57% which shows that the marketing of improved groundnut seeds was efficient. The fact that the marketing efficiency was greater than 100% is an indication that the improved variety of groundnut seed production in Kano State is profitable. This result agrees with Taruet *al.* (2010); Girei *et al.* (2013) and Abokiet *al.* (2018) that investing in groundnut is a viable enterprise.

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Factors Influencing Net Marketing Margin of Improved Variety of Groundnut Seeds

The result of the OLS regression model presented in Table 3 showed that the computed F-value of 147.10 is significant at the 1% level, denoting that the collective influence of these variables on net marketing margin is significant. The OLS regression model's result indicated that the R^2 was 0.9275. This suggests that the explanatory variables in the model specification were important and they explained about 92.8% variation in the dependent variable (net marketing margin). This shows that the model is of good fit and has a good predictive ability. Out of the ten explanatory variables, four of them namely, age of farmers, household size, farm size, and access to credit were significant. The result revealed that coefficient of age had a positive relationship with net marketing margin which means that an increase in age would result in an increase in the net marketing margin.

Table 1: Socioeconomic Characteristics of Respondents

Socioeconomic characteristics	Frequency	Percentages
Age		
≤ 30	30	24.0
31 – 40	38	30.4
41 – 50	29	23.2
51 – 60	21	16.8
Above 60	7	5.6
Mean	41.3 (12.174)	
Gender		
Male	120	96.0
Female	5	4.0
Education		
No formal education	30	24.0
Primary certificate	53	42.4
Secondary certificate	24	19.2
Tertiary	18	14.4
Farming experience		
1 – 10	27	21.6
11 – 20	42	33.6
21 – 30	38	30.4
31 – 40	14	11.2
Above 40	4	3.2
Mean	21.62 (11.317)	
Household size		
1 – 10	82	65.6
11 -20	39	31.2
21 – 30	4	3.2
Mean	9.696 (5.5142)	
Farm size		
1 – 5	92	73.6
6 – 10	32	25.6
11 – 15	1	0.8
Mean	4.122 (2.4416)	
Access to modern farm inputs		
Yes	122	97.6
No	3	2.4
Access to credit		
Yes	29	23.2
No	96	76.8
Membership of cooperative society		
Yes	75	60.0
No	50	40.0
Source of seeds		
Extension agents	12	9.6
Previously harvested seeds	35	28.0
Market	78	62.4
Access to extension agents		
Yes	100	80.0
No	25	20.0

Source: Data Analysis, 2018

Note: Figures in parenthesis represents the Standard Deviations

Table 2: Marketing Margin per Hectare per Producer of Improved Groundnut Seeds for 2015 Production Season

Item	Quantity/Ha/Kg	Price (₦/Kg)	Total (₦)
A. Selling Price (SP)	161.9	700	113,330
B. Purchased Price (PP)	4 kg	125	500
C. Marketing Cost (MC)			
(i) VARIABLE COSTS			
Land clearing	5 MD	5,000	25,000
Weeding Cost	4 MD	5,000	20,000
Fertilizer Cost	5 kg	3,500	17,500
Pesticide and herbicide Cost	1 litre	1,300	1,300
Harvesting and Transportation		2,000	2,000
Total Variable Cost			65,800
(ii) FIXED COST			
Rent on land			15,000
Depreciation cost on tools			6,283.33
Total Fixed Cost			21,283.33
D. Total Marketing Cost			87,083.33
E. Gross Marketing Margin (A – B)			112,830
F. Net Marketing Margin (E – D)			25,746.67
G. MARKETING EFFICIENCY $\left(\frac{E}{D}\right)$			1.2957 (129.57%)

Source: Data Analysis, 2018. Note: MD indicates Man Day

Table 3: Relationship between Producers' Demographic Characteristics and Marketing Margin

Variable	Coefficient	t	P>t
Age	1.114***	2.68	0.009
Gender	1.571	1.14	0.256
Farm experience	-0.244	-0.50	0.616
Education level	0.031	0.13	0.897
Household size	0.701*	1.81	0.073
Size of farm	1.043***	3.25	0.002
Access to input	-1.780	-1.00	0.321
Membership of Cooperative	-0.411	-0.70	0.483
Access to extension agent	-0.338	-0.49	0.625
Access to credit	1.192*	1.95	0.054
R-squared	0.9275		
Adjusted R-squared	0.9212		
F-value	147.10***		

Source: Data Analysis, 2018

Note: *, **, *** signifies 10%, 5% and 1% level of significance respectively

The positive relationship between age and net marketing margin implies that older producers have a better understanding of the market. The coefficient of household size was also positive which means that the producers with more household member had more margin of profit. The reason for this was due to the fact that family members were used in the marketing of improved variety of groundnut seeds and as such little or no cost was incurred in hiring labour.

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The coefficient of farm size was positive which means that higher net marketing margin was obtained from larger farm size. This could be due to the fact that more output was obtainable from larger farm size and as such more could be sold which will consequently result to an increase in the net marketing margin. The coefficient of access to credit was also positive, implying that the more the access to credit, the more the net marketing margin. The positive relationship between access to credit and marketing margin is as a result of the fact that producers made use of the credit they had access to.

CONCLUSION AND RECOMMENDATIONS

The study was conducted to analyse the economics of improved variety of groundnut seeds' production in North-Western, Nigeria. The result revealed that though the improved variety of groundnut seeds' enterprise was marginally profitable, the marketing of improved variety of groundnut seeds was efficient and the enterprise considered viable. It also identified age, household size, farm size and access to credit as the factors that influenced the net marketing margin.

The study therefore recommends that older producers should be encouraged and motivated to go into improved variety of groundnut seeds production. This is because older producers have a better chance at enjoying increased marketing margin due to their experience at coping with farm challenges. Also, sufficient farm lands should be provided for those who are interested in improved variety of groundnut seeds' production. Furthermore, adequate credit facilities should be made available and improved variety of groundnut seeds should be subsidized so that producers can be motivated to use and adopt them. It is hoped that the application of these measures would help reduce food insecurity, and consequently improving farming households living standard.

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