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EFFECTS OF ARMTI VILLAGE ALIVE DEVELOPMENT INITIATIVE ON THE BENEFICIARIES IN KWARA STATE

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ABSTRACT
Increasing poverty in the rural areas has been identified as a bane to rural development in Nigeria. Bearing this in mind, the Agricultural and Rural Management Training Institute, (ARMTI) developed an action-oriented research laboratory called Village Alive Development Initiative (VADI). The general objective of this study (conducted in 2019) was to assess the activities of VADI towards poverty alleviation. Both primary and secondary sources of data were used. Descriptive statistics (frequency counts, mean scores and percentages) and Pearson Product Moment Correlation (PPMC) were used to analyze data collected. The result revealed that the average age of the beneficiaries was 51.8 years, 55.8% male and 48.2% female, majority were married (74.6%) with primary education (37.6%) as the highest level of education. All the beneficiaries agreed that VADI has contributed (100%) positively to the growth of their enterprise. The relationship between the socio-economic characteristics of the beneficiaries and their saving culture showed that age (0.000), educational status (0.000), source of income (0.018), agricultural activities (0.011), farm size (0.003) and herd size (0.042) have significant relationship on the saving culture of the beneficiaries. Village Alive Development Initiative scheme was very effective and has helped the beneficiaries in their saving culture and growth of their agricultural enterprise. The study recommended that interest rate should be reduced to a considerable amount for the VADI beneficiaries and, that loan should be processed within the shortest possible time.

Keywords: VADI, ARMTI, *poverty alleviation, saving culture, beneficiaries*

INTRODUCTION

In most developing countries including Nigeria, there is an increased awareness of the important functions of small and micro enterprises in the urban and rural informal economy in terms of supply and employment creation. Consequent upon the constraints of rural dwellers and coupled with the fact that developmental issues cannot be left in the hand of government alone to address, the public and private sectors have taken important steps to promote livelihood activities of the host communities where they operate by introducing Corporate Social Responsibility (CSR) project. The major aim of the CSR is geared towards alleviating poverty among rural dwellers.

In order to assist government policy on poverty alleviation in the rural settings, Agricultural and Rural Management Training Institute (ARMTI) as an establishment of the Federal Government of Nigeria came up with a programme called “The Village Alive Development Initiative (VADI)”. It is an action-oriented research laboratory of ARMTI, which initially took off in 1995 as Village Alive Women Association (VAWA). After a period of dormancy of the original VAWA, ARMTI Management resuscitated the project as VADI in 2011, to include men, women and youth as beneficiaries in the project.

This was followed by the conduct of a socio-economic survey of four selected communities (Falokun-oja, Fufu, Apa-ola and Elerinjare) in Kwara State, Nigeria, who were mainly engaged in rain-fed farming and largely unemployed during the dry season. During the survey, it was observed that the men were often less busy during the dry season and experienced severe food shortage. Their income and literacy levels were low and these largely accounted for the low nutritional status of the food they consumed. Hence, they were usually prone to health hazards. Their productivity was low as a result of their poor access to modern farm inputs and extension services.

In addition, they used traditional methods in processing their farm produce resulting to post-harvest losses and inability to expand their production activities. They also lacked adequate access to credit facilities and market. Lack of market information, and access to finance by the rural poor, are part of the main reasons they remain poor. It is in this regard that Burgess *et al* (2003) argued that access to finance is critical to enable the poor to transform their production system and thus exit poverty. Most of the rural communities under the programme are involved in agricultural production as the major means of sustenance. According to VADI baseline report (2011), the major food crops cultivated by the people in the study area include cereals like maize, rice, sorghum, prominent horticultural crops are citrus, mango, cashew, tomatoes, pepper, water melon, cucumber, pepper and okra. Legumes (groundnut, cowpea, soybeans) and tuber crops (yam, cassava, potatoes) as well as industrial crops like sugarcane are also cultivated. The persistent level of poverty in rural communities despite various interventions by the government and various NGOs' is a source of worries to ARMTI management. Intervention has been targeted towards poverty alleviation by creating rural-level opportunities for these communities. Consequent upon these findings, ARMTI designed an action research to evolve a sustainable strategy for poverty alleviation using the selected villages as social laboratory. The project was aimed at creating village-level opportunities for rural dwellers to alleviate poverty and also used the result to strengthen ARMTI's training programmes. This study examined the performance of VADI to reverse the age-long vicious cycle of 'Low income, low savings and low investment' into a desirable cycle of "injection of credit for more income, more savings, more investment" in the villages where VADI is in operation. The general objective of the study was to assess the activities of Village Alive Development Initiative (VADI) towards poverty alleviation while the specific objectives were to: describe the socio-economic characteristics of the beneficiaries; examine the effect of VADI (loan) on saving culture and enterprise growth among beneficiaries; assess the relationship between selected socio-economic characteristics of beneficiaries and the effects of VADI on their saving culture.

METHODOLOGY

Kwara State is located in the Savannah region of Nigeria. The region is characterized by favourable weather with single peak annual rainfall of 400-1400mm (LNRBDA, 2015). As a result of this, the zone has a great potential for food production as farming is the predominant occupation of the people in the region. The study area for this study consisted of Ifelodun and Ilorin South Local Government Areas (LGAs) of Kwara State. The selected communities for the study were Falokun-Oja, Apa-Ola, Elerinjare, Igbo-Owu, Omomere-Oja, and Ilota.

Multi stage sampling procedure was employed for the study. The first stage was stratified selection of 70% community groups that were involved in the VADI programme. The second stage is selection of 75% credit groups in the selected communities while the third stage involved selection of all the beneficiaries in the communities that were pre-selected (Table 1). Questionnaire (totaling 319 were distributed and all retrieved) was used to collect primary data for the study. Descriptive and inferential statistics such as frequency distribution, percentages, mean scores, standard deviation and Pearson's Product Moment Correlation (PPMC) were used for data analysis. All the data were analysed to show impact (before and after) of the VADI programme on the beneficiaries.

RESULTS AND DISCUSSION

Socio-economic Characteristics of respondents

As shown in Table 2, the majority of the beneficiaries (40.1%) were aged between 51-60 years. This showed that the beneficiaries were quite advanced in age and the people that were found in all communities were predominantly farmers by occupation. This finding contradicts the reports of Oladeji and Thomas (2010) and Okoroji and Folorunsho (2015) both research works carried out in Oyo and Plateau States Nigeria respectively, who reported that the population within the age group 31-40 years were the most productive, energetic and constitute the realistic active work force. The result also showed that male (55.8%) beneficiaries were more than their female (44.2%) counterparts. This is to show that there were more male farmers than female in the study area. This is in line with the work of Freddie *et al* (2013) who opined that since men are predominantly stronger than the female and agricultural work therefore is for the strong ones. Thus, men are more involved in agriculture than female. More so, the result also showed that 74.6% of the beneficiaries were married. The result here buttresses the findings of Holvoet (2005) who opined that mainly, farmers get married quickly with many wives so they can have a handful of family labour working for them on their farms, most of whom (68.3%) had household size of 6-10 persons. This shows that there was an appreciable source of family labour available to the beneficiaries. The household size determines the available family labour force to be employed in carrying out agricultural activities involved in. This connoted with the findings of Okoroji *et al*. (2015) who agreed that a fairly big household size has a great capacity to reduce the incidence of food insecurity. The main source of income of VADI beneficiaries as seen in Table 2 was farming (52.0%), they were involved mostly in crop production (66.9%) but their level of education was relatively poor with over 37.3% of the beneficiaries having no formal education. The literacy level of beneficiaries in any study is expected to greatly influence the development of initiatives, decision making and adoption of innovation by the beneficiaries which may enhance their enterprise activities. Information is needed as noted by Annan (2002) that, an informative society is a way for human capacity to be expanded, built up, nourished, and liberated by giving people access to tools and technologies, with the education and training to use them effectively. In 1992, the World Bank conducted a survey to measure the relationship between farmers' education and their agricultural efficiency in low-income countries and found out that farmers with basic education were 8.7% and were more productive than farmers with no education (Gasperini, 2000).

Effect of VADI (Loan) On Saving Culture and Enterprise Growth

The result in Table 3 distinguished the impact of VADI on the beneficiaries saving culture before and after VADI intervention. The result showed that before the advent of VADI, 48.0% due to crude nature kept their money in the house, few (17.8%) in the bank, 4.1% kept their money through thrift, 5.0% through cooperatives they partook in while 25.1% didn't save at all. However, after VADI's intervention, there was a tremendous improvement where majority (48.3%) could save their money in banks, 27.3% saved their money into their cooperatives, 17.2% saved theirs through thrift collection, 7.2% saved it in the rooms and there was no one who didn't save at all. The implication of the findings above is that since the adoption of VADI by the beneficiaries, they have been able to save more due to the bureaucratic measures laid down by ARMTI. This was also supported by the trainings and supervisions of farmers by ARMTI. They were informed of the need to save in order to be able to access loan under the project, this implies that there should be a conventional way of savings by each and every one of the beneficiaries before they can access loan. This was supported by the work of Carroll *et al.* (1994) who opined that people changes from their traditional saving culture when they are convinced that the conventional ways of savings is better and advantageous. The result revealed a considerable improvement in all the available means of saving among the beneficiaries within the communities after VADI intervention.

As shown in Table 4 below, is the distribution of the beneficiaries in the study area by the growth impact that VADI scheme had on their enterprise. It was clearly revealed that when they were non-partakers in VADI, the beneficiaries were going by their normal enterprise activities not minding whether any activities could have come to affect their enterprise growth. The advent of VADI and participation of the beneficiaries clearly showed that all beneficiaries (100%) accepted in totality that VADI had greatly affected their enterprise growth. Ayyagari *et al* (2007) opined that small and medium sized enterprises (SMEs) are of great value to the stable and sustainable development of the economy and attracted high attention from government worldwide. According to Nahata

(2008), financial support is the cornerstones for rapid growth of SMEs. This was buttressed by the growth shown in VADI beneficiaries' enterprise.

Relationship between selected socio-economic characteristics of beneficiaries and the effects of VADI project on their saving culture

Result from Table 7 shows the relationship between the socio-economic characteristics of the beneficiaries and their saving culture. Findings shows that there was significant relationship between age (0.000), farm size (0.003) and herd size (0.042). This showed that, for every VADI beneficiaries, the higher the age, the better the saving culture. The herd and farm sizes also enhanced a good attitude on saving culture. When VADI beneficiaries' herd and farm sizes increases, more income was generated and this helped them to save more. In most developing countries, sustained growth in agriculture is often the keystone of overall socio-economic growth and development (Dethier and Effenberger, 2011).

CONCLUSION AND RECOMMENDATION

It was therefore concluded that VADI scheme was very effective and has helped the beneficiaries to improve in their saving culture via increased income which has led to the growth of their agricultural enterprise. However, from the findings, it is recommended that beneficiaries with high level of education with agricultural activities as their main source of income should be incorporated into the programme for more impact in the study area and in the country at large.

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Table 1: Sampling Procedure and Sample Size of each community under study area

Selected communities	Total number of credit group	Seventy-five (75) percent credit group selected	Total number of participants
Falokun-Oja	5	4 (Irewolede, Omowumi, Omolere, Opeyemi, Oluwaseun)	65
Apa-Ola	5	4 (Asejere, Ifelodun, Oredegbe and Ifelagba)	50
Elerinjare	4	3 (Irewumi, Ifedapo and Opeyemi)	61
Igbo-Owu	5	4 (Bomodeoku, Fomologba I, Agbelere and Irewumi)	47
Omomere-Oja	3	2 (Orelope and Surulere)	33
Ilota	6	5 (Anjorin, Owolarafe, Irenitiwa, Ojasope, and Afenifere)	63
Total	28	21	319

Source: Field work, 2018.

Table 2: Distribution of the Beneficiaries by their Socio-economic Characteristics at the study area

Variable	Frequency	Percentage (%)	Average
Age (years)			
≤ 30	8	2.5	51.8 years
31-40	44	13.8	
41- 50	81	25.4	
51-60	128	40.1	
≥ 61	58	18.2	
Sex			
Male	178	55.8	
Female	141	44.2	
Marital status			
Single	4	1.3	
Married	238	74.6	
Separated	33	10.4	
Divorced	16	5.0	
Widowed	28	8.8	
Household size			
1-5	64	20.1	7 persons
6-10	218	68.3	
≥ 11	37	17.6	
Education status			
Unlettered	119	37.3	
Primary education	120	37.6	
Secondary education	56	17.6	
Tertiary education	24	7.5	
Main source of income			
Salary	20	6.3	
Sales of farm produce	17	5.3	
Artisan	56	17.6	
Farming	166	52.0	
Trading	60	18.8	
Agricultural activities			
Crop	223	66.9	
Livestock	24	7.5	
Aquaculture	12	3.8	
Size of farm (hectares)			
1	184	52.7	1 hectare
2	96	30.1	
3	39	12.2	
Herd size			
1-10	16	44.4	12 herd size
11-20	17	47.2	
21-30	3	8.3	
Total	319	100	

Source: Field survey, 2019.

Table 3: Distribution of the Beneficiaries by their Saving Culture

	BEFORE VADI		AFTER VADI	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Thrift	13	4.1	55	17.2
Secret place in the room	153	48.0	23	7.2
Cooperative	16	5.0	87	27.3
Bank	57	17.8	154	48.3
No savings at all	80	25.1	00	00.0
Total	319	100	319	100

Source: Field survey, 2019.

Table 4: Distribution of the Beneficiaries by their Growth Enterprise.

	BEFORE VADI		AFTER VADI	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Yes	00	0.0	319	100.0
No	319	100.0	00	0.0
Total	319	100	319	100

Source: Field survey, 2019.

Table 5: Pearson Product Moment Correlation between the Selected Socio-economic Characteristics of the VADI Beneficiaries and the Effects of VADI on their Saving Culture in the Study Area.

Variables	r – value	Remark
Age	0.000	Significant
Farm size	0.003	Significant
Herd size	0.042	Significant

Source: Field survey, 2019. *Sig at 0.05 level

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EFFECTS OF NITROGEN FERTILIZER ON THE GROWTH, YIELD, NUTRITIONAL AND PHYTOCHEMICAL QUALITIES OF BASIL CULTIVARS

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ABSTRACT
Pot experiment was conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso in 2015. Three Basil cultivars (purple, sweet and local small leaves) and five nitrogen fertilizer rates (0, 30, 60, 90 and 120 kg N/ha) were evaluated. The experiment was laid out as 3 x 5 factorial fitted into a randomized complete block design replicated three times. Data were subjected to analysis of variance and treatments means were compared using least significant difference at 0.05 probability level. Results revealed that fertilizer rates, significantly ($p < 0.05$) influenced the growth and yield parameters of basil cultivars. The plants that received 120 kg N/ha produced the tallest (42.50 cm) plants while the shortest (26.30 cm) plants were obtained from 0 kg N/ha. The widest leaf area (19.67cm2) was recorded for local basil at 90 kg N/ha while sweet basil gave the least (4.00 cm2) value when no fertilizer was applied at 12 weeks after planting (WAP). The highest seed weight (9.19 kg/ha) was recorded for the local basil plants that received 120 kg N/ha while the plants in the control plots gave the least (1.59 kg/ha, 3.30 kg/ha and 4.25 kg/ha) values for all cultivars. Purple basil produced the highest fresh shoot yield (94.87 g/plant), dry leaf (19.60 g) and dry shoots (38.78 g) yield while the sweet basil recorded the least values of 48.35 g, 10.02 g and 17.80 g, respectively at 120 kg N/ha. However, the highest dry seed yield (7.33 g) per plant was observed from local basil while sweet basil recorded the least value (14.1 g), irrespective of fertilizer rate. Purple basil gave highest (25. 65 g/mg) leave crude protein, while sweet basil gave least (17.70 g/mg) value. Application of nitrogen fertilizer at 90 kg N/ha produced optimum performance of basil and this fertilizer rate is most efficient with the purple basil. Application of 90 kg N/ha with purple basil could be recommended in the study area.

Keywords: *Ocimum basililum, cultivars, nitrogen fertilizer, growth, yield, nutritional, phytochemical, quality*

INTRODUCTION

Basil is a tender growing aromatic herb. It is annual plant, a fragant leafy vegetable and belongs to the mint family *Labiateae*. Basil derives from the greek word Basilikos meaning "herbs worth of kings". Its origin have been reported in India and Iran (Zargari, 1995) more than 60 varieties of Basil are identified with green, red, violet and purple leaves (Lachowiiz *et al.*, 1997). Basil is a well known appreciated spice and medicinal plant (Omer et al., 2008). Apart from biological active compounds, such as volatile oil, tanins, terpenes and flavonoids it is also a valuable source of macro and micro elements (Kohiminzzer, 2003). According to Lachowics (1997) fresh green basil comprises of calcium, magnesium, potassium and vitamins A and B and it is high in calories (Chris *et al.,* 2003). Basil oil is volatile and the chemical compound in the essential oil of green basil plant materials are ocimen, pipenel, terpin, hydrate, cineol, methyl, chiviol, anethol, eugenoil, thymol, vitral, camphor (Lachowinz *et al.,* 1997). These phyothchemicals offers protection for many chronic diseases such as diabetes, cancer, heart diseases and Asthma, it also reduces oxidative damage to cells. The extract oil is mainly used in food industry and perfumery. The basil essential oil also has insecticidal and insect repellent properties (Umerie *et al.,* 1998). However, the plants are scare during off seasons which necessitates good preservation. Also the plants is highly perishable and has to preserved against spoilage and deterioration. Nitrogen is needed for vigorous vegetative leaf, yield and quality of Basil and dark green leaf colour (Chlorophyll production) (Al-Moshilen, 2001). Optimum nitrogen used by plant is influenced not only by climate and certain soil characteristics, but also by management practices such as tillage, time and method of nitrogen application. Nitrogen interaction with some other elements helps to improve root system development, dry matter production and other plant functions regulating crop yield and quality (Williams, 2011). Nitrogen is essential for growth and of Basil and other plants but excessively high doses causes delay in maturing and encourages molting which is an undesirable characteristic. Shaikh *et al.,* (1987), reported that the application of 90kg N/ha increased the yield of Basil. In contrary, Pandey *et al.*, (1994) reported that application of Nitrogen rate of 80kg N/ha gave higher yield than lower rates, while Wiederfield (1994), and found no additional yield increase from applying nitrogen rates higher than 84kg N/ha. Nitrogen rate is important such that high nitrogen favours growth and yield (Erisinan, 2008). Lack of nitrogen is one of the most common nutritional stresses in plant (Marchetti, 2006). The objective of this study was to determine the effect of nitrogen fertilizer on the growth, yield, nutritional and phytochemical quality of basil cultivars in Ogbomoso, Guinea Savannah Zone South West Nigeria.

MATERIALS AND METHODS

The pot experiment was conducted during 2015 cropping season at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Ogbomoso lies between longitude 40 and 10'E and latitude 80 10'N with mean annual rainfall of between 1,150 and 1,250 mm. The temperature regime is high all year round. The mean minimum temperature is 28^0C and the maximum temperature is 33^0C with high humidity of about 74 all year round except in January when the dry wind blows from the North. Pre- treatment soil samples were collected randomly from the experimental area at the depth of 0-15cm for physical and chemical analysis. Soil particle size was determined by Boyoucos method (Bouyoucos, 1962). Total Nitrogen was determined by Kjeldal digesting method (Kjeldahl, 1983). The soil belongs to the textural class of sandy, loam and low in organic matter. The soil is moderate in organic carbon. Total available P, exchangeable and cation exchange capacities. The site was manually cleared and total number of 135 polybags were filled with 10kg top soil. These were divided into three replicates, with each replicate containing 45ploybags. Each treatment had three polybags and 45pots constituted a replicate. The seeds of each basil cultivar were some in respective polybags.

Three basil cultivars (purple, sweet and local small leaves basil obtained from National Horticultural Research Institute, Idi-Isin Ibadan Oyo state, Nigeria (NIHORT) were subjected to nitrogen fertilizer rates applied at 0,30,60,90 and 120kg N/ha rates. Treatments were applied randomly to their respective beds. Insects pests was controlled with the use of cypermethrin insecticides at two weeks interval with the aid of knapsack sprayer. Data collection on growth and yield of Basil convenience at 4 weeks after sowing and continued till harvesting. Plant height was measured with a meter ruler. Number of leaves was recorded by counting fully opened and functional leaves. The stem girth was determined by using venier caliper and the leaf area was assessed by measuring the length and breadth of the leaves and multiplying by correction factor (0.65). The yield attributes; plant shoot and seed weight were measured with the use of sensitive weighing balance and recorded. The phytochemical quality was carried out after the plant has reached harvest stage. Three basil plants were harvested from each treatment at flower initiation and dried in the oven at 650C till constant weight. Samples were enveloped separately and taken to the laboratory for nutritional analysis of (crude protein, crude fibre, total fat, ash content and moisture content) and phytochemical quality analysis such as Ocimen, Pipenes, Terpin and Cinenol. Data collected were analyzed using Statistical Analysis Software (SAS, 2011), for analysis of variance (ANOVA) and the means were separated by the least significant difference at 5% probability level.

RESULTS AND DISCUSSION

Growth parameters: The growth parameters of basil cultivars as influenced by nitrogen fertilizer rates are presented in tables 1 and 2.

The number of leaves of different basil cultivars increased as plant aged. These growth characters increased with increasing rate of applied nitrogen fertilizer. Although the highest values were obtained from plants that received 120kgN/ha, there was no significant difference from the values recorded at 60 and 90 kg N/ha. The number of leaves was significantly CP<0.05 influenced by the nitrogen fertilizer application rate at 12WAP, while Nitrogen only improved the basil cultivar at 4WAP and 8WAP respectively. Purple basil cultivar closely followed by sweet basil cultivar gave the highest number of values while local basil cultivars closely followed by sweet basil cultivars gave the highest number of leaves while leaves basil gave the least values when no fertilizer was applied. The intersection of fertilizer rats and basil cultivars shows highly significant effect at 12 WAP CP< 0.05 while an improvement at 4WAP and 8WAP respectively. The increased in the growth parameter (number of leaves) with applied nitrogen fertilizer rats revealed that the applied nitrogen fertilizer contained and supplied adequate amount of essential nutrient especially nitrogen needed for the rapid growth and development of basil plants. This is in accordance with the work of Olaniyi and Akanbi (2017) which stated that nitrogen fertilizer are capable of supplying the essential nutrient elements needed for plant growth and optimum productively. The optimum fertilizer rates of 90 kg N/ha and a decline thereafter obtained in the study revealed that normal rate should be supplied over application must be avoided (Olaniyi and Ajibola, 2008). Application of Nitrogen has been reported to significantly improved basil growth (Kandil *et al.,*2009), and the variation among the cultivars reconfirmed the work of Olaniyi *et al.,* (2000) for amaranths. The result obtained in this study reconfirmed the work of Akanbi *et al.,* (2004) who reported that application of organic manure significantly increased the growth of Okra.

Table 2 shows the effects of nitrogen fertilizer on the plant height of basil plants. The height increased with increasing rate of applied Nitrogen fertilizer. The significant effects of fertilizer application on the growth of basil collaborates the findings of Dzida (2010), who earlier reported significant differences between evaluated basil varieties with varying Nitrogen rates. The fertilizer applied shows a significant effect on the basil cultivars at 4WAP while only improved the height of the plant at 8WAP and 12WAP respectively. Furthermore, the increasing rates of fertilizer which produced increase across the plant height might not be fetched as it has been reported severally that this observation might be as a result of higher concentration at essential mineral elements required for optimum growth in the higher rates of fertilizer (Akanbi *et al.,* 2005).

The interaction of Nitrogen fertilizer rates and basil cultivars improved the highest of the plant at 8WAP and 12 WAP but shows a significant effects ($P<0.05$) at 4WAP. Yield: The yield and yield components of Basil cultivars as influenced by Nitrogen fertilizer rates is shown in table 3. The dried leaf weight, fresh shoot weight, dried seed weight, dried shoot weight increased with the increase in Nitrogen fertilizer rate. The highest values were obtained at the optimum rate of 90 kg N/ha and thereafter a declined or remained stable for all cultivars. The yield and yield components measured were significantly ($p<0.05$) different for the cultivars effects with purple cultivars followed by sweet basil which recorded the least value, when no fertilizer was applied. The interaction of Nitrogen fertilizer application rates and basil cultivars only improved the fresh shoot weight of basil plant. The great increased in the yield components of basil with fertilizer application was in accordance with the other researchers. Agunbade *et al* (2015) who reported a significantly improvement in basil plant yield. Anwar, (2005) noted that the use of fertilizers was responsible for 50% yield increase in crops. Baines and Robert (2001) reported that application of Nitrogen increased fresh shoot weight of basil plant. The significant differences in the entire yield components among the cultivars meant that basil cultivars responded differently to the applied treatment which may be due to difference in genetic constitution (Kandii *et al.,* 2009).

Phytochemical contents of basil plants. The effects of fertilizer rates on basil cultivars phytochemical content is of Ocimen, Pipene, Terpene and Cinemol is presented in Table 4.

The phytochemical content of basil plants were significantly (P <0..05) influenced by fertilizer rate, and fertilizer rate by cultivar combined effects. The phytochemical content of basil plant increased as the fertilizer level increased from 0 up till 90 kg N/ha. There were significant differences in Ocimen, Pipenel, terpene and Cinemol. The highest phytochemical contents were found in purple basil while sweet basil gave the interactions between the fertilizer rates and basil cultivar was significant for all the phytochemical and consequently the cultivars reacted differently to fertilizer rates. Local basil basil was highest in Ocimen, sweet basil for pipenel while sweet basil and purple basil for terpene and cinemol respectively. This shows that genetic composition might be more important for the accumulation of phytochemicals than fertilizers rates.
This confirm the work of Green wood (2004) who reported that the genetic composition might be more important for the accumulation of phytochemicals than fertilizers rates. Nutrients contents of basil plants: The percentage compositions of Cp, Cf, Tf, Ac and Tl of basil plants is presented in table.

CONCLUSION

The growth parameters were significantly influenced by the fertilizer rates and basil cultivars, most especially number of leaves and plant height fertilizer rate of 90 kg N/ha improved the growth of basil mostly. Purple basil produced the highest value at a rate of 120 kg N/ha, although yield obtained at 90 kg N/ha were not mostly significantly different from rate 120 kg N/ha and can be recommended for farmers because of the economic implication of purchasing fertilizers.

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Table 1: Effect of N fertilizer rates on the number of leaves of basil cultivar

		Cultivars	
	Local basil	Purple basil	Sweet basil
Rate (kg/ha)		4WAP	
0	10.00	50.87	15.00
30	12.60	63.87	23.00
60	15.35	56.30	29.40
90	19.50	68.67	29.80
120	19.00	93.50	30.00
LSD RATE	NS		
LSD VAR	NS		
LSD VAR x RATE	NS		
		8WAP	
0	20.70	89.60	19.00
30	22.50	95.70	29.80
60	29.10	119.30	32.10
90	48.00	135.60	33.50
120	33.30	115.30	39.00
LSD RATE	1.44		
LSD VAR	2.49		
LSD VAR x RATE	3.58		
		12WAP	
0	39.20	103.00	29.40
30	42.33	115.77	38.80
60	53.40	144.47	42.50
90	54.00	170.20	45.00
120	65.50	154.00	46.21
LSD RATE	0.01		
LSD VAR	0.02		
LSD VAR x RATE	0.002		

NS = data not significant at $P \geq 0.05$

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Table 2: Effect of N fertilizer rates on the plant height of basil cultivars

		Cultivar	
	Local basil	Purple basil	Sweet basil
Rate (kg/ha)		4WAP	
0	21.84	29.50	15.00
30	20.25	29.81	19.30
60	25.80	30.00	22.00
90	23.37	31.30	24.00
120	25.00	29.30	20.00
LSD RATE	0.03		
LSD VAR	0.05		
LSD VAR x RATE	0.02		
		8WAP	
0	25.50	31.30	25.10
30	25.80	33.60	25.50
60	27.50	34.90	26.65
90	29.60	37.70	32.00
120	27.97	36.00	28.45
LSD RATE	NS		
LSD VAR	NS		
LSD VAR x RATE	NS		
		12WAP	
0	27.59	37.70	26.30
30	32.60	38.00	26.65
60	32.30	38.10	29.40
90	35.27	42.50	33.00
120	34.20	39.10	29.30
LSD RATE	1.44		
LSD VAR	2.49		
LSD VAR x RATE	3.50		

ns: data not significant at P$\geq$0.05

Table 3: Effect of Nitrogen fertilizer rates on yield and yield components of basil cultivars

	Varieties		
	Local basil	Purple basil	Sweet basil
Rate (kg/ha)	Dried Leave Weight (g)		
0	10.67	11.00	6.00
30	11.35	12.77	7.56
60	13.86	15.06	8.09
90	14.42	16.05	8.50
120	16.50	19.60	10.02
LSD RATE	0.14		
LSD VAR	0.25		
LSD VAR X RATE	0.04		
	Fresh Shoot Weight (g)		
0	39.53	45.19	23.28
30	49.80	62.28	30.99
60	69.86	65.20	39.60
90	77.35	88.25	47.00
120	77.01	94.87	48.25
LSD RATE	Ns		
LSD VAR	Ns		
LSD VAR X RATE	Ns		
	Dried Seed Weight(g)		
0	4.25	3.30	1.59
30	6.94	4.49	2.07
60	7.27	6.44	2.36
90	9.00	7.65	6.74
120	9.19	9.00	6.76
LSD RATE	0.40		
LSD VAR	0.68		
LSD VAR X RATE	0.28		
	Dried Shoot Weight (g)		
0	20.39	20.41	9.00
30	20.63	28.17	10.58
60	21.85	29.63	16.55
90	22.89	28.18	16.57
120	21.37	38.74	17.80
LSD RATE	0.01		
LSD VAR	0.02		
LSD VAR X RATE	0.02		

Table 4: Effect of fertilizer rates and basil cultivars on photochemical contents of basil seed

	Photochemical					
	Local basil	Purple basil	Sweet basil	Local basil	Purple basil	Sweet basil
Rate (kg/ha)	Vitamin A			Carotene		
0	0.32	0.32	0.32	0.29	0.31	0.25
30	0.32	0.33	0.33	0.31	0.32	0.32
60	0.32	0.34	0.34	0.31	0.32	0.32
90	0.32	0.34	0.34	0.32	0.33	0.32
120	0.33	0.34	0.35	0.32	0.33	0.33
LSD RATE	0.01			0.01		
LSD VAR	0.02			0.03		
LSD VAR x RATE	0.02			0.03		
	Vitamin C			Cryptoxanthin		
0	11.76	12.86	12.93	0.13	0.13	0.13
30	12.85	12.91	12.95	0.13	0.13	0.13
60	12.80	12.98	13.83	0.13	0.14	0.14
90	12.81	13.13	13.90	0.13	0.14	0.14
120	12.855	13.25	14.24	0.13	0.14	0.15
LSD RATE	0.01			0.0004		
LSD VAR	0.02			0.0009		
LSD VAR x RATE	0.01			0.04		
	Vitamin E			Lutein		
0	0.02	0.02	0.03	0.02	0.02	0.02
30	0.03	0.03	0.03	0.02	0.02	0.03
60	0.03	0.03	0.04	0.02	0.02	0.03
90	0.03	0.03	0.04	0.02	0.03	0.03
120	0.12	0.04	0.04	0.02	0.04	0.04
LSD RATE	Ns			0.004		
LSD VAR	Ns			0.01		
LSD VAR x RATE	0.10			0.02		
	Vitamin K			Zeanthin		
0	0.01	0.01	0.01	0.01	0.01	0.01
30	0.01	0.01	0.01	0.02	0.02	0.02
60	0.01	0.01	0.01	0.02	0.02	0.02
90	0.01	0.01	0.01	0.02	0.02	0.03
120	0.01	0.02	0.02	0.02	0.03	0.03
LSD RATE	0.01			0.0008		
LSD VAR	0.03			0.002		
LSD VAR x RATE	0.03			0.02		

ns = data not significant at $P \geq 0.05$

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INFLUENCE OF INDIGENOUS *BACILLUS* STRAINS ON GROWTH OF BELL PEPPER (*CAPSICUM ANNUUM* VAR. *ABBREVIATUM*) IN A GREEN HOUSE

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ABSTRACT
Indigenous bacteria in the rhizosphere of plants are capable of stimulating plant growth either directly or indirectly. The present study was conducted to assess the influence of indigenous *Bacillus* strains on the growth of bell pepper (*Capsicum annuum* var. *abbreviatum*) in the green house. *Bacillus* species were isolated from the rhizosphere of pepper plants, identified and screened for plant growth-promoting traits. The *in-vitro* germination assay was conducted using potential plant growth-promoting *Bacillus* isolates, followed by greenhouse experiments which were conducted in 2018 and 2019 at FUNAAB. Each experiment was performed in a completely randomized design with five treatments (no *Bacillus*, *B. licheniformis*BP01, *B. subtilis*BP03, *B. subtilis*BP08 and *B. megaterium*BP11) in four replicates. Data on agronomic traits were collected and analyzed using One-way analysis of variance. The *in-vitro* germination assay revealed that inoculation of bell pepper seeds with *Bacillus* strains resulted in 4.63% to 41.64% germination increase over un-inoculated seeds. The green house studies showed that the bacterial strains significantly ($p \leq 0.05$) promoted the growth of bell pepper plants in all trials. The plant heights, leaf lengths, leaf numbers and stem girths of the inoculated plants ranged from 35.25 – 39.58 cm, 6.93 – 8.98 cm, 15.25 – 16.75, and 0.35 – 0.48 cm respectively compared to the un-inoculated plants (24.35cm, 5.05cm, 10.25 and 0.20cm respectively). The shoot and root weights were also significantly increased with bacterial inoculation. Therefore, *B. licheniformis*BP01, *B. subtilis*BP03, *B. subtilis*BP08 and *B. megaterium*BP11could be utilized as effective bioinoculants to promote growth of bell pepper under greenhouse conditions.

Keywords: *Capsicum annuum var. abbreviatum, Bacillus strains, growth promotion, bioinoculants*

INTRODUCTION

Pepper (*Capsicum annuum* L.) is one of the species in the genus *Capsiucm* and it is most widely cultivated in the world. It ranks second important vegetable in the world after tomatoes, and it is usually utilized for culinary purposes and seasonings (Idowu – Agida *et al*., 2010). Pepper is an important spice that is very rich in vitamins, minerals, capsaicin and capsochrome. It is an essential source of natural micronutrient antioxidants (vitamins C and E, and carotenoids) which help in preventing or reducing chronic and age-related diseases such as cancer, atherosclerosis and hemorrhage (Akinyemi and Liamngee, 2018). Pepper has also been found to be useful internally as a stimulant and carmative, and externally as a counter-irritant. It is also used for the treatment of toothache and sore throat (Sanusi and Ayinde, 2013). In organic farming systems, pepper extracts could be utilized as botanical pesticides against crop pests.

In Nigeria, pepper is cultivated mostly during the rainy season, but it could also be cultivated during the dry season in places where irrigation is available. It is usually grown for cash by the small holder farmers. Although pepper is widely cultivated in large quantities, yields obtained by the peasant farmers are often very low. This could be due to low soil fertility, weeds, pests and diseases (Sanusi and Ayinde, 2013).However, the improvement of soil fertility using chemical fertilizers is one of the strategies commonly adopted to increase pepper production in most developing countries. Although, these agrochemicals are easy to handle and improve agricultural productivity, they generate several environmental and public health problems such as destruction of soil organisms, interruption of the natural ecological nutrient cycles, deterioration of agricultural soils, and heavy metals' contamination of groundwater and crop products which could lead to cancer occurrence (Noumavo *et al*., 2016; Sharma and Singhvi, 2017). In order to minimize the human health and environmental hazards posed by the excessive use of chemical fertilizers, there is an urgent need to search for cheap, safe and environmental friendly strategies for improving soil quality and pepper production. One of the promising approaches is the use of bioinoculants such as plant growth-promoting rhizobacteria. Plant growth-promoting rhizobacteria is a group of bacteria capable of actively colonizing the plant root system in a competitive environment, improving their growth and yields (Wu *et al*., 2005). These free-living bacteria could colonize all ecological niches of root in all stages of plant development and exert a beneficial effect on plant growth (Bakker *et al*., 2007). Among the plant growth-promoting rhizobacteria are the different strains of *Bacillus* which are capable of forming endospores that allow them to survive unfavourable conditions for longer periods (Saharan and Nehra, 2011). *Bacillus* species could elicit plant growth promotion through solubilization of phosphate, biological fixation of atmospheric nitrogen, production of phytohormones such as auxins, cytokinin, etc (Deepa *et al*., 2010; Saharan and Nehra, 2011). These bacteria could also indirectly enhance crop growth and yields by acting as biocontrol agents through production of antibiotics, hydrolytic enzymes and hydrogen cyanide as well as induction of systemic resistance to diseases (Deepa *et al*., 2010). Thus, the application of *Bacillus* strains as crop inoculants could be an alternative option to reduce the use of chemical fertilizers. The present study was conducted to assess the growth promotion potential of indigenous *Bacillus* strains on bell pepper in the greenhouse.

MATERIALS AND METHODS

Bacterial strains

The *Bacillus* strains used in this study were isolated from the rhizosphere of bell pepper (*Capsicum annuum* var. *abbreviatum*) seedlings, assayed for plant growth promotion traits *viz:* antifungal antagonism, solubilization of phosphate, ammonia production, indole acetic acid production, production of hydrolytic enzymes and hydrogen cyanide. The fifteen potential plant growth-promoting *Bacillus* strains were then identified by morphological and biochemical methods as strains of *Bacillus subtilis, B. megaterium, B. licheniformis, B. polymyxa* and *B. cereus.*

Planting materials

Bell pepper (*Capsicum annuum* var. *abbreviatum*) seeds were sourced from the Institute of Agricultural Research and Training (IAR&T), Ibadan, Oyo State. The viability test was conducted on the seeds using the paper towel method in the laboratory of the Department of Microbiology, Federal University of Agriculture, Abeokuta.

In vitro seedling bioassay

The seed germination assay was conducted on fifteen potential plant growth-promoting *Bacillus* isolates by adopting the method described by Islam *et al*. (2016) with slight modifications. Surface-sterilization of bell pepper seeds was carried out by immersing the seeds in 70% ethanol for 1 minute, 5% Sodium hypochlorite solution for 2 minutes, rinsed five times in sterile distilled water and then air dried in a laminar flow at room temperature (25±2^{o}C).The bacterial inoculants for seed treatment were prepared by growing each *Bacillus* isolate in sterile nutrient broth at 30^{0}C for 24 hours with constant agitation at 120 rpm, followed by centrifugation at 5,000 ×g for 10 minutes at 4^{0}C.The supernatant was carefully discarded and the cell pellets were washed twice with sterile distilled water. Each bacterial cell was then suspended in a sterile 0.1M phosphate buffer (pH 7.0) and adjusted to 1.0×10^{8} cfu mL^{-1}. Then, dry sterilized seeds were soaked in each bacterial suspension at a rate of 0.1 mL per seed and stirred frequently for two hours. The treated seeds were air-dried overnight at room temperature (25±2^{0}C). The seeds used for control experiments were treated with sterile distilled water. For the germination bioassay, twenty five seeds each were placed in four petri dishes (9.0 cm diameter) lined with moistened Whatman filter paper No. 1, followed by incubation at room temperature (25±2^{0}C) for 7 days. The germinated seeds were counted on the 7th day and the germination percent was determined as follows:

Germination percent (GP) = $\Sigma GP \times 100/TS$

Σ GP: Number of germinated seeds

TS: Total number of seeds planted

Percent germination increase (PGI), the amount to which a *Bacillus* strain increased the seed germination percent over un-treated control, was calculated as:

PGI = (Germination percent of the treatment – Germination percent of the control) × 100 / Germination percent of the control

Influence of selected *Bacillus* strains on growth of bell pepper in a greenhouse

The pot experiments were carried out in the green house of College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta. The experiments were performed during the dry seasons of 2018 and 2019 using four *Bacillus* strains having higher plant growth-promoting traits *viz*: *Bacillus licheniformis* BP01, *Bacillus subtilis* BP03, *Bacillus subtilis* BP08 and *Bacillus megaterium* BP11 and each experiment was conducted in a completely randomized design with five treatments in four replicates. Each replicate consisted of a single pot with one plant per pot. The treatments consisted of T_1: Un-inoculated control (bell pepper plants without *Bacillus* inoculation), T_2: bell pepper plants inoculated with *B.licheniformis* BP01, T_3: bell pepper plants inoculated with *B.subtilis* BP03, T_4: bell pepper plants inoculated with *B.subtilis* BP08 and T_5: bell pepper plants inoculated with *B. megaterium* BP11. Seeds of bell pepper were surface – sterilized and inoculated with each *Bacillus* strain as described above. Un-inoculated seeds were treated with sterile distilled water. Prior to planting, inoculated and un-inoculated seeds were pre-germinated on moistened Whatman filter paper No.1 for 5 days and two pre-germinated seeds were sown in each pot. At 7 days of sowing, the seedlings were thinned to one plant per pot of comparable height. The second bacterial inoculations were then performed by soil drenching in which 50 mL of each bacterial suspension was applied to each plant. Sterile water was applied to un-inoculated control plants. All the pots were then maintained in the green house (at a 12h photoperiod and temperature of 25 to 30^{0}C) and the plants were watered twice in a day (morning and evening) without fertilizer application. Each experiment was conducted for 5 weeks.

Data collection and Statistical analysis

Data were collected on plant heights, leaf lengths, stem girths and leaf numbers at 5 weeks after sowing. The plant heights and leaf lengths of the plants were measured with a ruler, stem girths were measured using a pair of vernier calipers while leaf numbers were determined by counting the number of leaves. The plants were then carefully uprooted and the soil was washed off the roots. The shoot and root fresh weights were determined. The shoot and root dry weights were also determined after drying the shoots and roots in the oven at 60^{0}C for 3 days. The data collected from each trial were analyzed using One-way analysis of variance (ANOVA). Means were separated using the Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

RESULTS

Seed germination bioassay

The *in vitro* seed germination assay showed that treatment of bell pepper seeds with *Bacillus* strains resulted in increased germination percentage when compared to untreated control seeds. The percent germination increase (PGI) over untreated control seeds ranged from 4.63% to 41.64% (Figure 1). The highest germination percentages were observed in seeds treated with *B. subtilis* BP03 and *B. subtilis* BP08 resulting in highest percentage germination increase while the least increase was recorded in seeds inoculated with *B. subtilis* BP04 (Figure 1).

Effect of selected *Bacillus* strains on growth of bell pepper plants in a green house

The results of pot experiments revealed that inoculation with selected *Bacillus* strains (BP01, BP03, BP08 and BP11) stimulated the growth traits of bell pepper plants in the green house. In both trials, there were significant ($p \leq 0.05$) increases in plant heights, leaf lengths, number of leaves and stem girths of bell pepper plants inoculated with *Bacillus* strains as compared to un-inoculated control plants. Significantly ($p \leq 0.05$) higher plant heights and leaf lengths were observed in plants inoculated with *Bacillus subtilis* BP03 compared to the plants inoculated with other *Bacillus* strains and un-inoculated control plants (Table 1). In terms of number of leaves, the highest was recorded in plants treated with *B. licheniformis* BP01 in 2018, while both *B. licheniformis* BP01 and *B. subtilis* BP03 supported highest number of leaves in 2019 and the un-inoculated plants had lowest number of leaves in both years (Table 1). Furthermore, *Bacillus* inoculation had significant ($p \leq 0.05$) effect on the stem girths of bell pepper plants in both years. Though, no significant differences were observed among the four *Bacillus* strains, *Bacillus* strain BP03 recorded the highest stem girth in 2018 while *Bacillus* strain BP08 recorded the highest in 2019 (Table 1).

Effect of selected *Bacillus* strains on shoot and root growth of bell pepper plants

Inoculation of bell pepper with selected *Bacillus* strains significantly ($p \leq 0.05$) increased the shoot and root weights in both years as compared to un-inoculated plants. Inoculation with *B. licheniformis* BP01 recorded the highest shoot fresh weight (10.58 g/plant) in 2018, followed by *B. subtilis* BP03. However, *B. subtilis* BP03 gave significantly highest shoot fresh weight (10.88 g/plant) in 2019 (Table 2). There were no significant differences in shoot fresh weights of inoculated bell pepper plants in both years. Similarly, bacterial inoculation resulted in significantly ($p \leq 0.05$) higher shoot dry weights of bell pepper plants in both years than the un-inoculated control plants. The highest shoot dry weights were found in plants inoculated with *B. subtilis* BP03 (5.18 g/plant) and *B. subtilis* BP08 (5.58 g/plant) in 2018 and 2019, respectively (Table 2). Also, *Bacillus* inoculation significantly ($p \leq 0.05$) enhanced the root fresh and dry weights of bell pepper plants in both years when compared to un-inoculated control plants (Table 3).

DISCUSSION

The utilization of plant growth-promoting rhizobacteria (PGPR) as biological inoculants for improving the growth and yields of agricultural crops could be a viable and safer alternative to synthetic fertilizers in sustainable agriculture. However, *Bacillus* species are considered as the potential bioinoculants due to their abilities to synthesize several plant growth-promoting substances. In the present study, fifteen potential plant growth-promoting *Bacillus* strains were evaluated for their effects on seed germination of bell pepper and it was ascertained that these strains could enhance seedling emergence. The result of this present study corroborates the report of Islam *et al*. (2016). The capability of these *Bacillus* strains to improve seed germination could be attributed to their ability to produce some enzymes, most importantly α-amylase and proteases. The α-amylase enhances hydrolysis of starch into metabolizable sugars that provide energy for growth and development of embryo, and roots and shoots in germinating seedlings. Similarly, the proteases catalyze seed proteins into amino acids and peptides that are transferred to growing embryo (Akazawa and Nishimura, 2011; Joshi, 2018). As evident from the results of two experimental trials, inoculation of bell pepper with four effective plant growth-promoting *Bacillus* strains (*B. licheniformis* BP01, *B. subtilis* BP03, *B. subtilis* BP08 and *B. megaterium* BP11) significantly increased the plant heights, leaf lengths, leaf numbers and stem girths over non-inoculated control and the performances of these strains under green house conditions were consistent over the years. Also, inoculation with these *Bacillus* strains produced consistently improvement in plant biomass under potted conditions in the two trials. Growth promotion of different crops by several strains of rhizobacteria has been widely reported. Mandyal *et al*. (2012) reported that inoculation of *Capsicum annuum* with a native strain of *Bacillus* not only increased plant emergence, root and shoot lengths, but also caused an increase in fruit yield under green house conditions. Similar green house studies conducted by Hyder *et al.* (2020) showed that *Bacillus subtilis, B. megaterium* and *B. cereus* significantly suppressed the *Phytophthora capsici* infections and enhanced the growth characters of chilli pepper. Similarly, application of *Bacillus subtilis* individually or mixed with vermicompost improved growth of sweet pepper plants under green house conditions (Lara – Capistran *et al*., 2020). The efficacy of *B.licheniformis* BP01, *B. subtilis* BP03, *B. subtilis* BP08 and *B.megaterium* BP11 in promoting growth of bell pepper plants could be due to some growth promotion features associated with these *Bacillus* strains. These features include solubilization of phosphate and production of indole acetic acid (IAA). Indole acetic acid (IAA) secreted by most rhizobacteria is an effector molecule that plays an important role in plant-microbe interactions (Spaepen and Vanderleyden, 2011). It interferes with several physiological processes of plants by altering the plant auxin pool. It contributes to the regulation of plant development like organogenesis, cellular responses such as cell expansion, division and differentiation, and gene regulation (Ryu and Patten, 2008). It also increases the rate of xylem and root development; controls processes of vegetative growth; initiates lateral and adventitious root formation; mediates responses to light, gravity and florescence; affects photosynthesis, pigment formation, biosynthesis of various metabolites, and resistance to stressful conditions (Ahemad and Kibret, 2014). Also, rhizobacterial IAA increases root surface area and length, and thereby, provides the plant greater access to soil nutrients. Phosphorus, being one of the macronutrients needed for plant growth and development, plays a major role in photosynthesis, respiration, storage and transfer of energy, as well as in cell division and elongation (Sagervanshi *et al*., 2012). The *Bacillus* strains used in this study, being phosphate-solubilizing bacteria, could solubilize soil insoluble phosphate, making phosphorus available to the bell pepper plants. Other growth promotion traits possessed by these *Bacillus* strains include production of ammonia, hydrolytic enzymes, hydrogen cyanide and antifungal antagonism.

CONCLUSION AND RECOMMENDATION

Inoculation with indigenous strains of *Bacillus* effectively enhanced growth of bell pepper plants in a greenhouse and these strains may be applied as bio-inoculants to minimize the use of synthetic fertilizers in bell pepper production under greenhouse conditions. Further studies need to be conducted to determine the effectiveness of these strains under field conditions.

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Table 1: Influence of *Bacillus* strains on agronomic traits of bell pepper seedlings under green house conditions

Treatment	2018				2019			
	Plant height (cm)	Leaf length (cm)	Leaf number	Stem girth (cm)	Plant height (cm)	Leaf length (cm)	Leaf number	Stem girth (cm)
T_1	24.35 ± 0.81^{b}	5.78 ± 0.44^{c}	11.50 ± 0.96^{c}	0.20 ± 0.00	25.13 ± 1.54^{b}	5.05 ± 0.50^{c}	10.25 ± 0.48^{b}	0.28 ± 0.03^{b}
T_2	37.58 ± 0.76^{a}	7.80 ± 0.11^{b}	16.75 ± 0.63^{a}	0.35 ± 0.05^{a}	37.73 ± 2.10^{a}	7.15 ± 0.19^{b}	15.50 ± 0.75^{a}	0.40 ± 0.04^{a}
T_3	38.93 ± 1.27^{a}	8.98 ± 0.10^{a}	16.00 ± 0.71^{ab}	0.43 ± 0.05^{a}	39.58 ± 2.10^{a}	8.23 ± 0.16^{a}	15.50 ± 0.50^{a}	0.45 ± 0.03^{a}
T_4	35.25 ± 1.70^{a}	7.95 ± 0.22^{b}	15.75 ± 0.71^{b}	0.38 ± 0.03^{a}	36.50 ± 1.29^{a}	7.10 ± 0.17^{b}	15.25 ± 0.48^{a}	0.48 ± 0.05^{a}
T_5	36.52 ± 1.68^{a}	7.75 ± 0.30^{b}	16.25 ± 0.75^{a}	0.38 ± 0.05^{a}	36.20 ± 1.68^{a}	6.93 ± 0.23^{b}	15.25 ± 1.03^{a}	0.43 ± 0.03^{a}

Meanvalues (± standard error) followed by different superscripts within the same columnare significantly different at 5% level of probability using Duncan's Multiple Range Test (DMRT)

Keys: T_1: Un-inoculated bell pepper plants; T_2: Bell pepper plants inoculated with *Bacillus licheniformis*BP01

T_3: Bell pepper plants inoculated with *Bacillus subtilis* BP03; T_4:Bell pepper plants inoculated with *Bacillus subtilis* BP08

T_5:Bell pepper plants inoculated with *Bacillus megaterium* BP11

Table 2: Influence of *Bacillus* strains on shoot biomass of bell pepper seedlings in a green house

Bacterial strains	Fresh shoot weight (g)		Dry shoot weight (g)	
	2018	2019	2018	2019
T_1	7.13 ± 0.30^b	7.50 ± 0.25^b	2.83 ± 0.20^b	3.13 ± 0.27^c
T_2	10.58 ± 0.33^a	10.65 ± 0.40^a	4.73 ± 0.23^a	5.13 ± 0.08^{ab}
T_3	9.95 ± 0.33^a	10.88 ± 0.30^a	5.18 ± 0.19^a	4.98 ± 0.12^b
T_4	9.78 ± 0.28^a	10.53 ± 0.35^a	4.80 ± 0.12^a	5.58 ± 0.14^a
T_5	9.55 ± 0.40^a	10.18 ± 0.68^a	4.85 ± 0.17^a	5.23 ± 0.19^{ab}

Mean values(± standard error) followed by different superscripts within the same column are significantly different at 5% level of probability using Duncan's Multiple Range Test (DMRT)
Keys: T_1: Un-inoculated bell pepper plants; T_2: Bell pepper plants inoculated with *Bacillus licheniformis*BP01
T_3: Bell pepper plants inoculated with *Bacillus subtilis* BP03; T_4:Bell pepper plants inoculated with *Bacillus subtilis* BP08
T_5:Bell pepper plants inoculated with *Bacillus megaterium* BP11

Table 3: Influence of *Bacillus* strains on root biomass of bell pepper seedlings in a green house

Bacterial strains	Fresh root weight (g)		Dry root weight (g)	
	2018	2019	2018	2019
T_1	4.40 ± 0.18^b	4.93 ± 0.38^b	1.70 ± 0.16^b	1.80 ± 0.18^b
T_2	8.20 ± 0.36^a	8.75 ± 0.25^a	2.63 ± 0.25^b	2.83 ± 0.20^a
T_3	8.45 ± 0.23^a	9.43 ± 0.47^a	3.13 ± 0.15^a	3.28 ± 0.28^a
T_4	8.03 ± 0.29^a	8.95 ± 0.40^a	2.40 ± 0.38^{ab}	2.68 ± 0.34^{ab}
T_5	7.90 ± 0.17^a	8.83 ± 0.14^a	2.40 ± 0.34^{ab}	2.65 ± 0.38^{ab}

Mean values(± standard error) followed by different superscripts within the same columnare significantly different at 5% level of probability using Duncan's Multiple Range Test (DMRT)
Keys: T_1: Un-inoculated bell pepper plants; T_2: Bell pepper plants inoculated with *Bacillus licheniformis*BP01
T_3: Bell pepper plants inoculated with *Bacillus subtilis* BP03; T_4:Bell pepper plants inoculated with *Bacillus subtilis* BP08
T_5:Bell pepper plants inoculated with *Bacillus megaterium* BP11

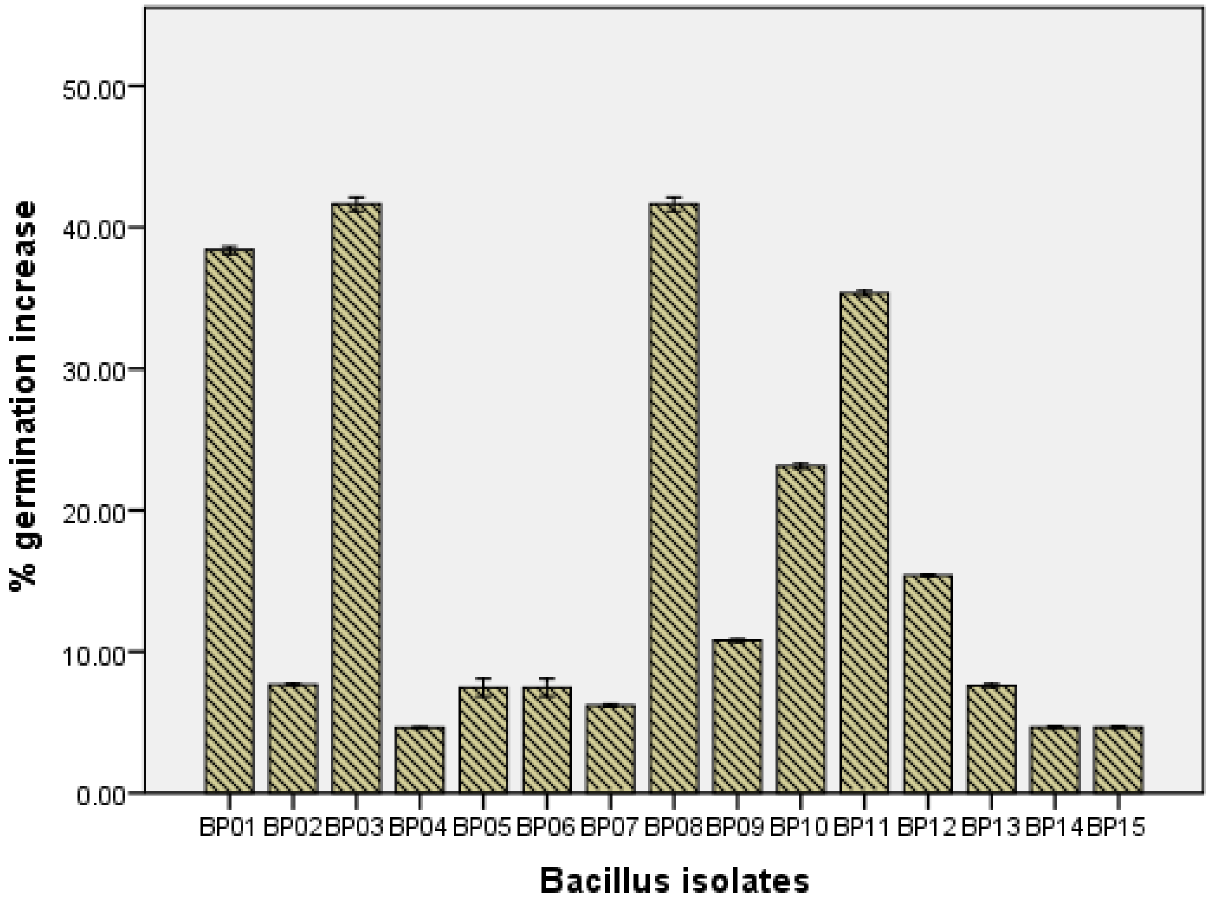

Figure 1: Influence of *Bacillus* isolates on seed germination of bell pepper
Error bars indicate ± standard deviations of means. Isolates are: BP01: *Bacillus licheniformis*; BP02: *B. polymyxa*; BP03: *B. subtilis*; BP04: *B. subtilis*; BP05: *B. megaterium*; BP06: *B. polymyxa*; BP07: *B. megaterium*; BP08: *B. subtilis*; BP09 *B. subtilis*; BP10: *B.licheniformis*; BP11: *B. megaterium*; BP12: *B. cereus*; BP13: *B. subtilis*; BP14: *B. megaterium* and BP15: *B. subtilis*.

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COMPARATIVE ECONOMIC ANALYSIS OF THE USE OF COVER CROPS, MULCH MATERIALS AND HERBICIDES AS WEED MANAGEMENT OPTIONS IN SWEET ORANGE (*CITRUS SINENSIS* L. OSBECK VAR. AGEGE-1) ORCHARD

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ABSTRACT
Weed management is imperative to achieve adequate growth and economic returns in Sweet Orange orchard. Field experiments were carried out to evaluate economics of the use of cover crops: Pumpkin, Egusi melon at 40,000 plants/ha, Sweetpotato (10,000 plants/ha), Akidi (53,333 plants/ha), Hand slashing at 6 times/year and No weeding as control. Also, black polyethylene sheet (0.2µ), cassava peel 30 t/ha, and sawdust (25 t/ha) as mulch, paraquat (276g a.i/L), glyphosate (480g a.i/L) as (post-emergence application) herbicide and no weeding as control. The spacing for Sweet Orange was 5m x 5m, while the experiment was laid out in randomized complete block designs in four replications. Data were collected on cost of inputs, labour and output from the cover crops at the prevailing market prices. Budgeting analysis was used to estimate level of profitability. Results revealed that hand slashing treatments recorded higher costs of production (₦ 248,165.00/ha**)** compared to the cover crops combination of Sweet Orange and Akidi in the first year (₦209,315/ha). For the mulch materials and herbicide treated plots, highest cost (₦217,165/ha) was incurred with Cassava Peel plots, while No Weeding plots gave the lowest (N148,165/ha) production cost in the first season. Highest revenue of ₦125,125/ha was obtained in the pumpkin plots in the first year. Cover Crop plots gave returns to investment in the 2 season of production compared to mulch materials and herbicide treatment plots. The study recommends appropriate Cover Crop combination that may help farmers manage weeds and also lessen the cost of management especially when the Sweet Orange are in the unproductive phase.

Keywords: *Sweet orange, Cover crops, Mulch materials, Herbicides, Budgeting analysis*

INTRODUCTION

Weed management is an important component of citrus production while inadequate weed management can influence tree growth negatively and reduce fruit yield (Rios *et al*, 2015). Weeds interfere with growth and development of fruit plants by competing for nutrients and harbour several insects' pests and diseases (Mandeep *et al*, 2019). Weeds are the class of crop pests and are responsible for marked losses in crop yields (Rana and Rana, 2016). Weeds can create a favourable environment for pathogens in citrus production (Futch and Singh, 2010). Tillage and hand slashing are common methods used for weed management in sweet orange orchards. The associated cost and seasonal labour shortage necessitate the need for alternatives such as the use of cover crops, mulches and herbicides (Aiyelaagbe, 2001). Cover crops are crucial in sustainable agriculture to improve sustainability of agro-ecosystem. It is important in soil conservation apart from controlling the weeds. Cover crops are also known to suppress weeds through allelophathy (Singh *et al*, 2011). Cover crop permits reduction of herbicide inputs, help in soil fertility maintenance and erosion control (Teasdale, 1996). Organic mulch is any material spread on the soil surface to improve soil and water conservation, and soil productivity (Sarolia and Bhardwaj, 2012). Mulching is also important for weed control, soil conservation, soil temperature modification, nutrient addition, improvement in soil structure and crop quality control. Mulching according to Liu *et al* (2009) reduces the deterioration of soil preventing the surface runoff and soil loss, reducing weed infestation and conserving water evaporation. Mulch can control erosion and when it decomposes, it becomes manure. It is worthy of note that weed management programs should focus on environmental safety as well as benefits to the farmers (Safdar *et al*, 2011). There is little information on economics of weed control in sweet orange orchard. Previous empirical work on economics of weed management in Nigeria include those of Osipitan *et al*, (2018). The authors analysed economics of weed management methods as influenced by row spacing in cowpea and found that pre-herbicide for weed management could help to optimize yield and increase profitability under a narrow spacing in cowpea cultivation. Samant and Prusty (2014) in India investigated effect of weed management on yield, economics and nutrient uptake in tomato and found that application of straw mulch was economically viable for control of weeds in case of labour scarcity with better nutrient uptake and maximum fruit yield and higher net profit. Chemical weed control refers to the use of chemicals otherwise known as herbicides to kill weeds or suppress their growth. Chemical weed control reduces human labour, improves tree growth, minimizes damage to tree stems, and enhances movement within the alleys (Dourán Zuazo *et al*., 2004). Herbicides must be carefully selected and applied for a specic tree age, scion and soil types so as to avoid causing injury to the citrus trees (Abouziena *et al.*, 2008). Herbicides could be selective or non-selective; contact or systemic; pre-emergence, post-emergence or pre-plant incorporated. George, (1982), reported that application of herbicide saves 20-67 % energy depending on tillage type and other physical weed control methods adopted. Farmers prefer pre-emergence/preplanting to post-emergence herbicide in monocropping systems rather than in mixed cropping systems. Energy saving and economic advantage of herbicide over mechanical labour intensive methods gives it a prime place in adoption by farmers. However, chemical weed control is not an alternative to good crop husbandry but to compliment it (Carson, 1987). Ikuenobe (2005) reported that in Nigeria, majority of farmers indicated reduction in labour (75.2%), cost of production (66.8 %), improved weed control (89.4%) and higher crop yield (69.7%) as benefits derived in using herbicide. Arising from the above, the study therefore examined economic efficiency of using various control strategies of weed management in sweet orange production. This is necessary to come up with sustainable practices that will lead to best management practices and adequate income to the producers.

MATERIALS AND METHODS

Two field experiments were carried out at the Citrus Research Programme of National Horticultural Research Institute (NIHORT) Ibadan, (07^0 $24^{\prime}$ $36.88^{\prime\prime}$ N, 003^0 $51^{\prime}$ $16.05^{\prime\prime}$ E, 213 meters) above sea level, where a juvenile citrus orchard was established with sweet orange (var. Agege-1) budded on Cleopatra mandarin rootstock. Ibadan lies in the derived savannah of South West Nigeria. The cover crop tested were pumpkin (*Cucurbita pepo* L.) at 1m x 0.5m (40,000 plants/ha), egusi melon (*Colocynthis vulgaris* L.) at 1m x 0.5m (40,000 plants/ha), sweetpotato (*Ipomoea batata* L.) at 1m x 1m (10,000 plants/ha). akidi (*Vigna sesquipedalis*) at 50cm x 75cm (53,333 plants/ha), hand slashing (6 x/year) and no weeding as control. In second field experiment, the mulch materials tested were black polythene sheet (0.2µ) at 765 kg/ha, cassava peel at 30 t/ha, sawdust at 25 t/ha, while herbicides; (Paraquat dichloride) at 276 g a.i/L and glyphosate (Isopropylamine salt) at 480 g a.i/L and no weeding (weedy check) also served as control. The plot size was 10m x 10m, while the spacing for sweet orange seedlings was 5m x 5m within and between rows, with total land area of 2400 m^2. The experimental design was a randomized complete block design (RCBD) in four replications.

Economic analysis of the performance of sweet orange with the cover crops, mulch materials and herbicide treatments were carried out using gross margin analysis, benefit to cost ratio and rate of return to investment (Gittinger 1972)

Gross Margin = TR - TVC

TR = Total Revenue

TVC = Total Variable Cost

BCR = TR/TVC

BCR = Benefit to Cost Ratio

BCR > 1 = Viability of the business

BCR = 1 is break even point

BCR < 1 = business not viable.

Return on Invesstment = Net return/Total cost

Gross margin, BCR and ROI were computed for each treatment using the prevailing price in the study area. The BCR and ROI were used to examine the viability and rate of Return on investment.

RESULTS AND DISCUSSSION

Estimated cost of Production and revenue with the cover crops (First cropping season)

The cost of production of sweet orange with the cover crops is presented in Table 1. At first cropping season, with the interplanted cover crops, highest cost of production was incurred in hand slashing plots (₦248,165.00/ha) followed by egusi melon plots (₦209,315.00/ha) and akidi plots (₦209, 315.00/ha). The lowest cost of production (₦150, 165.00/ha) was recorded from no weeding plots. Cost of production was lower in cover crop plots compared with hand slashing plots (Table 1). With the mulch materials and herbicide treatments plots, highest total variable cost of ₦217,165.00/ha was recorded in sweet orange plots mulched with cassava peel, black polythene sheet mulched plots with an establishment cost of ₦202,196.00/ha. Paraquat (N183,525/ha) and glyphosate treated plots recorded total variable costs that is less than ₦200,000, while the least cost of ₦171,165/ha was recorded from sweet orange plots mulched with sawdust (Table 2). Succinctly, costs of production were higher in cover crop plots compared to mulch materials and herbicides treated plots. This may be attributable to the cost of planting of the cover crops and the cost involved in weeding in plots with sweet orange and the various cover crops. There were returns from the cover crops in the first cropping season. The highest total revenue of ₦125, 125.00/ha was obtained from pumpkin plots followed by egusi melon plots (₦112, 000.00/ha), while the least was obtained from akidi plots (₦66, 825.00/ha). There was no revenue from hand slashing and no weeding plots at first planting. Similarly, no returns were obtained from the mulch treatments and herbicides treatments. The results of the gross margin analysis indicated negative returns to investment in the first cropping season. Hand slashing gave the highest negative returns of ₦248,165/ha and negative returns of 150,165/ha was obtained in the no weeding plots. In the Sweet Orange + cover crops double combination, highest negative returns was obtained in akidi plots (142,310/ha) followed by Sweet potato plots (134,007/ha), while the least negative returns was recorded for pumpkin plots. This occurred as a result of returns obtained from the cover crops. For the various mulch materials and herbicide treatments, there were also negative returns to investments in first cropping season.

Estimated cost of Production and revenue with the cover crops, mulch materials and herbicides treatments (second cropping season)

There were reductions in the production cost (Table 3) in the second cropping season with the cover crops, multch materials and herbicides treatment. The lowest production cost of ₦48,000.00/ha was recorded from sweet orange plots interplanted with sweet potato plots, while other cover crops recorded values that ranged between ₦50,268.00/ha in pumpkin plots and ₦51,150.00/ha in egusi melon plots. The highest gross margin of ₦106,000.00/ha was recorded from plots interplanted with sweetpotato plots followed by pumpkin plots (N84,176/ha) and egusi melon plots (N53,850/ha), while there was a negative return to investment of ₦80,000.00/ha in hand slashing plots. Also, no cost was incurred in no weeding plots, mainly because no activity was carried out on the plots during the period of observation. There were no revenue from the mulch materials and herbicides treated plots in the two cropping seasons (Table 4)

CONCLUSION AND RECOMMENDATION

Weed management in Sweet orange production is imperative for good growth and economic returns. The experiment evaluated economic implication of the use of cover crop, mulch materials and herbicides in the management of weeds in sweet orange orchards. Economically, sweet orange and cover crops combination produced certain level of returns in the first and second season of production that may be employed in orchard management when the sweet orange is yet to produce fruit. Based on the economic evaluation, the study recommends appropriate sweet orange + sweet potato and sweet orange + pumpking cover crop combination. The combinations may help farmers manage weed effectively and at the same time conserve nutrient for good growth and adequate returns.

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Singh Megh, Shiv D. Sharma, Analiza H. M. Remirez and Amit J. Jhala (2011). Glyphosate efficacy, absorption, and translocation in selected four weed species common to Florida citrus. *Hort Technology* 21(5) 599 - 605

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Table 1: Partial budget for a hectare sweet orange based cropping system as influenced by cover crops (₦) in 2012.

Production Variables	Pumpkin	Egusi melon	Sweetpotato	Akidi	Hand slahing	No weeding
Material Inputs						
Cost of sweet orange seedlings (400/ha)@ ₦250/seedling	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00
Cost of cover crop seeds	2,268.00	3,150.00	2,000.00	2,970.00	0.0	0.0
Sub – Total	102,628.00	103,150.00	102,000.00	102,970.00	100,000.00	100,000.00
Labour						
Slashing	29,640.00	29,640.00	29,640.00	29,640.00	29,640.00	29,640.00
Ploughing 1st and 2nd	12,350	12,350.00	12,350.00	12,350.00	12,350.00	12,350.00
Harrowing	6,175.00	6,175.00	6,175.00	6,175.00	6,175.00	6,175.00
Labour cost of planting sweet orange seedlings	20,000.00	20.000.00	20.000.00	20.000.00	20.000.00	20.000.00
Labour cost for planting cover crops	10,000.00	10,000.00	10,000.00	10,000.00	0.0	0.0
Labour cost for weeding @ ₦1000/manday x 20 mandays	20,000.00	20,000.00	20,000.00	20,000.00	80,000.00	0.0
Labour cost for harvesting	5,000.00	5,000.00	6,000.00	5,000.00	0.0	0.0
Labour cost for seed processing	3,000.00	3,000.00	0.0	3.000.00	0.0	0.0
Sub – Total	105,805.00	106,165.00	104,165.00	106.165,00	148,165.00	50,165.00
Total Variable Costs	208.433.00	209.315.00	206.165.00	209.135.00	248.165.00	150.165.00
Cropping system						
Average crop yield						
Sweet orange (kg/ha)	0	0	0	0	0	0
Pumpkin (kg/ha)	455.0	-	-	-	-	-
Egusi melon (kg/ha)	-	326.0	-	-	-	-
Sweet potato (kg/ha)	-	-	1202.0	-	-	-
Akidi (kg/ha)	-	-	-	225.0	-	-
Revenue (₦/ha)						
Citrus @ ₦30/kg	0	0	0	0	0	0
Pumpkin @ ₦275.50/Kg	125,125.00	-	-	-	-	-
Egusi melon @ ₦350.00/Kg	-	112,000.00	-	-	-	-
Sweet potato @ ₦60.60k/kg	-	-	72,158.80	-	-	-
Akidi @ ₦297.00/kg	-	-	-	66,825.00	-	-
Sub – Total	125,125.00	112,000.00	61,849.00	75,845.00	(248,165.00)	150;165.00
Gross Margin (₦/ha)	(83,308.00)	(97,315.00)	(134,007.00)	(142,310.00)	(248,165.00)	(150,165.00)

Table 2: Partial budget (₦) for a hectare sweet orange based cropping system as influenced by cover crops in 2013

Items	Pumpkin	Egusi melon	Sweetpotato	Akidi	Hand slashing	No weeding
Field clearing	10.000.00	10.000.00	10.000.00	10.000.00	0.0	0.0
Cost of cover crop seeds	2.268.00	3.150.00	2.000.00	2.970.00	0.0	0.0
Labour cost of planting cover crops	5.000.00	5.000.00	5.000.00	5.000.00	0.0	0.0
Labour cost for weeding @ ₦1000/ manday x 20 mandays	20.000.00	20.000.00	20.000.00	20.000.00	80.000.00	0.0
Labour cost for rogueing @ ₦5000/ha	5000.00	5000.00	5000.00	5000.00	0.0	0.0
Labour cost for harvesting	5.000.00	5.000.00	6.000.00	5.000.00	0.0	0.0
Labour cost for seed processing	3.000.00	3.000.00	0.0	3.000.00	0.0	0.0
Sub Total (Labour Costs)	38,000.00	38,000.00	36,000.00	38,000.00	80,000.00	00
Total Variable Cost	50.268.00	51.150.00	48.000.00	50.970.00	80.000.00	0.0
Average crop yield						
Sweet orange (kg/ha)	0	0	0	0	0	0
Pumpkin (kg/ha)	488.0	-	-	-	-	-
Egusi melon (kg/ha)	-	300.0	-	-	-	-
Sweet potato (kg/ha)	-	-	2220	-	-	-
Akidi (kg/ha)	-	-	-	287.0	-	-
Revenue (₦/ha)						
Sweet orange @ ₦30/kg	0	0	0	0	0	0
Pumpkin @ ₦275.50/Kg	134,444.00	-	-	-	-	-
Egusi melon @ ₦350.00k/Kg	-	105.000.00	-	-	-	-
Sweet potato @ ₦70.00/Kg	-	-	154,000.00	-	-	-
Akidi @ ₦297.00/kg	-	-	-	85.239.00	-	-
Sub – Total	134,444.00	105,000.00	154,000.00	85,239.00	-	-
Gross Margin (₦/ha)	84,176.00	53, 850.00	106.000.00	34,269.00	(80,000.00)	-

Table 3.:Partial budget (₦) for a hectare sweet orange based cropping system as influenced by mulch materials in 2012

Items	Black polythene sheet	Sawdust	Cassava peel	Paraquat	Glyphosate	No weeding
Material Inputs						
Cost of seedlings (400/ha @ ₦250/seedling	100.000.00	100.000.00	100.000.00	100.000.00	100.000.00	100.000.00
Cost of polythene sheet @ ₦65.40k/Kg X 765 Kg/ha	50.031.00	0.0	0.0	0.0	00	0.0
Cost of cassava peel @ ₦5.00/kg x 10,000 m^2	0.0	0.0	50,000.00	0.0	0.0	0.0
Cost of sawdust	0.0	5,000.00	-	-	-	-
Cost of herbicides @ ₦960 and ₦830/L x 4 operations	0.0	0.0	0.0	15.360.00	13.280.00	0.0
Sub – Total	150,031.00	105,000.00	150,000.00	115,360.00	113,280.00	100,000.00
Labour						
Slashing	29,640.00	29,640.00	29,640.00	29,640.00	29,640.00	29,640.00
Ploughing 1st and 2nd	12,350	12,350.00	12,350.00	12,350.00	12,350.00	12,350.00
Harrowing	6,175.00	6,175.00	6,175.00	6,175.00	6,175.00	6,175.00
Labour cost for mulch transportation	-	5,000.00	5,000.00	-	-	-
Cost of mulch application	2,000.00	5,000.00	6,000.00			
Labour cost for application of herbicide @ ₦5.000/ha x 4 operations	0.0	0.0	0.0	20.000.00	20.000.00	0.0
Labour cost of rogueing @ ₦1.000.00/ manday x 2 operations	2.000.00	8.000.00	8.000.00	0.0	0.0	0.0
Sub – Total	52,165.00	66,165.00	67,165.00	68,165.00	68,165.00	48,165.00
Total Variable Cost	(202,196.00)	(171,165.00)	(217.165.00)	(183.525.00)	(181.445.00)	(148.165.00)

Table 4.: Partial budget (N) for a hectare sweet orange based cropping system as influenced by mulch Materials and herbicide treatments in 2013

Items	Black polythene sheet	Sawdust	Cassava peel	Paraquat	Glyphosate	No weeding
Field clearing	10.000.00	10.000.00	10.000.00	10.000.00	10.000.00	0.0
Cost of polythene sheet @ ₦65.40k/Kg x 765 Kg/ha	50.031.00	0.0	0.0	0.0	00	0.0
Cost of cassava peel @ ₦5.00/kg x 10,000 m^2	0.0		50.000.00	0.0	0.0	0.0
Cost of herbicides x 4 operations	0.0	0.0	0.0	15.360.00	13.280.00	0.0
Cost of sawdust		4,000.00				
Sub – Total (mulch materials)	50,031.00	4,000.00	50,000.00	25,360.00	23,000.00	0.0
Labour cost of spreading mulch materials	2,000.00	4,000.00	6,000.00	-	-	-
Labour cost for mulch transportation	-	5,000.00	5,000.00	-	-	-
Cost for application of herbicide @ ₦5.000 x 4 operations	0.0	0.0	0.0	20.000.00	20.000.00	0.0
Labour cost of rogueing @ ₦1.000.00/ manday x 2 operations.	2.000.00	8.000.00	8.000.00	0.0	0.0	0.0
Sub – Total	4,000.00	17,000.00	19,000.00	20,000.00	20,000.00	0.0
Total Variable Cost	(64.031.00)	(31,000.00)	(79,000.00)	(45.360.00)	(43.280.00)	(0.0)

THE INFLUENCE OF SOIL AMENDMENTS ON SNAKE TOMATO PRODUCTION IN AN EXISTING IMMATURE RUBBER PLANTATION IN IYANOMO, NIGERIA

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ABSTRACT

This study compared the influence of different rubber effluents and NPK fertilizer rates and their combinations on the profitability of snake tomato production in the rubber/snake tomato intercrop in an existing but immature two years old plantation at Iyanomo, Edo State, Nigeria in 2018 and 2019 cropping seasons. This study involved 10 treatments derived from a combination of sole and intercropped combination with NPK and rubber effluent application rate laid out in a randomized complete block replicated three times. Data were collected on fruit yield. The economic analysis of the trials was carried out by partial farm budgeting. The results showed that NPK and rubber effluent application had significant effect on the yield components of snake tomato ($P<0.05$). Yield of snake tomato increased with increasing rate of rubber effluent application. However, NPK was more effective than rubber effluent at the highest application rate. Sole and intercropped snake tomato with or without soil amendments had similar yield values. The highest fruit yields were obtained from sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15 (STNPK) and Rubber-snake tomato intercrop treated with 60 kg N ha^{-1} of NPK 15:15:15 (RSNPK). However, STNPK had the highest revenue, gross margin and return per naira invested and hence the most viable.

Keywords: *Economic analysis, Fruit yield, Soil amendment, Variable cost.*

INTRODUCTION

Rubber (*Hevea brasiliensis* Wild ex A. de Juss. Muell.Arg.) belong to the family *Euphorbiceae,* it is commercially grown in plantations for the white exudates (latex) which is commonly referred to as white gold. Rubber is very significant in world's industrialization as expressly emphasized in the production of Elastomers (materials that are made of polymers or rubber), the use of which is indispensable in land, space, and water technologies (Howstuffworks, 2013). Natural rubber production in Nigeria suffered serious reduction in production from mid 1970s to late 1990s, as a result of low prices of rubber in the international market and other agronomic challenges (NRAN, 2013). Most serious among these challenges are, the long gestation period of rubber (5 to 7years), that deprived farmers of a sustainable income (income is tied down for 5-7 years without returns) during the immature phase and the fallow land brought about by rubber spacing (Michael, 2006). Though, the price of natural rubber in the international market has increased in recent times, but has not resulted in a corresponding increase in rubber production, and also, the need for the transformation of the economy through Agricultural transformation Agenda to help diversify the economy and cut down on the sole dependence on crude oil as the only export product and the quest to satisfy the world's growing demand for natural rubber have drawn government attention to rubber cultivation, as one of the crop that must receive priority attention (IRSG, 2001). To be able to achieve this feat in Natural rubber production in Nigeria, efforts must be put in to encourage the smallholder rubber farmers that contribute seventy-five percent of total rubber production (NRAN, 2013). Hence, there is the need for appropriate plantation management systems that can assist farmers to reduce the gestation period of rubber, reduce cost of production and ensure early returns on investment. One way to achieve these goals is the development of an agronomic system that will intercrop rubber with other arable crops. Snake tomato *(Trichosanthes cucumerina L.*

Haines) is an orphan crop that is gradually going extinct though its importance is increasing in several African countries including Ghana and Nigeria. This crop is mainly cultivated for the red fruit pulp used as a substitute for the regular tomato sauce, components which provide protection against harmful free radicals. Its use as an intercrop with rubber will create awareness of the existence and importance of the crop particularly to Iyanomo community, state, nation and the world at large and revenue generated from the sales of the harvested crop will serve as an additional income/ early returns to the rubber farmer during the immature period of rubber and also help in control of weeds, efficient resource use in the plantation and also reduce the cost of plantation maintenance and production. Rubber factory effluent is considered as a by-product (waste) from rubber processing factories and its disposal has been a source of concern to rubber factory owners and environmentalist. Its use as soil amendments will go a long way in the reduction of the cost of rubber production, improving soil fertility for the benefit of the crop and also taking care of issues of water pollution raised by environmentalist and the problem of disposal posed to rubber processing factories. Hence this study was set up to evaluate the influence of soil amendments on snake tomato production in an existing immature rubber plantation.

MATERIALS AND METHODS

The study was located at the Research Farm, Rubber Research Institute of Nigeria (RRIN), Iyanomo near Benin City, Edo State, Nigeria. RRIN lies within the rain forest zone of Nigeria. Prior to cropping with rubber and snake tomato, soil samples were randomly collected from the experimental site at a depth of 0 - 30 cm depth using auger and bulked to form a composite sample. The composite soil sample was air-dried and sieved through a 2 and 0.5 mm mesh and analyzed for its physical (particle size) and chemical (pH, organic C, total N, available P, exchangeable cations and acidity) properties using standard laboratory procedures. The study involved 10 treatments derived from sole rubber and snake tomato and their intercropped combination with NPK and rubber effluent application laid out in a randomized complete block design in three replications, the rates of rubber effluent application were; 50, 60, and 70 kg N ha^{-1}. The treatment combinations were as follows:

- Rubber Effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (RE1RS)
- Rubber Effluent at application rate of 50 kg N ha^{-1} cropped with sole snake tomato (RE1ST)
- Rubber Effluent at application rate of 60 kg N ha^{-1} cropped with rubber and Snake tomato (RE2RS)
- Rubber Effluent at application rate of 60 kg N ha^{-1} cropped with sole snake tomato (RE2ST)
- Rubber Effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (RE3RS)
- Rubber Effluent at application rate of 70 kg N ha^{-1} cropped with sole snake tomato (RE3ST)
- Rubber and Snake Tomato intercrop control (RSC)
- Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15 (RSNPK)
- Sole Snake Tomato control (STC)
- Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15 (STNPK).

The snake tomato was sown in a polybag filled with a mixture of top soil and poultry manure in ratio 4:1 at a depth of 3cm on the 11th of June 2018 and 2019. Emerged seedlings were watered once in three days. Transplanting was done on the 29th of June 2018 and 2019. Only seedlings with three fully expanded leaves were transplanted to the field. A two years already established plantation in the Institute was cleared of the existing vegetation except for the rubber planted and debris packed out of the plantation in the 2018 cropping season. Thereafter the field was marked out into plots measuring 3 x 7 nm with a metre pathway. Rubber effluent was applied to the designated plots as per treatment on the 3rd of June 2018 and 2019, and snake tomato transplanted on the 29th of June 2018 at a spacing of 0.5 by 0.5 m. NPK fertilizer was applied on the 13th of July 2018 and 2019, using the ring method of fertilizer application. After harvest in the three years old plantation (2018 cropping season), the plantation was left to fallow until the next growing season (2019 cropping season), thereafter the plantation was cleared in preparation for the next planting and the debris packed out of the plantation, rubber effluent was applied to the already established plot on the 2nd of June 2019, snake tomato was transplanted to the field on the 17th of June 2019, NPK fertilizer was then applied on the 31st of June 2019. Trellis were erected on the plots immediately after planting since the snake tomato is an annual herbaceous climber, this was done by cutting sticks (pegs) of 1.2m, six per plot and pegged at different points within the plot and connected together with a 2mm twine, then the crops were trained to climb through the twine. Weeding was done six weeks after transplanting manually using hoe and cutlass. Fertilizers used for the experiment were both organic (Rubber effluent) which was applied two weeks before transplanting with the aid of a watering can as per treatment. Inorganic fertilizer (NPK 15:15:15) which was applied as per treatment using the ring method of application at two weeks after transplanting. At harvesting of fruits of snake tomato, data were collected on fruit length, fruit diameter, number of fruits per plant, fruit weight, number of rotten fruits per plant and fruit yield. Economic analysis was used to determine the cost and economic return for snake tomato fruit production from treatments. All expenses (The total variable cost include item total cost of labour (Land preparation, sowing, transplanting, fertilizer application/manuring, vine caring, harvesting, processing), cost of planting materials, cost of NPK/rubber effluent, transportation, stakes, twine, etc) and revenue were estimated per hectare. The expenses and revenue data were collected through personal interview, money spent in the course of executing this study and revenue realized from the sale of the harvested product. The gross margin and viability ratio were used to determine the profitability of the effect of soil amendment on snake tomato fruit production in rubber-snake tomato intercrop. The model used for estimating gross margin can be expressed by this equation and thus:

$$GM = \sum_{i=1}^{n} P_{yi} \cdot Y_i - \sum_{j=1}^{m} P_{xj} \cdot X_j \; \ldots.. (1)$$

Where GM - gross margin
Y_i – Enterprise's product (s) where (I = 1, 2, 3……………n products)
P_{yi} – Unit price of the product
Xj – Quantity of the variable input (where j = 1, 2, ..3 ….n variable inputs)
i.e. GM = Total revenue (TR) – Total variable cost (TVC)………..(2)
Returned per naira invested = $\frac{TR}{TVC}$

The data collected were subjected to analysis of variance using GENSTAT statistical package twelfth edition. Means were separated using least significant difference (LSD) at 0.05 level of probability.

RESULTS

Soil physical and chemical properties prior to cropping with rubber and snake tomatoand the chemical composition of the rubber effluent

The soils were strongly acidic and low in organic C, total N, available P and exchangeable Ca (Table 1). The Ca/Mg ratios were moderate. The soils were texturally sandy loam. The chemical analysis of the rubber effluent used for the study showed that it was moderately acidic with total dissolved solids, chemical oxygen demand and biochemical oxygen demand (Table 2). It contained total N, available P, organic C, K, Mg, Na and Ca in appreciable amount.

Fruit yield and components of snake tomato

The results of the effects of NPK and rubber effluent on fruit yield and its components of snake tomato in sole and intercrop with rubber in an existing rubber plantation is shown in Table 3. The longest fruits were observed in STNPK and RSNPK plants in both experiments and in the combined analysis. Plants in STC, RSC and RE1ST had the shortest fruits in 3rd year experiment and in the combined analysis. In the 4th year experiment, STC plants had the shortest fruits, which was identical with fruits of RE1RS, RE1ST and RSC plants. Fruits were longer in the 4th year experiment than in the 3rd year experiment. This distribution pattern of the 4th year experiment for fruit length was repeated for the fruit diameter. Fewest numbers of fruits per plant were produced by plants in RSC and RE1RS which was comparable with the number of fruits produced by plants in STC, RE1ST, RE2RS and RE3ST in the 3rd year experiment. The highest number of fruits per plant was produced by plants in RSNPK which was comparable with STNPK and RE3ST. In the 4th year experiment and in the combined analysis, RSNPK had the highest number of fruits per plant which was comparable with the number of fruits produced in plants in STNPK while plants in STC had the fewest number of fruits per plant which were comparable with RSC, RE1ST and RE1RS. More fruits per plant were produced in the 4th year experiment than in the 3rd year experiment. Increase in rubber effluent application rate brought increase in the number of fruits per plant up to the highest rate which was lower than snake tomato treated with NPK (RSNPK and STNPK). Fruits with the lowest weights were in STC plants which was not significantly different from other treatments except RSNPK STNPK and RE1RS which had the highest fruit weights in the 3rd year experiment. In the 4th year experiment and in the combined analysis, increase in the rate of rubber effluent application led to an increase in the fruit size. However, rubber effluent application of 50 and 60 kg N ha^{-1} resulted in similar fruit size with RSC and STC plants. In the 4th year analysis, experiment, RSNPK and STNPK plants had the heaviest fruits which were not significantly heavier than RE3ST. In the combined analysis, STNPK and RSNPK had heaviest fruits while the lightest fruits were recorded with RSC and STC plants. Fruits were heavier in the 4th experiment than in the 3rd experiment. The number of rotten fruits per plant was more with fertilized plants than untreated plants. Plants in STC had the lowest number of rotten fruits per plant in both experiments and in the combined analysis. However, in the 3rd year experiment, rotten fruits in STC plants were comparable with RSC, RE2RS and RE2ST plants. 4th year experiment, rotten fruits in STC plants were identical with all other treatments except RE3ST which had the highest number of rotten fruits. Plants in STC had the highest number of rotten fruits per plant which were identical with RSC, RE2ST and RE2RS plants. Most rotten fruits were recorded in RSNPK plants which were comparable with STNPK, RE3ST and RE3RS in both experiments and in the combined analysis. In both experiments and in the combined analysis, RSNPK plants had the highest fruit yield which was similar with plants in STNPK. Unfertilized plants (STC and RSC) had the lowest fruit yield. However, in the 3rd year experiment, unfertilized plants were similar with RE1RS, RE1ST and RE3RS plants. In the 4th year experiment, plants in STC and RSC were similar with the plants in RE1RS and RE2ST while in the combined analysis, RSC and STC plants were similar with plants in RE1RS. Fruit yield was higher in the 4th year experiment than in the 3rd year experiment. Fruit yield increased with increasing rate of rubber effluent application and peak at the highest rate of application. The fruit of the effluent highest application rate was inferior to NPK treated plants (RSNPK and STNPK).

Economic analysis of snake tomato fruit production

The results of the economic analysis in Table 4 showed that the variable cost increased with increasing rubber effluent application rate. It ranged from ₦ 200,917.75 to ₦ 296,667.75 with RSC and RSNPK, respectively. The total variable cost of the sole cropping was lower than those of the intercrops. Revenue, gross margin and return per naira invested increased with increasing rubber effluent application rate. However, revenue, gross margin and return per naira invested were higher in NPK treated plants (both sole and intercrop) than rubber effluent treated plants. The lowest and highest revenue, gross margin and return per naira invested were recorded in RSC and RSNPK, respectively. Total variable costs were lower in sole and intercrop plants without fertilizer treated than plants treated with soil amendments (Table 5). Total variable cost increased with increasing effluent application rate both for sole and intercrop. However, both sole and intercrop plants treated with NPK had higher variable cost than those treated with rubber effluent. Gross margins were negative and less than one in respect to return per naira invested with RE1RS, RSC and STC. RSNPK had the highest revenue, gross margin and return per naira invested.

DISCUSSION

The soil of the experimental site were strongly acidic with values lower than critical level for some essential nutrients. This implied that the soil has low fertility status. Law-Ogbomo and Osaigbovo (2018) reported that most Nigerian soils are low in native fertility owing to the highly weathered soils coupled with leaching and continuous cropping. Soil fertility is a very important factor in soil productivity in relation to nutrient and yield (Erhabor, 1995). Plants need supply of appropriate proportionate essential nutrients from the soil for optimum growth, development and yield. Low soil fertility status without adequate soil nutrient amendment will result in growth and yield depression due to nutrient deficiencies (Law-Ogbomo *et al*., 2020). The analysis of the rubber effluent showed variability depending on location. They were moderately acidic and contain N, P, K and Ca in appreciable quantity. The effluent has high concentration of organic carbon, COD and BOD at safe level. This finding is in agreement with Orhue *et al*. (2007) who reported highly significant amount of total suspended and dissolved solids, phosphate and total N in rubber effluent. Orhue and Osaigbovo, (2013) reported that rubber effluent had great potential as organic fertilizer and could be beneficial to arable crops without additional cost as effluent are waste product of rubber processing factories and its disposal has been a major concern to factory owners. This is an indication that rubber effluent which ought to be waste and pollutant to the environment can be made to be an avenue for wealth creation through its conversion to organic fertilizer. This study has showed that during the first four years of rubber cultivation, snake tomato can be cropped successfully within rubber plants spaces thereby contributing positively to national food security and ensuring land sustainability. This study has showed the need to save this crop from extinction. The high snake tomato yield with low rotten, longer and heavier and higher number of fruits per plants accrued to plants treated with soil amendment is clear evidence that rubber effluent and NPK enhanced yield positively. This observation is in agreement with Mbonu and Arifalo (2016) who reported that, the use of readily available fertilizer enhances the yield of the plant. However, yield was most enhanced with NPK. Snake tomato plant treated with rubber effluent applied at 50 Kg N ha^{-1} had similar yield with plants without fertilizer treatment. This implies that rubber effluent application only enhanced fruit yield at higher application rate. The reduction in fruit yield of snake tomato observed in plants grown on unfertilized plots could have arisen from insufficient nutrient uptake as the plant have to rely on nutrients from the soil which have been found to be less than the critical level in some essential plant nutrients. Apart from the nutrient being low, there could be a problem of availability of phosphorus, calcium and magnesium to the plant since pH was less than 5.50 indicating strong acidity. The cropping of snake tomato in rubber plantation yielded revenue, this is an indication that cropping snake tomato in rubber plantation guaranteed regular flow of income which will help to upset the initial capital invested in rubber plantation thereby reduces the farmers financial burden. The early initial income from growing snake tomato in the rubber plantation will enhance the maintenance of the rubber plantation and sustain rubber latex production efficiency in the long run. The success of this system is an indication that rubber farmers can begin to draw revenue from their investment from the early stage of cropping. This will spearhead economic development leading to improvement of their standard of living for sustainable rural development and poverty alleviation. The revenue accrued from snake tomato is an indication that under-utilized land resources in within rubber plant space at the early stage of its growth and development is efficiently utilized by snake tomato to ensure income flow to the farmers. Giroh *et al.* (2011) reported that rubber intercropped with other crops was profitable as additional source of revenue to the farmer which is capable of improving the farmer's socio-economic wellbeing. According to Joshi *et al*. (2002) smallholder rubber farmers generated approximately 70 percent of the total household income from rubber based intercropping system (RBIS). Thus, additional incomes were created from a range of added crop mixtures to rubber. The profitability analysis of intercropping rubber with snake tomato plants and fertilized with rubber effluent and NPK were feasible and viable since their revenues were higher than the variable cost (Esekhade *et al*, 2014) and their returns per naira invested were greater than 1.00 (Law-Ogbomo and Osaigbovo, 2016). Fertilization has ensure the achievement of profitability as the unfertilized snake tomato plant yielded negative gross margin and less than 1.00 returns per naira invested. The economic viability of the fertilized intercropped snake tomato production will improve the farmer's standard of living and reduced the financial burden on them maintaining the rubber plantation. This observation was in line with Giroh *et al*. (2011) who reported that intercropping rubber with arable crops is economically viable and a means of poverty alleviation among small holder rubber farmers. The economic viability of the fertilized plants was due to higher fruit yield and low rotten and discarded fruits. The unfertilized snake tomato plants both sole and intercropped were not viable due to poor yield production and higher proportion of rotted fruits.

CONCLUSION AND RECOMMENDATION

The study shows that intercropping rubber plant with snake tomato was desirable. It ensures income flow to farmers early to offset the initial cost of investment on rubber plantation. Fertilizer application increased the yield of snake tomato. Based on these findings, snake tomato intercropping with rubber should be supplemented with fertilizer application to improve the fertility of the soil to sustain the yield of snake tomato. There were yield disparity between NPK and rubber effluent treated plants, however, the application of rubber effluent at 70 kg N ha^{-1} was promising. NPK should be applied at 60 Kg N ha^{-1} (400 Kg NPK ha^{-1}) to increase fruit yield of snake tomato.

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Table 1: Pre-cropping characterization of soils from the experimental site

Parameter	Existing plantation	Critical level	Fertility class
pH(H_2O) 1:1	5.40		SA
Organic carbon (g kg^{-1})	17.20	30.00 g kg^{-1} (Enwezor *et al*., 1989)	Low
Total nitrogen (g kg^{-1})	0.81	1.50 g kg^{-1} (Sobulo and Osiname, 1981)	Low
C:N	21.23		
Available phosphorus (mg kg^{-1})	13.00	16.00 mg kg^{-1} (Adepetu *et al*., 1979)	Low
Exchangeable cation (cmol kg^{-1})			
Calcium	0.82	2.60 cmol kg^{-1} (Agboola and Corey, 1973)	Low
Magnesium	0.25		
Ca/Mg	3.40	3.00 (FDALAR, 1975)	Adequate
Potassium	0.17	0.16 - 0.20 (Hunter, 1975)	
Sodium	0.06		
Exchangeable acidity (cmol kg^{-1})			
Hydrogen	0.16		
Aluminum	0.11		
Particle size (gk g^{-1})			
Sand	886.00		NA
Silt	64.00		NA
Clay	50.00		NA
Textural class	Sandy loam		NA

SA - Strongly acidic
NA – Not applicable

Table 2: Chemical composition of rubber effluent

Parameter	Value
pH (H_2O)	6.20
Organic carbon (%)	29.60
Total nitrogen (%)	1.10
Phosphorus (%)	2.03
Potassium (%)	0.22
Magnesium (%)	0.38
Calcium (%)	0.49
Sodium (%)	0.04
Zinc (%)	0.05
Copper (%)	0.02
Manganese (%)	0.08
Iron (%)	0.10
Chemical oxygen demand (mg l^{-1})	410.00
Biochemical oxygen demand (mg l^{-1})	250.00
Total dissolved solids (mg l^{-1})	760.00

Table 3: Effect of NPK and rubber effluent on fruit yield and its components of snake tomato cropped in an existing rubber plantation

Treatment	Fruit length (cm)			Fruit diameter (cm)			Number of fruits per plant			Fruit weight (kg fruit^{-1})			Number of rotten fruits			Fruit yield (t ha^{-1})		
	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined
RE1RS	38.00	39.33	38.67	3.10	3.97	3.53	9.33	8.67	9.00	0.77	0.73	0.75	3.67	3.33	3.50	27.30	24.10	25.70
RE1ST	37.33	38.00	37.67	3.23	3.67	3.45	10.00	10.33	10.17	0.73	0.73	0.73	3.67	3.67	3.67	28.07	28.83	28.45
RE2RS	38.33	42.67	40.50	3.50	4.70	4.10	11.00	12.67	11.83	0.70	0.77	0.73	3.00	3.33	3.17	29.57	36.70	33.13
RE2ST	37.67	41.00	39.33	3.43	4.73	4.08	11.67	13.67	12.67	0.73	0.70	0.72	3.33	4.00	3.67	32.40	36.33	34.37
RE3RS	39.00	43.67	41.33	3.60	5.00	4.30	10.67	14.00	12.33	0.73	0.80	0.77	4.00	4.00	4.00	29.97	42.27	36.12
RE3ST	38.33	43.33	40.83	3.57	5.13	4.35	12.00	14.33	13.17	0.73	0.83	0.78	4.00	4.67	4.33	33.27	45.47	39.37
RSC	36.00	38.00	37.00	3.00	3.23	3.11	9.33	8.33	8.83	0.63	0.67	0.65	2.67	3.00	2.83	22.63	21.00	21.87
RSNPK	47.33	58.00	52.67	3.73	5.13	4.43	13.33	19.33	16.33	0.87	0.90	0.88	4.67	4.67	4.67	44.03	66.07	55.05
STC	36.33	36.67	36.50	3.20	3.17	3.18	9.67	7.67	8.67	0.63	0.70	0.67	2.00	3.00	2.50	23.10	20.20	21.65
STNPK	48.33	57.00	52.67	3.67	5.13	4.40	12.33	18.33	15.33	0.83	0.93	0.88	4.00	4.33	4.17	39.07	64.73	51.90
Mean	39.67	43.77	41.72	3.40	4.39	3.90	10.93	12.73	11.83	0.74	0.78	0.76	3.50	3.80	3.65	30.94	38.58	34.76
$LSD_{(0.05)}$ trt	1.647	3.531	2.052	2.501	0.833	0.513	2.005	2.674	1.91	0.127	0.120	0.086	1.325	1.341	1.073	8.036	9.051	6.100
$LSD_{(0.05)}$ year	0.918			0.229			0.854			0.0385			0.480			2.728		

Foot note
RE1RS - Rubber effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
RE1ST - Rubber effluent at application rate of 50 kg N ha^{-1} snake tomato (Sole)
RE2RS - Rubber effluent at application rate of 60 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
RE2ST - Rubber effluent at application rate of 60 kg N ha^{-1} snake tomato (Sole)
RE3RS - Rubber effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
RE3ST - Rubber effluent at application rate of 70 kg N ha^{-1} snake tomato (Sole)
RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)
STC - Sole snake tomato (control)
STNPK - Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15
RSNPK - Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15
Trt - treatment

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Table 4: Economic analysis of snake tomato cropped in an existing rubber plantation (3rdyear) treated with NPK and rubber effluent

Item cost and return (N ha^{-1})	RE1RS	RE1ST	RE2RS	RE2ST	RE3RS	RE3ST	RSC	RSNPK	STC	STNPK	$LSD_{(0.05)}$
Land preparation	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	ns
Planting material	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	ns
Sowing	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	ns
Pre-emergent herbicide and its application	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	ns
Fertilizer and its application	9,000.00	9,000.00	11,000.00	11,000.00	13,000.00	13,000.00	0.00	69,000.00	0.00	69,000.00	1147.100
Stake collection and staking	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	ns
Harvesting, processing and packaging	54125.00	65087.50	66962.50	70000.00	67462.50	71587.75	58287.75	85037.75	58875.00	78837.50	543.700
Total variable cost	205755.00	216717.50	220592.50	223630.00	223092.50	227217.75	200917.75	296667.75	201505.00	290467.50	31800.800
Revenue	235875.00	245612.50	258737.50	283500.00	262237.50	291112.50	198012.50	385262.50	202125.00	341862.50	32282.600
Gross margin	30120.00	28895.00	381445.00	59870.00	39145.00	63894.75	-2905.25	88594.75	620.00	51395.00	8172.700
Return per naira invested	1.15	1.13	1.18	1.27	1.18	1.28	0.99	1.30	1.00	1.18	0.069

Foot note

RE1RS - Rubber effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE1ST - Rubber effluent at application rate of 50 kg N ha^{-1} snake tomato (Sole)

RE2RS - Rubber effluent at application rate of 60 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE2ST - Rubber effluent at application rate of 60 kg N ha^{-1} snake tomato (Sole)

RE3RS - Rubber effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE3ST - Rubber effluent at application rate of 70 kg N ha^{-1} snake tomato (Sole)

RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)

STC - Sole snake tomato (control)

STNPK - Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

RSNPK - Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

Table 5: Economic analysis of snake tomato cropped in an existing rubber plantation (4th year) treated with NPK and rubber effluent

Item cost and return (N ha^{-1})	RE1RS	RE1ST	RE2RS	RE2ST	RE3RS	RE3ST	RSC	RSNPK	STC	STNPK	$LSD_{(0.05)}$
Land preparation	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	ns
Planting material	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	ns
Sowing	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	ns
Pre-emergent herbicide and its application	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	34,630.00	ns
Fertilizer and its application	9,000.00	9,000.00	11,000.00	11,000.00	13,000.00	13,000.00	0.00	69,000.00	0.00	69,000.00	1402.900
Stake collection and staking	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	ns
Harvesting, processing and packaging	60,125.00	66,037.50	75,875.00	75,412.50	82,837.50	86,837.50	56,375.00	112,587.50	55,250.00	110,912.50	12.480
Total variable cost	211,755.00	218,667.50	229,505.00	229,042.50	238,467.50	242,467.50	199,005.00	324,217.50	197,880.00	322,542.50	625.700
Revenue	210,875.00	252,262.50	321,125.00	317,887.00	369,862.50	387,862.50	184,625.00	578,112.50	176,750.00	566,387.50	5.267
Gross margin	-880.00	33,595.00	91,620.00	88,844.50	131,395.00	145,395.00	14,380.00	253,895.00	-21,130.00	243,845.00	13.030
Return per naira invested	0.99	1.15	1.40	1.39	1.55	1.60	0.93	1.78	0.89	1.76	0.034

Foot note

RE1RS - Rubber effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE1ST - Rubber effluent at application rate of 50 kg N ha^{-1} snake tomato (Sole)

RE2RS - Rubber effluent at application rate of 60 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE2ST - Rubber effluent at application rate of 60 kg N ha^{-1} snake tomato (Sole)

RE3RS - Rubber effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE3ST - Rubber effluent at application rate of 70 kg N ha^{-1} snake tomato (Sole)

RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)

STC - Sole snake tomato (control)

STNPK - Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

RSNPK - Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

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COMPARATIVE MORPHOLOGY AND REPRODUCTIVE MECHANISM OF NIGERIAN *PASIFLORA FOETIDA* AND *PASIFLORA EDULIS*

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ABSTRACT
Passiflora species are important ornamental and fruit crops with high medicinal properties. This study compared morphology and reproductive mechanism of *Passiflora foetida* L. and *Passiflora edulis* F. from Nigeria. Each of the *Passiflora* species was scored for diagnostic morphological traits. Also pollination mechanisms were investigated on 50 flowers in the opened and bagged treatments which include: emasculation, natural self-pollination, manual self-pollination, geitonogamy and manual crosspollination methods. The foragers that visited the plants and their activities were documented. Result showed that the two species varied in their morphological traits. The fruits of *P. foetida* remained green when matured while fruits of *P. edulis* turned yellow. All the open pollination treatments of *P. edulis* produced more fruits than the bagged treatments. *P. foetida* produced fruit mainly through autonomous self-pollination but *P. edulis* produced fruit by self-pollination and cross pollination enhanced by insect visit to the flowers. Floral visitors were not observed on *P. foetida* but floral visitors such as *Xylocopa caffra*, *Xylocopa frontalis*, *Dactylurina staudigeri* and *Trigona fuscipennis* were observed on *P. edulis* to collect either nectar or pollen grains. The study concluded that the two species varied in their morphological traits and reproductive mechanism. *P. foetida* is adapted to reproduction through autogamy while *P. edulis* exhibit mixed pollination system of selfing and outcrossing which is enhanced by bees that visit the flower for pollen and nectar.

Keywords*:* *Passiflora, Pollination, Insect, Fruit set*

INTRODUCTION

Passiflora is the most important genus in the passion flower family, distributed within the tropical and sub-tropical regions (MacDougal and Feuillet, 2004). Few of the *Passiflora* species are cultivated for their edible fruit and many have ornamental values, and medicinal properties (Guire, 1999; Patil *et al.*, 2013). More than 350 species have been reported in tropical regions and rain forests of South America out of which 60 are edible species. Although all *Passiflora* species produce complex flowers with structural similarities, species vary substantially in their colour, flower structure and behaviour (Burks and Lanza, 2008). Flowers of *P. edulis* are large, attractive, colourful with fragrance and produce plenty nectar and pollen that facilitates insects visit for cross pollination (Yahia, 2011). An increasing numbers of various interspecific hybrids have been produced in the genus, thus contributing to broad morphological variability within the genus (Muschner *et al*., 2006)**.** *Passiflora* species are expected to have an efficient pollination mode and flexible breeding system, since the extent of fruit set is dependent on efficient pollination for such a wide adaptability (Amela and Hoc, 2011). Self- incompatibility have been reported in many *Passiflora* species (Amorim *et al*., 2011; Alkamin and Girolami, 1959). Nishida (1968), showed that insects were the main problem relative to crop production and observed an average of 37% from open pollination. Wind pollination is ineffective in *Passiflora* species since pollen is heavy and sticky thus making pollen transfer to occur through insects (Burks and Lanza, 2008). Bees have been reported to play important role in the pollination of many *Passiflora* species. Fruit production in *Passiflora* species have been reported to increase when hives are located near the areas where planting is done. Benevides (2006), reported that some *Passiflora* species can reproduce through xenogamy in 95% of the flowers tested, but self-pollination and geitonogamy pollination treatment occurred in lower percentages *Passiflora* species varies in their pollination mechanisms in relation to their environment which could be within or between species. There are no report on the pollination mechanisms of *P. edulis* and *P. foetida* from Nigeria. This study compared the reproductive mechanisms and morphological characters of *P. edulis* and *P. foetida* from Nigeria.

MATERIALS AND METHODS

This study was carried out at the Department of Botany, Obafemi Awolowo University Ile-Ife between March 2019 and October 2019. The seedlings of *P. edulis* and *P. foetida* used were collected from the genetic unit of the Department of Botany, Obafemi Awolowo University Ile-Ife. At four leaves stage, the seedlings of each species were transplanted into a field at a spacing of 5m by 5m, at the rate of one plant per stand with 10 replications for each species. Each plant was staked with bamboo stem to serve as support for each plant to climb. The plants were scored for important qualitative and quantitative morphological characters. In each of the species the time of opening and closing of flowers and anther dehiscence were observed every three days for a period of three months.

On each species the following pollination system were investigated on 50 flowers (10 per plant in the opened and bagged treatments). The flowers were bagged using muslin bags. The pollination systems include Emasculation (E), Natural self-pollination (NSP), Manual self-pollination (MSP), Geitonogamy (G), and Cross pollination (CP). Observations on the behaviour of different foragers were recorded. The observations were carried out three times a week from 6am to 6pm for 3months mostly after the opening of the flower. The part of the plant visited and the type of reward collected by different visitors were recorded through close observation. Each type of foragers was captured with a hand net, preserved and identified. Data obtained from fruit sets were subjected to one-way analysis of variance and their means compared using Duncan's multiple range test (DMRT).

RESULTS

Morphological Studies

Passiflora foetida L.:It is an annual creeping vine that stinks, with strong aroma. The leaves are hairy, trifoliate and green, with 3 pointed lobes. The fruits are hairy, with black seeds (34 per fruit) and fruits remained green when matured.

Passiflora edulis : It is a perennial climber without an aroma. The leaves are glabrous, cuspidate and green with lobed margin. The fruits are glabrous with black seeds (151 per fruit) and fruits turn yellow when matured.

The flower of *P. edulis* started opening from 12:30pm–3:30pm and closes from 10:00pm – 10:30pm each day. The flowers of *P. foetida* started opening from 5:00am–6:00am and closes from 11:00am – 11:30am each day. The number of stigma ranges from 2-4(3) in *P. foetida* and 3-5(3) in *P. edulis*. The two species had five anthers per flower.

Pollination Studies

The average number and percentage fruit set for each species treatment and pollination method are indicated in Table 1. In *P. edulis* all the opened treatment of the pollination methods produced significantly higher number of fruits than the bagged treatments. In *P. foetida* there is no significant difference in the number of fruits produced in the opened and bagged treatments for each of the pollination methods. Only the emasculation opened treatment of *P. edulis* produced fruit when compared with the other emasculation pollination methods of *P. foetida*.

Forager-Plant Relationship

Foragers were not observed on *P. foetida*. The foragers observed on *P. edulis* and their interactions are indicated in Table 2. The bees visited the flowers of *P. edulis* mainly to collect nectar and pollen grains. *Apis cerena* and *Apis mellifera* collected nectar and pollen from the flower while other bees observed collect either nectar or pollen. The bees' time of visit ranged from 1:00 hour - 6:00 hour when flower were fully opened. *Dactylurina staudingeri* and *Trigona fuscipennis* visited flowers to collect pollen grains on their legs Figure (1A and D). In the process of collecting pollen the bees land on the stigma which get dusted with pollen and subsequently effecting pollination. *Xylocopa frontalis* and *Xylocopa caffra* visited the flower of *P. edulis* to collect nectar, and during this process, the back of the bees get dusted with pollen grains Figure (1B and C). As the bees move from one flower to another in search of nectar, the back of the bee rub the stigmatic surface which points downwards which also get dusted with pollen and allowing pollination to occur.

DISCUSSION

The bees visited the flower generally to rob the plants of their pollen. The number of floral parts of the two *Passiflora* species studied (stigma, anther and petal) were observed to be the same. The two *Passiflora* species vary in their flower size; *P. edulis* flower is larger than that of *P. foetida*. The two species varied in their time of anthesis; *P. foetida* opens very early in the morning and closes before mid-day while, *P. edulis* opens in the mid-day and closes late in the night. The pollination study revealed that *P. foetida* produce fruit mainly through self-fertilization in the absence of pollinators. *P. edulis* is self- autonomous but require insect visits to increase fruit set. Vandeplank (1991), reported that most *Passiflora* species are self- sterile and self-incompatible which lead to poor fruit set. The production of fruit set of 55% in emasculated opened pollination of *P. edulis* and 0% in emasculated bagged, showed the floral foragers that visited the flower in emasculated, opened treatment assisted in fruit production. The low fruit set observed in the bagged, self-pollination of *P. edulis* compared to significantly higher fruit set in the opened treatment of *P. edulis* indicated that self-pollination sometimes fails when the stigma does not take pollen from the anther and insect visit to the flower in the opened enhanced pollination. Natural self-pollination of 65% fruit set in the opened treatment observed in *P. edulis* in this study exceeded 20% observed by Yamamoto *et al*., (2000) for *P. edulis*. It has been reported that most *Passiflora* species appeared to require an animal pollen vector and non-self-pollen to increase fruit set (Snow 1982; Amela and Hoc, 1998; Varassin *et al*., 2001 and Storti, 2002)

Forager- Plant Relationship

Bees represent the largest proportion of foragers that visited *P. edulis* and most effective in activating pollination. Factors such as large body size, and navigating pattern of bees have been reported to aid pollination in *Passifllora* species (Cobert and Willmer, 1980; Sazima and Sazima, 1989; Angel *et al.*, 2011; Ozeigbe *et al*., 2016). Nates *et al*., (2012) reported that *Xylocopa* species were the most efficient natural pollinators of *Passiflora* species because of their large body size and their behaviour during flower foraging. Similar observations were made in this study. Rego *et al.*, (2000) and Suassana *et al.,* (2003) reported that a complex self-incompatibility system in *Passiflora* species resulted in strict dependence on pollinator services. This study showed that two *Passifllora* species set fruit independent of pollination services. Though, no pollinator services were observed on *P. foetida* in this study, Amela Garcia and Hoc (1998) reported that *P. foetida* flowers are pollinated by large bees (*Ptiloglossa* species). The repeated and continuous visits by various bees to the flower of *P. edulis* to collect nectar and pollen suggests that the flower produced adequate reward to the visitors which in return enhanced pollination. The result revealed that the bees visit to the flower of *P. edulis* could effect, cross-pollination, self-pollinatiion and geitonogamy. Torres et al., (2012) reported *Bombus* species and *Xylocopa splendilulu* as main pollinators of *P. caerulea* and different species of wasp as pollinator of *P. foetida* in Argentina. Yamamoto *et al*., (2012) reported that large solitary bees of the genus *Xylocopa, Centris, Epicharis, Eulaema* and *Bombus* collect nectar reward from *Passiflora* species are the pollinators of *P. edulis* in Brazil. In this study, solitary bees (*X. caffra*, *X. frontalis* and *D. staudingeri*) were the main visitors of *P. edulis* while (*A. mellifera*, *A. cerena*) were bees that visited *P. edulis* to collect pollen and nectar. Kundan *et al.*, (2012) reported that *A. cerana* and *A. dorsata* are detrimental to fruit set in *Passiflora* species by removing pollen from flowers before stigma become receptive. Yamamoto *et al.*, (2012) reported only nectar collecting bees were pollinators while bees that collect pollen do not effect pollination in *P. edulis*. This study revealed that both the bees that collect nectar or pollen could effect pollination. This is in agreement with the report of Sazima and Sazima (1989) and Camillo (2003). This study concluded that the two *Passiflora* species varied in their vegetative and floral morphological characteristics. *P. foetida* is primarily adapted to reproduction by autogamy while *P. edulis* exhibit mixed reproduction of autogamy and out-crossing which was enhanced by bees that visited the flowers

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Figure 1: Pollen grains on floral visitors of *P. edulis* A. *D. staudingeri* with pollen grain on the legs. B. *X. frontalis* with pollen grains on the back. C. *X. caffra* with pollen grains on the back. D. *T. fuscipennis* with pollen grains on the legs. Scale bars =2cm.

Table 1: Results of different pollination method on fruit set in *P. foetida* and *P. edulis* in the opened and bagged treatments.

	NSP	MSP	G	CP	E
P. foetida					
OPENED	(90%)45[a]	(92%)46[a]	(60%)30[a]	(80%)40[a]	(0%)0.0[a]
BAGGED	(88%)44[a]	(90%)45[a]	(56%)28[a]	(76%)38[a]	(0%)0.0[a]
P. edulis					
OPENED	(65%)33[a]	(71%)36[a]	(55%)28[a]	(78%)39[a]	(55%)28[a]
BAGGED	(40%)20[b]	(57%)29[b]	(33%)17[b]	(60%)30[b]	(0%) 0.0[b]

*Means followed by the same letter in each column are not significantly different at $p = 0.05$ for each species

Table 2: Foragers observed on *P. edulis* and their interactions.

Forager	Time of visit	Part visited	Reward from foraging	Frequency
Leptoglossus fulvicornis	8am-3pm	Leaf	Plant juice	Regular
Xylocpa caffra	2pm-6pm	Flower	Nectar	Regular
Apis mellifera	2pm-7pm	Flower	Nectar and pollen	Regular
Xylocopa frontalis	1pm-5pm	Flower	Nectar	Regular
Zonocerus Variegatus	8am-9pm	Flower	Feeding	Rare
Acraea egina	12pm-4pm	Flower	Nectar	Rare
Apis cerena	2pm-6pm	Flower	Nectar and pollen	Regular
Trigona fuscipennis	2pm-5pm	Flower	Pollen	Regular
Dactylurina staudingeri	8am-7pm	Flower	Pollen	Regular

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ECONOMIC ANALYSIS OF DRY SEASON OKRA (*Abelmoschus esculentus*) PRODUCTION IN KADUNA SOUTH LOCAL GOVERNMENT AREA, KADUNA STATE

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Abstract
This study was carried out to examine the profitability of dry season okra production in Kaduna South Local Government Area of Kaduna State. To achieve this, the inputs-output relationship, costs and returns and the constraints to dry season okra production were examined. A multistage sampling technique was used to select eighty dry season okra farmers from four districts purposively selected from where two villages were randomly selected then ten farmers each were randomly selected. The primary data used for this study were obtained through the use of structured questionnaire administered to a total of eighty okra farmers from of the study area. The data were subjected to descriptive statistics, gross margin, and multiple regression analyses. The results show that the mean age of the farmers was 32 years, 96.26% were married and 40% had a minimum of secondary education. The average farming experience of the farmers was 12.6years and they put in about 22.20 man-days to cultivate an average farm size of 0.67ha and obtained a yield of 7.3tonnesper hectare. Dry season okra farming was found to be profitable with a gross margin of ₦244,399.0/ha and a return to investment of 3.98. The multiple regression results showed that farming experience, labour, farm size and agrochemicals had positive relationships with the output, however, only the latter two were significant at 1% level of Probability. The highest ranked constraints to okra production were high cost of inputs, inadequate capital, and prevalence of pests and diseases and. inadequate extension services. The study therefore recommends that cheap and effective machineries should be developed to ease cultivation and irrigation. There should be increased and regular extension visits to assist the farmers to cope with the menace pest and disease cases.

Keyword: *Okra, dry season, cost and return, profitability*.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) was domesticated in West and Central Africa, but is now widely cultivated throughout the tropics primarily valued for its edible green pods for local consumption. According to Uzowuru (2010) all parts of the okra plant are useful, its leaves and tender shoots which are equally rich in nutrients can be cooked and eaten for food and nutritional security. The green pods are rich sources of vitamins, calcium, potassium, and other minerals. The edible portions of the pod are good sources of protein as well as ascorbic acid content of 20g/100g and high level of calcium, fiber, ash, mature seeds contain about 21% of edible oil (Uzowuru, 2010). Okra provides market/income security- because it can easily be dried, mould (powder) and stored for long periods (unlike perishable vegetables), producers, and processors are better able to add value and take advantage of seasonal fluctuations in price; and other industrial uses. In Nigeria, okra ranks third in terms of consumption and production area following tomato and pepper (Plaisier *et. al.,* 2019). It yields approximately 1.6 tons of harvesting crop per hectare. Despite, the constrains limiting the production of the crop, its production has increased tremendously from 843,500 tonnes in 2011 to 2,067,900tonnes in 2017 and Kaduna State contributes the highest percentage (11%)of okra produced in Nigeria (Plaisier *et. al.*,2019*)*. Okra is fast gaining popularity as an economically viable cash crop in many global markets, especially in the context of small acreage farming. As a commercial vegetable crop it is presently grown in large quantities in different parts of Nigeria Okra farming is one of the most profitable farming ventures because most if not all Nigerians eat it (Plaisier *et. al.,* 2019).

It commands a high price in Nigeria markets because it features daily in the diet of most Nigeria. Okra's potential for research and contribution to enhanced livelihoods have not been attended to adequately. The economic importance of okra is attributed to the low cost per unit of resource use in the production, short gestation period and quick returns on invested capital compared to other crop enterprises especially during the dry season (Alimi, 2004). Okra is traditionally grown during the raining season but the demand for fresh exists even during the dry season. It has been observed that supply of fresh okra is very low during the dry season due to the fact that almost all the farmers tend to ignore its cultivation in the dry season and wait till raining seasons resumes. This study examined the economics of dry season production of okra in Kaduna South local Government area of Kaduna State.

METHODOLOGY

The study was carried out in Kaduna South Local Government area of Kaduna State located between latitudes $10^0 27"$ to $10^0 42"$ and longitude 7^0 25" to $7^0 37"$E with a land area of about 46.2km^{2}square kilometers and has a projection population of about 1,505,352.78 (NPC 2006 at population growth rate of 3.2). Kaduna South is the industrial area of Kaduna capital city and hence most inhabitants are engaged in mostly trade and commerce with a very few of them involved in farming. These few farmers are engaged in the production of grains and vegetables. Vegetables commonly grown in the area are tomato, Okra, spinach, garden egg, arrots, cabbage, and onion. Kaduna State experiences two distinct seasons of wet (May to October) and dry (November to April). River Kaduna and some few streams transverse this area thus making dry season farming feasible. In Kaduna, the wet season is warm, oppressive, and overcast and the dry season is hot and partly cloudy. Over the course of the year, the temperature typically varies from 55°F *to* 95°F and is rarely below 50°F or above 102°F (Table1). Multi-staged sampling method was utilized to select the respondents used for this study. Four districts of Barnawa, Kurmin-mashi, Sabon gari and Ungwan Muazu were purposively selected due to their active involvement in dry season Okra production. The second stage was the random selection of two villages from each of selected districts. Finally, ten farmers were randomly selected from each village to obtain a sample size of eighty (80) farmers that participated in the study. Descriptive statistics (mean and frequency) were used to examine the socioeconomic characteristics of the farmers while Gross margin was used to determine the Profitability using the implicit form of Multiple regressions were used to determine the factors influencing dry season Okra production.

GM= $\sum_{i-1}^{n} P1Q1 - \sum_{j-1}^{m} rixi$……………..(1)

Where:

GM= Gross Margin (₦/ha)

Q= Total output of Okra ((kg/ha)

P= Unit price of output (₦/ha)

Xi= Quantity of each variable input used (unit/ha.)

ri=Price associated with each input used (₦/ha)

∑=Summation

Model Specification.

The implicit form of the production function analysis for okra production in the study area as recommended by David *et al., (1996)* was stated as follows;

$Y = X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8$……………, X_n,+ U ……………..… (2)

Where

Y = Output (kg) i.e response (dependent) variable

X_1 = Quantity of seed (kg) X_2 = Labour use (in Mandays) X_3= Quantity of pesticides used (L), X4 = Farm size (in Ha) X_5=quantity of fertilizer used (kg), X_6 = Age (years), X_7= Level of education (number of years spent schooling), X_8 = Farming Experience (years)), u = error term.

The model was stated explicitly as $Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + U$……………………………….……..(3)

$b_1 \ldots b_8$ are the coefficients to be examined and $X_1 \ldots X_8$ are the explanatory variables as defined in equation (2) above.

Four functional forms (linear, double log, semi double log and exponential functions) of production function were tried and explicitly represented as

Linear function: Y = b0 + b1 x1 b2 x2 + b3 x 3 + b4 x4 + b5 x5… + ei………………... (4)

Double log function: ln(y) = lnb0 + b1lnx1 + b2lnx2 + b3lnx3 + b4lnx4 + b5lnx5…+ ei... (5)

Semi double log function: Y =lnb0 + b1lnx1 + b2lnx2 + b3lnx3 + b4lnx4 + b5lnx5… + ei.(6)

Exponential function: lnY = b0 + b1x1 + b2x2 + b3x3 + b4x4 + b5x5 …+ ei..................... (7)

The criteria used to choose the best functional form was based on the magnitude of the R^2 value, the high number of significant variables, size and signs of the regression coefficients as they conform to a priori expectation.

RESULTS AND DISCUSSIONS

Socioeconomic Characteristics of the respondents

Table 2 shows the socioeconomic characteristics of the dry season okra farmers in the study area. The mean age of the farmers was 37years with a standard deviation of 12.358. Majority (63.75%) of the farmers were within the active age bracket of 20-40years. The mean age of farmers in this study is lower than the 57.56 years earlier obtained by Farinde *et al.,* (2006) among okra farmers of Egbedore Local Government Area of Osun State. Ume *et al.,* (2016) however found that the farmers of older age brackets of 40-60years were the ones involved in okra production at Ayamelum Local Government Area of Anambra State. The least percentage (2%) in the age distribution in this study was recorded in the 61-70 age brackets that might not be able to withstand the rigors and stains in dry season production. The large percentage of the youthful farmers involved in dry season farming in an urban centre like Kaduna is a good index to improved productivity for okra production in the study area. This presents a chance for increase in scope of production and hours of operation as opposed to the results report by Fasina (2013) where majority of the old age bracket reduced their scope of operation by 69.5% and hours of work by 66.7% as they grew older. The average farming experience was 12years where most (47.50%) of the farmers had 1-10 years. The high percentage (47.5%) of few years of farming experience (1-10years) found in this study corroborates the 59.4% reported by Ume *et al.,* (2016). The implication is that the higher the farmers' years of farming experience, the higher the possibility of the farmers being able to set realistic goals in their farm business (Tanko, 2004). These years of experience are also said to be useful in early stages of adoption of innovations (Ainembabazi and Mugisha 2014). Additionally, 51.25% of the farmers had formal education (20% tertiary, 20% had secondary and 10% had Primary). The dry season farmers' educational levels are close to the 66.7% found by Ume *et al.,* (2016). The education status of the farmers is expected to have an effect on the profitability of okra production. It is said that high educational level farmers are capable of making informed decisions that could optimize their output at minimal costs and also boost their prudence in resource use efficiency and rational decision making for high production and productivity to ensure (Udo, 2005). The mean farm size of 0.67ha found in the study area is likely to be a major bottle neck to dry season farming in Kaduna. This may be due to fact that the operations were carried out by the river banks and that most (70%) of the farms were either rented or hired.

Cost and Returns

The profitability of dry season okra production was determined using the gross margin analysis. Maurya (2012) described Cost and Returns as cost structure in production which consists of the cost on production inputs like seed, irrigation, plant protection, manures and fertilizers, human labour and tractor power, rental value of land at the prevailing market rate and overhead costs, comprising of interest on working and fixed capital, repairs and depreciation etc. The average cost inputs and returns on the cultivation of okra per hectare in the dry season have been worked out in Table 3.

Variable Cost

The farmers incurred a total variable cost of ₦82,081.5. The results showed that labour attracted the highest cost (₦28,355) which accounted for 34.55% of the total variable cost. The labour intensity and wage rate employed during the dry season farming varied with operations as shown in Table 4. Fertilizer and fuel attributed 25.91% and 25.35% respectively. These three inputs (labour, fertilizer and fuel) made up 85.81% of the total variable costs.

Yield and Revenue

The results showed a total physical output of okra to be 7,255.12kg/ha. This output is higher than the 6000kg per hectare obtained at Ayamelum LGA of Anambra State (Ume *et al.,* 2016), and the 4531.6kg per hectare obtain at an Ekiti State University, experimental field (Omotoso *et al.,* 2018). The output found in this study yielded total revenue of ₦326,480.4

Gross margin and Return on investment

The gross margin was found to be ₦244,398.0 per hectare. . Ekwunwe *et al.,* (2018) report a gross margin of ₦156,884.81 while Osalusi *et al.,* (2019) estimated costs and return of okra production in Akinyele LGA, Oyo State and came up with ₦161,137 and ₦77,317.76. This return suggests that dry season production of okra is not only profitable but can be a sustainable enterprise for youths of 20-40years of age. Since okra matures between 50-65days (7-9weeks) after sowing and can continue to yield fruit from 10 to 12weeks after sowing, it suggest that it is possible to have two or three crops of okra during the a dry season. This can be said to be a lucrative and quick business. This confirms the report by Nwalieji *et al.,* (20015) that profits in okra were higher in the dry season than wet season. The return to investment was 3.98, implying that every ₦1 invested attracted ₦2.98 thus affirming the profitability of dry season okra production.

Econometrics Analysis for Okra Production

The results of the econometric analysis are presented in Table 6. Based on the statistical and econometric criteria, Exponential production functional form was chosen as the best fit equation due to its Coefficient of determination (R^2) value (0.85) and the number of significant values that were in line with the apriori expectations. The statistical test of the coefficient of Okra output showed positive correlation with farm size, farming experience, and agrochemical use. The coefficients of farm size and Agrochemicals weres significant at 1% level of probability. This implies that okra output increases with increase in farm size and application of agrochemicals, thus satisfying the apriori expectation of economies of scale. However, this contradicts the finding reported by Anyaegbunam *et al.,* (2012). A positive coefficient of farming experience was observed in this result though not significant, it agrees with the findings of Pimolwan *et al.,* (2018) who found coefficient of the years of farmers' experience to be positive and significant at % risk level. The number of years of farming experience helps farmers to set a goal that could be capable of increasing their farm output at a reduced cost (Tanko, 2004).

Nevertheless, the age of farmers exhibited a negative correlation in spite of the fact that the years of experience can stand proxy for age. This implies that an increase in the age of farmers decreases output by about 64.5%. This is in line with Iheke, (2010), who reported that younger household heads have the ability to comprehend new technologies and will therefore readily adopt thus improving the timeliness of operations as well as reducing costs of production. These suggest that experience is more important in improving dry season okra production than the actual age of the farmer. It might be than age is a disadvantage for dry season okra production because it involves more physical work as asserted by Okoye *et al.,* (2009). A negative correlation was found between level of education and okra output which suggests that increase in level of education results in decrease in dry season okra output by 142%. This result is in defiance to the apriori expectation of relationship between education and production. The result supports a negative coefficient reported by Pimolwan and Teerawat (2017) that resulted in reduction of the output by 3539.95%. However, it is contrary to the findings of Ume *et al., (2016)* who found a coefficient of the level of education was positive in line with apriori expectation and significant at 10% level of probability. Education status of the farmers is expected to have an effect on the profitability of okra production. They are capable of making informed decisions that could optimize their output at minimal costs. Labour coefficient was positive to Okra production though not significantly so. This implies that increase in labour brought about increase in output. Labour for dry season okra farming was scarce and expensive. The type of labour output relationship found in this study supports the findings of Anyaegbunam *et al.*, (2012) but is contrary to Pimolwan and Teerawat (2017). The results also revealed that Agrochemicals (pesticides and herbicide) use had direct relationship. Fertilizers and seeds on the other hand showed inverse relationships. The inverse relationship of fertilizer was significant at10% level of probability.

Base on all details above, the final equation of multiple regressions for okra output in Kaduna South local government area:

Yi=7.693 –0.0003X1 +0.0002X2 +0.00012X3 +0.854X4 –0.0018X5 -0.00292X6 -0.008X7 + 0.00313X8
(54.04) (-0.645) (1.419) (0.531) (7.39) (0.400) (-0.257) (1.960) (4.244)

Constraints to dry season Okra production.

The farmers identified a number of constraints that militating against their production (Table 7). The highest ranked constraints to dry season okra production were high cost of farm inputs (40%), inadequate capital 16.25%) prevalence of pests and diseases (12.50%) and. inadequate extension services 11.25%). These four constraints all together constituted 80% of the factors hindering dry season okra production. Chief among the high input cost items was labour which found to be scarce and expensive. Other inputs that attracted high cost were fuel and agrochemicals. The non-availability of capital further raised the cost of production. High prevalence of pests and diseases ranked third on the constraints list may be attributed to the fact that during the dry season, few crops are found in the fields as such dry season crops become feeding and hiding grounds for pests. Some pests harbor disease or serve as reservoirs. Furthermore, inadequate extension services may aggravated the above mentioned constraints. Other constraints of importance noted in the area were inadequate improved seeds and infrastructure accounting for 6.25% and 5% constraints respectively.

CONCLUSION

Dry season Okra production in Kaduna South Local Government Area of Kaduna State is operated on small sized farm land of about 0.67ha and the farmers obtained a gross margin of N₦244,399.0/ha and a return to investment of 3.98 thus indicating that the enterprise is profitable.

RECOMMENDATIONS

In view of the fact that labour was found to be the highest single item cost, it is recommended that simple and cheap hand tools should be designed and fabricated to reduce the labour input cost. Secondly, credit facilities in form of loan and subsidies should be made available to the dry season farmers to ease the purchase irrigation machines, praying equipment and other inputs. Thirdly, government should provide indirect subsidies on fertilizer, smart irrigation solutions like drip irrigation and sprinklers, equipment rentals. Lastly, extension agents should specifically trained on dry season farming and disease control measures and send to areas of dry season farming to facilitate and enhance dry season crops production.

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Table 1. Weather averages by month Kaduna

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	23.6 °C (74.5) °F	26.2 °C (79.2) °F	28.7 °C (83.6) °F	29.3 °C (84.7) °F	27.4 °C (81.3) °F	25.1 °C (77.1) °F	23.5 °C (74.4) °F	22.9 °C (73.2) °F	23.6 °C (74.5) °F	24.3 °C (75.8) °F	24.6 °C (76.3) °F	23.4 °C (74.2) °F
Min. Temperature °C (°F)	16.9 °C (62.5) °F	19 °C (66.3) °F	21.2 °C (70.1) °F	23.4 °C (74.2) °F	23.2 °C (73.7) °F	21.8 °C (71.2) °F	20.8 °C (69.4) °F	20.4 °C (68.7) °F	20.3 °C (68.6) °F	19.9 °C (67.9) °F	18.1 °C (64.5) °F	17.1 °C (62.8) °F
Max. Temperature °C (°F)	31.2 °C (88.1) °F	33.8 °C (92.9) °F	36 °C (96.8) °F	35.7 °C (96.2) °F	32.7 °C (90.9) °F	29.3 °C (84.8) °F	27.3 °C (81.2) °F	26.4 °C (79.5) °F	28 °C (82.4) °F	29.8 °C (85.6) °F	31.7 °C (89.1) °F	30.8 °C (87.5) °F
Precipitation / Rainfall mm (in)	0 (0)	0 (0)	4 (0.2)	29 (1.1)	101 (4)	123 (4.8)	179 (7)	259 (10.2)	212 (8.3)	91 (3.6)	0 (0)	0 (0)
Humidity(%)	23%	19%	20%	39%	63%	77%	84%	87%	85%	75%	38%	26%
Rainy days (d)	0	0	1	4	11	14	18	20	19	9	0	0
avg. Sun hours (hours)	10.4	10.6	10.8	10.4	8.8	6.0	5.0	4.8	6.2	8.3	10.4	10.4

The precipitation varies 259 mm | 10 inch between the driest month and the wettest month. The variation in annual temperature is around 6.4 °C | 11.5 °F.
Source:Climate-data.org/africa/nigeria/kaduna/ 2021

Table 2: Socio-Economic Characteristics of Farmers

S/No	Characteristic	Mean	Frequency	Percentages
1	Age (years)	37		
	20-40		51	63.75
	41-60		27	33.75
	61-70		2	2.50
	Total		80	100
2	Marital Status			
	Single		3	3.75
	Married		77	96.25
	Total		80	100
3	Highest Educational Level			
	Primary		9	11.25
	Secondary		16	20.00
	Tertiary		16	20.00
	Non-formal education		39	48.75
	Total		80	100
4	Farming Experience (years)	12.6		
	1-10		38	47.50
	11-20		31	38.75
	21-30		7	8.75
	31-40		4	5.00
	Total		80	100
5	Farm Size (Ha)	0.67		
	0.1-0.5		36	45.00
	0.6-1.0		31	27.50
	1.1-1.5		7	11.27
	2.0-2.5		4	16.25
	Average			
	Total		80	100
6	Mode of farm acquisition			
	Rented/Hired		56	70
	Inherited		14	17.5
	Purchased		10	12.5
	Total		80	100

Source: Field Survey 2018

Table: 3 Average Labour used per hectare for dry season Okra production

Operation	Man-hours	Cost/man-day	Frequency	Percentage
Ploughing	45	1500	37	46.25
Harrowing	22.5	1000	18	22.5
Ridging	18.75	1200	11	13.75
Weeding	15	800	9	11.25
Harvesting	11.25	500	5	6.25
Total	112.5		80	100

Table 4.Cost and Returns for Okra (₦/Ha)

Items	Unit/Ha.	Unit Price (₦)	Value (₦/Ha.)	% Cost per Ha.
Yield/ha (kg)	7,255.12	45	326,480.4	100
Variable Inputs				
Labour (man-days/ha)	56.71	500	28,355	34.55
Seeds (kg/ha)	9.92	250	2,480	3.02
Fertilizer (kg/ha)	204.5	5,200	21,268	25.91
Chemicals (L)	1.75	2000	3,500	4.26
Fuel (L/ha)	143.50	145	20,807.5	25.35
Transport (₦/basket)	113.42	50	5,671	6.91
Total Variable Cost			82,081.5	100
Gross Margin			244,399.0	
Return to investment			3.98	

Source: Field survey 2018

Table 5: Summary of Regression Analysis (four functional forms) on Dry season Okra production in Kaduna South Local Government Area.

Variables	Linear		Semi Log		Exponential		Double Log	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	567.712 (0.843)	673.578	4566.766 (0.825)	5538.628	7.693 (54.038)***	0.1424	8.965 (14.279)***	0.6278
Farmers Age (years)	22.395 (1.031)	21.715	1303.313 (0.886)	1470.789	-0.00292 (-0.645)	0.0045	-0.000303 (-0.002)	0.16673
Level of Education (years)	2.305 (0.088)	26.232	-38.827 (-0.164)	236.683	-0.008 (-1.419)	0.00587	-0.000303 (-1.195)	0.026831
Farming Experience (years)	-42.314 (1.497)	28.266	-716.475 (-0.164)	796.348	0.00313 (0.531)	0.0059	-0.00906 (-0.100)	0.0903
Farm Size (ha.)	4092.323 (7.391)***	553.680	3507.301 (3.678)***	953.533	0.854 (7.392)***	0.11551	0.7062 (6.533)***	0.108093
Labour (Man-days)	12.702 (4.218)***	3.011	1027.080 (1.718)*	597.960	0.0002 (0.400)	0.0006	0.09063 (1.337)	0.6779
Seeds (kg)	-17.287 (-2.923)	5.915	-58.881 (-0.084)	703.631	-0.0003 (-0.257)	0.00123	0.02086 (0.262)	0.07976
Fertilizer (kg)	-2.586 (-0.605)	4.275	48.166 (0.056)	866.319	-0.0018 (1.960)**	0.00089	-0.04943 (-0.503)	0.098207
Agrochemicals (L)	0.604 (4.654)**	0.130	-488.267 (-1.035)	471.556	0.00012 (4.244)***	2.71E-05	-0.04223 (-0.790)	0.053456
R^2	0.909		0.739		0.849		0.872	
$\bar{R}^2$	0.899		0.710		0.832		0.858	
F-Statistics	88.465		25.128		49.827		60.619	

Table 6: Constraints to dry season Okra production

Constraints	Frequency	Percentage	Rank
High cost of farm inputs	32	40.00	1st
Inadequate Capital	13	16.25	2nd
Incidences of Pests and diseases	10	12.50	3rd
Inadequate Extension services	9	11.25	4th
Inadequate Government assistance	7	8.75	5th
Inadequate improved seeds	5	6.25	6th
Inadequate infrastructure	4	5.00	7th
Total	80	100	8th

Source: Field Survey 2018

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EFFECTS OF CROPPING SYSTEMS AND SOIL AMENDMENTS ON THE GROWTH AND YIELD OF TWO TOMATO VARIETIES

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ABSTRACT
Tomato is an important vegetable, used for stew and other recipes in Nigeria. It is one of the most protective foods, which are nutritious and low in calories. A field study was conducted at the National Horticultural Research Institute, Ibadan, (Lat. 7^0 30N; Long. 3^0 50'E) during the 2011 and 2012 cropping seasons to determine the effects of cropping system, variety and soil amendment on growth and yield of tomato. The experiment was a 2x2x5 factorial experiment laid out in Randomized Complete Block Design, comprising of two cropping systems, two tomato varieties (Uc82B and Ibadan local) and five soil amendments (0, 60 and 120 kg N/ha NPK and 10 and 20 ton/ha poultry manure). Data collected include plant height, number of leaves and yield of tomato and maize. Intercropping efficiency was determined by calculating the land efficiency ratio (LER). Results showed fruits yield were reduced in the intercropped tomato. The highest yields (24.50, 28 ton/ha) were obtained with the application of 120 kg N/ha NPK and the lowest (6.84, 4.05 ton/ha) with the control (0 kg) in the two years of assessment. Land equivalent ratio (LER) greater than unity (>1) were obtained in the intercropping system. In 2011, the highest LER (1.69) and the lowest (1.2) were obtained from the Ibadan local /maize mixture given 120 kg N/ha NPK and 0 kg/ha respectively, in 2012, the highest (1.80) and the lowest LER (1.47) were from the Ibadan local /maize mixture treated with 10 t/ha poultry manure and the control.

Key words: *Intercropping, organic manure, inorganic fertilizer, tomato varieties*

INTRODUCTION

Tomato is an important vegetable condiment used for stew and other recipes. Demand for tomatoes is usually high because of the high level of consumption. It is one of the most protective foods, which are nutritious and low in calories. Consumption of tomato products has been associated with decreased risk of some cancer types (Vinson *et al*., 1996). Cultural benefits are derived when tomato is intercropped with two or more plants in close proximity, maize (*Zea mays* L.) has also been recognized as a common component in such intercropping systems in Nigeria (Ibeawuchi, 2007). Tomatoes perform well on medium textured sandy loams or loams; preferably slightly acidic soils with a pH of 6.0 to 6.8. Adequate nutrients supply is essential for optimum production of tomato. However, low soil fertility and physical limitations affect tomato production especially in Nigeria (Yadava *et al*., 2012). The soils therefore require appropriate soil amendment to be able to supply the needed nutrient for optimum profitable cropping. Tomatoes require close attention on fertilizer programs to ensure high yields and high quality fruits production. Fertilizer management is a part of the production practices that must be well handled and the basics properly understood. On the other hand, poor fertilizer management can lead to serious quality problems that may take long periods to correct (Hochmuth *et al.,* 2015). Selection of the most suitable cultivar or variety is a prerequisite for successful tomato production. Tomato producers should consider the type of tomato desired by the buyer (consumer, broker, retailer, etc.). Important considerations are size, shape, and colour (Hochmuth *et al.,* 2015). It was also noted that the selection of a tomato cultivar is a complex decision, because making the correct cultivar choices and implementing the appropriate production technology are critical for successful and optimum production. In most part of Nigeria, tomato is intercropped with other crops; intercropping which is the simultaneous planting of two or more crops in the same field (Nassef and El-Gaid, 2012), helps in pest and weed control and also ensure efficient land and soil use (El-Gaid *et al.,* 2014). It allows maximum use of environmental resources and improves soil fertility, thereby leading to optimum yield per land area. Maize is staple to man and livestock and one of the most important grain crops in world agricultural economy. Maize (*Zea mays* L.) has been recognized as a common component in most intercropping systems in Nigeria. It was reported that about 75 percent of the area of maize growing in Nigeria is in association with other crops (Ibeawuchi, 2007). The objective of the study was to determine the effects of cropping systems, variety and application of soil amendments on the growth and yield of tomato. Specifically, to evaluate the treatment effects of sole and intercropping systems, application of 60 and 120 kg N/ha of NPK 15-15-15 and 10 and 20 t/ha of poultry manure on plant height, number of leaves and yield of two varieties of tomato and yield (Uc82B and Ibadan local) and to determine the land equivalent ratio (LER) of tomato/maize intercrop.

METHODOLOGY

The research was carried out at the National Horticultural Research Institute, Ibadan, (Lat. 7^0 30N; Long. 3^0 50'E) during the 2011 and 2012 cropping seasons. The experimental field was ploughed and harrowed and prior to the laying-out of the experiment, composite soil sample was collected at the depth of 0-15 cm, air dried, sieved and subjected to routine soil analysis using the standard analytical laboratory procedure of IITA (IITA, 1994). Thereafter 25 plots were marked out with wooden pegs into 3m × 3m plot size, representing the 20 treatments for tomato and additional five for sole maize, and were replicated three times to give a total of 75 plots,. The planting materials were seeds of two varieties of tomatoes: Uc82B and Ibadan local and maize cultivar SAMMAZ 1. The treatments consisted of two cropping system (sole cropping, intercropping), two varieties (Ibadan local and Uc82B) and five soil amendments: control (0), inorganic fertilizer (60 and 120 kg N/ha NPK 15-15-15) and organic fertilizer (10 and 20 ton/ha poultry manure).The experiment was a 2x2x5 factorial experiment laid out in Randomized Complete Block Design and replicated three times.

Pre-planting seed germination test was carried out; tomato seedlings were raised in the nursery for four weeks. Transplanting of tomato seedlings and planting of maize seeds to the main field were carried out on 24th May, 2011 and 27th May, 2012. The resulting maize seedlings were thinned to one per stand 2 weeks after planting (2WAP). Tomato plants were staked at 4WAP. Routine weeding operations were carried out on the field manually. The tomato in sole cropping was transplanted at a spacing of 0.75m x 0.30m, this gave a plant population of 44,445 plants/ha. Tomato and Maize were intercropped at a space of 0.75m × 0.50m which gave a plant population of 26,667 plants/ha each. The levels of fertilizer adopted in the study were 0, 60 and 120 kg N/ha (inorganic fertilizer) and 10 and 20 ton/ha poultry manure (organic fertilizer). Poultry manure (PM) was obtained from a farm at College of Animal Health and Production, IAR&T, Moore Plantation, Ibadan. Poultry manure was stacked under a shed and was air-dried and spread in a well-ventilated area 5 weeks before the beginning of the experiment. It was then worked into the topsoil using hoe and garden fork two weeks before planting. NPK15-15-15 fertilizer obtained from an ADP commercial outlet was applied using ring placement method into drills 5cm deep and 7.5 cm away from the plant and covered with soil, 3 weeks after transplanting (3WAT). Five plants were randomly selected and tagged from the inner rows for observation and required data collection. The number of leaves were counted and recorded for each plant sampled and the meter ruler was used for the measurement of the tomato plant height from base to the tip of the main shoots at two weeks interval. Tomato fruits were harvested per plot and from these selected/tagged plants, counted and weighed two times a week. Data were subjected to analysis of variance using GenStat Discovery Edition 4 (2011). Significant means separated where appropriate by the least significant difference at 5% probability level ($LSD_{0.05}$).

The LER can be calculated using any measure of units (Willey, 1985). The LER was calculated by dividing the amount of the intercropped yield by the amount of the monocropped yield for each crop in the field. The partial LERs were added together to find the total LER:

$$\text{LER} = \frac{Ya}{Sa} + \frac{Yb}{Sb}$$

Where; Y_a, Y_b were the individual crop yields in intercropping and S_a, S_b were their yields as sole crops.

RESULTS AND DISCUSSION

The results of the pre-treatment soil analysis indicated that the N, P, and K contents: (0.30, 0.65 gkg-^{1}, 8.09, 12.5 mgkg-^{1} and 0.23, 0.13 cmol) were relatively low (Table 1), this may due to the established fact that native fertility status of most agricultural soils in Nigeria is low and cannot support suitable crop production over a long period without fertilizers (Sobulo, 2000). According to Adekiya and Ojeniyi (2002) low soil fertility and physical limitations affects tomato production in Nigeria, especially in area where there were con physical limitations and nutrient deficiency. Considering the pH (5.7, 6.5), the soil maybe seen as appropriate because according to Yadava *et al*., (2012) tomatoes perform well on preferably slightly acidic soils. Adequate nutrients supply is essential for optimum production of tomato. The poultry manure was cured because the use of fresh manure is harmful to plant, since it can result in the release of ammonia, as well as the introduction of plant diseases and weed seeds. The nutrients composition of the poultry manure (Table 1), N (2.92, 2.90 gkg-^{1}), P (1.65, 1.55 mgkg-^{1}) and P (1.80, 1.83 cmol) suggested that it could increases the soil fertility and consequently it improves the performance of the crop.

The results of the main effects for the two years under consideration (Table 2) showed that planting of tomato as sole crop resulted in significantly higher number of leaves per plant than in the intercrop except at 4 WAT in 2011 when there was no significant difference. Also, the number of leaves were not significantly different between the two varieties except at 8 WAT in which Ibadan local produced fewer leaves than Uc82B but in 2012, Ibadan local had more leaves than Uc82B at all period of assessment. Soil amendment application significantly influenced the number of leaves produced except at 4 WAT, while the application of 20 t/ha PM resulted in the highest number of leaves at 8 and 12 WAT in 2011, but in 2012, application of 120 kg N/ha NPK resulted in the highest number of leaves per plant 4, 8 and 12 WAT, although not significantly different from others except the control (0) at 4 WAT. No soil amendment (control) consistently produced the lowest number of leaves at all assessment periods but not significantly different from application of 60 kg N/ha NPK at 12 WAT in 2011.

In 2011, it was also observed that sole planting of tomato resulted in taller plants at 4 and 8 WAT than under the intercrop (Table 3) and vice versa at 12 WAT. However, in 2012 (Table 3), the sole plants consistently produced taller tomato plants. In contrast to a similar work by Olga *et al.* (2007) in which intercropped tomato plants were taller at 4 and 8 WAT than the sole. The significant differences between the two varieties in their growth responses to soil amendment and intercropping may be attributed to their different genetic background and adaptation to the ecological zone. The positive influence of the soil amendments on tomato growth might also be connected with the established fact that effective tomato fertilizer, whether organic or inorganic provides the nutrients needed at different growth stages (IFA/FAO, 2000).

The yields of tomato (Table 4) were significantly affected by planting, either in sole or intercrop. The sole tomato yield was higher than the yield from the intercrop in both years of assessment: 2011 (20.22 and 14.04 t/ha) and 2012 (20.90 and 15.21 t/ha). It could be suggested that there was a yield depression in the intercrop due to the competition between the component crops for water, light, nutrients, and other resources. Similarly, Ramkat *et al.* (2008) observed that tomato in a tomato–maize intercrop produced the lowest yield in the intercropping system assessment that was carried out. This is also supported by Liu et al. (2014) who also found out that intercropping reduced the total spring tomato yield but produced a higher net income than did monoculture in tomato/garlic intercropping system. Contrary to this result, El-Gaid *et al* (2014) showed that different intercropping system compared to sole did not significantly affect the yield and some yield components of tomato when tomato and common bean were intercropped. The productivity and classification of tomato fruits were not influenced by having lettuce intercropped with it, but lettuce production was lowered when tomato was intercropped with it in a research work by Cecílio *et al.* (2011). The reduced tomato yield from the intercropping system was due to the competition between the crops for the required resources and nutrients in the intercropping system.

The results (Table 4) further show that the Ibadan local tomato variety had significantly higher fruits yields than the Uc82B during the two years of assessment (Ibadan local produced 18.13 and 19.76 t/ha, Uc82B produced 16.13 and 15.35 t/ha in 2011 and 2012 respectively). There were also significant higher yields due to the application of various soil amendments compared to the control in both years. However, there were no significant differences in tomato yields due to the application of 60kg N/ha NPK, 10 and 20 ton/ha PM in 2011; while yields varied significantly due to the application of different type and rates of soil amendments in 2012. Nevertheless, the highest yield was obtained with the application of 120 kgN/ha NPK (24.50, 28.79 kg/ha) and the lowest with the control (0 kg N/ha); 6.84 and 4.05 t/ha within the two years.

The response of a crop, such as tomato, to a particular nutrient status may vary with cultivar and exogenous factors, such as cultural practices, substrate and environmental conditions (Passam *et al.,* 2007). The higher yields from plots which received organic and inorganic soil amendments could be attributed to the fact that tomato usually responds well to fertilizer application (Hebbar et al., 2004). The highest yields in the two seasons were recorded in the plots treated with 120 kg N/ha NPK due to the fact that tomato has been reported to be a heavy feeder of NPK and thus requires large quantity of nutrients to support its growth and yield (Hebbar *et al.,* 2004). Yield from fields treated with poultry manure (organic fertilizer) was lower than in those treated with NPK 15-15-15 (inorganic fertilizer). This is in line with the findings of Lee (2010), who concluded that the apparent inadequate supply of plant nutrient from organic fertilizer, resulting from a slow rate of mineralization, makes crop yields in such fields lower than in those treated with chemical (inorganic) fertilizers. The decrease in yield due to the application of poultry manure may also be attributed to insufficient availability of essential nutrients especially P and K which are however, available in optimum dose for the plant with NPK15:15:15 fertilizer (Srinivas and Shaik, 2002). In a related study by Ayeni *et al.,* (2010), the cumulative yield for two seasons were: 9.6 ton/ha for the control and 18.1 ton/ha for the application of 20 ton/ha PM, with a suggestion that an increase in the amount of poultry manure up to 30 ton/ha may maximize yield. Moreover, apart from the higher yields obtained with the application of poultry manure, the improvement of environmental conditions and public health is another important reason to advocate for increase in the use of organic materials.

Results in Table 5 show that in 2011, LERs of 1.69 and 1.67 were obtained from the Ibadan local /maize mixture given 120 and 60kgN/ha NPK fertilizer, while the application of 10 and 20t/ha poultry manure, resulted in LERs of 1.32 and 1.59 respectively. The lowest LER (1.2) from the Ibadan local/ maize mixture was obtained with none application of any form of soil amendment (control). However, in the Uc82B/maize mixture, the application of organic fertilizer resulted in higher LER of 1.67 and 1.63 with 10 and 20 t/ha PM respectively compared with the application of inorganic fertilizer at rates of 60 and 120kgN NPK fertilizer which gave LER of 1.60 and 1.55 respectively. Similar results in 2012 (Table 5) show that the LERs followed the same trends with the organic soil amendment showing relatively higher LER in comparison with the application of inorganic soil amendment (60 and 120kgN NPK fertilizer). In both seasons and at all levels of soil amendment, the land equivalent ratio (LER) for the two varieties of tomato was greater than unity (>1) which is an indication of a good intercropping efficiency. This was in agreement with a simulation model produced by Tsubo *et al*. (2005) to determine the best planting methods for maize and bean intercrops in sub-arid South Africa. Cecílio (2011) also observed that tomato yielded land use efficiency indices of 1.63 to 2.22 in the intercropping established with lettuce. Also, land equivalent ratio of 1.71 has been reported for cassava/maize intercrop (CATIE, 1977).

CONCLUSION

The vegetative growth and fruit yield of tomato were affected by cropping system, variety and soil amendment: the sole tomato yield was higher than the yield from the intercrop in component crops with or without soil amendment application. Ibadan local gave higher yield than Uc82B. Inorganic fertilizer (NPKK 15-15-15) produced higher yield than the organic manure (poultry manure) and 120 kg N NPK 15-15-15 gave the best yield. Land equivalent ratio for the intercropping system at all soil amendment levels is greater than unity (>1); Ibadan local/maize mixture with application of 120 kg N NPK 15-15-15 gave the best LER.

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Table 1. Weather averages by month Kaduna

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	23.6 °C (74.5) °F	26.2 °C (79.2) °F	28.7 °C (83.6) °F	29.3 °C (84.7) °F	27.4 °C (81.3) °F	25.1 °C (77.1) °F	23.5 °C (74.4) °F	22.9 °C (73.2) °F	23.6 °C (74.5) °F	24.3 °C (75.8) °F	24.6 °C (76.3) °F	23.4 °C (74.2) °F
Min. Temperature °C (°F)	16.9 °C (62.5) °F	19 °C (66.3) °F	21.2 °C (70.1) °F	23.4 °C (74.2) °F	23.2 °C (73.7) °F	21.8 °C (71.2) °F	20.8 °C (69.4) °F	20.4 °C (68.7) °F	20.3 °C (68.6) °F	19.9 °C (67.9) °F	18.1 °C (64.5) °F	17.1 °C (62.8) °F
Max. Temperature °C (°F)	31.2 °C (88.1) °F	33.8 °C (92.9) °F	36 °C (96.8) °F	35.7 °C (96.2) °F	32.7 °C (90.9) °F	29.3 °C (84.8) °F	27.3 °C (81.2) °F	26.4 °C (79.5) °F	28 °C (82.4) °F	29.8 °C (85.6) °F	31.7 °C (89.1) °F	30.8 °C (87.5) °F
Precipitation / Rainfall mm (in)	0 (0)	0 (0)	4 (0.2)	29 (1.1)	101 (4)	123 (4.8)	179 (7)	259 (10.2)	212 (8.3)	91 (3.6)	0 (0)	0 (0)
Humidity(%)	23%	19%	20%	39%	63%	77%	84%	87%	85%	75%	38%	26%
Rainy days (d)	0	0	1	4	11	14	18	20	19	9	0	0
avg. Sun hours (hours)	10.4	10.6	10.8	10.4	8.8	6.0	5.0	4.8	6.2	8.3	10.4	10.4

The precipitation varies 259 mm | 10 inch between the driest month and the wettest month. The variation in annual temperature is around 6.4 °C | 11.5 °F.
Source:Climate-data.org/africa/nigeria/kaduna/ 2021

Table 2: Socio-Economic Characteristics of Farmers

S/No	Characteristic	Mean	Frequency	Percentages
1	Age (years)	37		
	20-40		51	63.75
	41-60		27	33.75
	61-70		2	2.50
	Total		80	100
2	Marital Status			
	Single		3	3.75
	Married		77	96.25
	Total		80	100
3	Highest Educational Level			
	Primary		9	11.25
	Secondary		16	20.00
	Tertiary		16	20.00
	Non-formal education		39	48.75
	Total		80	100
4	Farming Experience (years)	12.6		
	1-10		38	47.50
	11-20		31	38.75
	21-30		7	8.75
	31-40		4	5.00
	Total		80	100
5	Farm Size (Ha)	0.67		
	0.1-0.5		36	45.00
	0.6-1.0		31	27.50
	1.1-1.5		7	11.27
	2.0-2.5		4	16.25
	Average			
	Total		80	100
6	Mode of farm acquisition			
	Rented/Hired		56	70
	Inherited		14	17.5
	Purchased		10	12.5
	Total		80	100

Source: Field Survey 2018

Table: 3 Average Labour used per hectare for dry season Okra production

Operation	Man-hours	Cost/man-day	Frequency	Percentage
Ploughing	45	1500	37	46.25
Harrowing	22.5	1000	18	22.5
Ridging	18.75	1200	11	13.75
Weeding	15	800	9	11.25
Harvesting	11.25	500	5	6.25
Total	112.5		80	100

Table 4.Cost and Returns for Okra (₦/Ha)

Items	Unit/Ha.	Unit Price (₦)	Value (₦/Ha.)	% Cost per Ha.
Yield/ha (kg)	7,255.12	45	326,480.4	100
Variable Inputs				
Labour (man-days/ha)	56.71	500	28,355	34.55
Seeds (kg/ha)	9.92	250	2,480	3.02
Fertilizer (kg/ha)	204.5	5,200	21,268	25.91
Chemicals (L)	1.75	2000	3,500	4.26
Fuel (L/ha)	143.50	145	20,807.5	25.35
Transport (₦/basket)	113.42	50	5,671	6.91
Total Variable Cost			82,081.5	100
Gross Margin			244,399.0	
Return to investment			3.98	

Source: Field survey 2018

Table 5: Summary of Regression Analysis (four functional forms) on Dry season Okra production in Kaduna South Local Government Area.

Variables	Linear		Semi Log		Exponential		Double Log	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	567.712 (0.843)	673.578	4566.766 (0.825)	5538.628	7.693 (54.038)***	0.1424	8.965 (14.279)***	0.6278
Farmers Age (years)	22.395 (1.031)	21.715	1303.313 (0.886)	1470.789	-0.00292 (-0.645)	0.0045	-0.000303 (-0.002)	0.16673
Level of Education (years)	2.305 (0.088)	26.232	-38.827 (-0.164)	236.683	-0.008 (-1.419)	0.00587	-0.000303 (-1.195)	0.026831
Farming Experience (years)	-42.314 (1.497)	28.266	-716.475 (-0.164)	796.348	0.00313 (0.531)	0.0059	-0.00906 (-0.100)	0.0903
Farm Size (ha.)	4092.323 (7.391)***	553.680	3507.301 (3.678)***	953.533	0.854 (7.392)***	0.11551	0.7062 (6.533)***	0.108093
Labour (Man-days)	12.702 (4.218)***	3.011	1027.080 (1.718)*	597.960	0.0002 (0.400)	0.0006	0.09063 (1.337)	0.6779
Seeds (kg)	-17.287 (-2.923)	5.915	-58.881 (-0.084)	703.631	-0.0003 (-0.257)	0.00123	0.02086 (0.262)	0.07976
Fertilizer (kg)	-2.586 (-0.605)	4.275	48.166 (0.056)	866.319	-0.0018 (1.960)**	0.00089	-0.04943 (-0.503)	0.098207
Agrochemicals (L)	0.604 (4.654)**	0.130	-488.267 (-1.035)	471.556	0.00012 (4.244)***	2.71E-05	-0.04223 (-0.790)	0.053456
R^2	0.909		0.739		0.849		0.872	
$\bar{R}^2$	0.899		0.710		0.832		0.858	
F-Statistics	88.465		25.128		49.827		60.619	

Table 6: Constraints to dry season Okra production

Constraints	Frequency	Percentage	Rank
High cost of farm inputs	32	40.00	1st
Inadequate Capital	13	16.25	2nd
Incidences of Pests and diseases	10	12.50	3rd
Inadequate Extension services	9	11.25	4th
Inadequate Government assistance	7	8.75	5th
Inadequate improved seeds	5	6.25	6th
Inadequate infrastructure	4	5.00	7th
Total	80	100	8th

Source: Field Survey 2018

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EFFECTS OF ORGANIC MANURE AND NPK MINERAL FERTILIZER ON THE GROWTH AND YIELD OF EGGPLANT (*Solanum spp* L.*)* VARIETIES IN JOS, PLATEAU STATE, NIGERIA

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ABSTRACT
Field experiment was conducted at the students' Demonstration Federal College of Forestry, Jos, Plateau State, Nigeria to determine the effects of organic manure and NPK mineral fertilizer on the growth and yield of eggplant varieties. A factorial experiment was used for this study involving two organic manure sources (poultry droppings and cow dung each applied at 10t/ha) with NPK fertilizer applied at 300 kg/ha (as control) and three eggplant varieties (dark green, white-green striped and light green) replicated three (3) times. Data were collected from five randomly tagged plants from each plot on growth (plant height, number of leaves, number of branches and stem girth) and yield (days to 50% flowering, number of fruits/plant, fruit weight and total yield) characters and were analyzed using XLSTAT 18 statistical package and where significance was declared, means were separated using Turkey's test at 5% probability level. The result indicates that application of poultry manure at 10t/ha produced the highest plant height (103.89cm), number of leaves(128.67), number of branches (13.67), stem girth (6.47cm), number of fruits/plant (26.33), fruit weight (570.00g) and total yield(28.00 tha^{-1}). *Solanum gilo,* was found to perform better that the other two varieties on plant height (105.78cm), number of leaves(120.67), number of branches (12.78), stem girth (6.09cm), number of fruits/plant (25.22), fruit weight (543.33g) and total yield(30.55tha^{-1}). Therefore, organic manure in the form of poultry droppings at the rate of 10 t/ha and *Solanum gilo* variety should be used by farmers who embark on large scale production of eggplant in the study area maximum yield and productivity.

Keywords: *Eggplant, Growth, Yield, Jos, Poultry Manure, Guinea Savannah*

INTRODUCTION

Eggplant is one of the most important herbs among vegetable crops belonging to the genus *Solanum* and Solanaceae family which was thought to originate from India (Kashyap *et al.*, 2014).It has now spread throughout the tropics, subtropics and the warm temperate regions and has become an important vegetable. There are over 100 species of *Solanum* native to Africa, and several of them have been cultivated as vegetables in other areas of the world (Schippers, 2000). According to Aliero (2007) *S. melongena L*. is the most well-known species, which was domesticated in the Indo-Burma region and is now grown all over the world. The leaves are eaten raw as a vegetable and are equally more nutritive and more consumed than the fruit and the fruit is eaten both raw and cooked (Abolusoro *et al*., 2013). According to Oniah *et al*. (2010), eggplant fruit is an excellent source of proteins, carbohydrate, minerals, fats, water, fibre, salts and other vital mineral sources. The fruits of eggplant are eaten with rice, groundnut or yam. In the absence of kola-nut, eggplant fruits are served as substitute in burials and ceremonial functions in most Nigerian communities today (Oniah *et al*., 2010). The crop has great potential for income generation as the fruits are consumed almost on daily basis by urban families (Okpara *et al*., 2014). Majority of soils in Nigeria is constrained by low level of soil fertility, coupled with poor prevailing climatic conditions and this result in low yield of plants (Nafiu *et al*., 2011). One of the methods to maintain soil fertility and continuous cropping is to put back into the soil what plants has taken out. According to Nafiu *et al*. (2011) eggplant is a heavy feeder and occupies the ground for a long period of time. The main causes of such reduction in the productivity of eggplant are decreasing fertility and organic matters in the soil (Ullah *et al.*, 2008).Good soil fertility management program, proper timing and good fertilization are necessary to maintain high yield of crop.

The yield of eggplant in Nigeria is generally low due to the use of varieties that are of narrow genetic base, which are grown on soils of inherent low fertility (Dauda *et al.,* 2005). Moyin-Jesu (2007) states that efforts aimed at increasing the yield of eggplants using inorganic fertilizer are limited by scarcity at the farmers' level, high cost and degradation of soil properties due to continuous usage. According to Esan and Omilani (2018) in Nigeria, huge amount of animal manures are generated and heaped on dumpsite, posing potential environmental hazard and incorporating this waste material into the soil for crop production is expected to be beneficial since most Nigerian soils are low in organic matter, which is crucial for maintaining soil fertility as well as supplying primary, secondary and micronutrients for crop production. Organic manuring, although used for thousands of years in agricultural soils, has only recently been on the spot due to its positive effects on the physical, chemical, and biological soil properties (Santos *et al*., 2001). Manure is a readily available organic source of essential plant nutrients. It is used primarily as a source of plant nutrients (Mullins *et al.,* 2002).Organic manures act not only as a source of nutrients and organic matter, but also increases microbial biodiversity and activity in soil, influence structure, nutrients get turnover and many other changes related to physical, chemical and biological parameters of the soil (Albiach *et al.*, 2000). The soil having higher organic matter concentrations have been proven to enhance the growth and yield of different crops (Sarwar, 2005) as well as soil aeration, soil density and maximizing water holding capacity of soil for seed germination and plant root development. Despite the considerable social, economic and health benefits of eggplants, the optimum yield has not been fully harnessed in Nigeria due to declining soil fertility and choice of variety. To fill this gap, this study was carried out to determine the effects of organic manure and NPK mineral fertilizer on the growth and yield of eggplant varieties in Jos.

MATERIALS AND METHOD

Experimental area : The experiment was conducted at the students' Demonstration farm Federal College of Forestry, Jos, Plateau State, Nigeria. Jos is in the Northern Guinea Savanna between latitude 9^0 9' and longitude 8^0.8', with an elevation of 1,200 meters above sea level and an average annual rainfall of 1, 200 mm. The rain usually starts from April and terminates between October and November with temperatures ranging from 20 to 30ºC (Ibrahim *et al*., 2019).

Treatments and Experimental design : A factorial experiment involving Randomized Complete Block Design (RCBD) was used for this study involving two organic manure sources (poultry droppings and cow dung) with NPK fertilizer (as control; this is because most of the farmers in the study area were using NPK fertilizer for the production of eggplant) and three eggplant varieties (*Solanum gilo*, *Solanum melongena*L. and *Solanum eathiopicum* L.) arranged factorially in 12 treatment combinations replicated three (3) times.

Agronomic Practices: The experimental field was tilled and leveled manually with hoe to obtain fine tilled area. Soil at different locations on the field was collected at 30 cm depth, sieved and take to Agricultural Services Training Centre (ASTC), Vom, Jos, Plateau State for nalysis. The three eggplant varieties (*Solanum gilo*, *Solanum melongena*L. and *Solanum eathiopicum* L.) were sourced from Farin Gada seeds market. Poultry manure (10 tha^{-1}) was sourced from poultry farms practicing battery cage system and Cow dung (10 t/ha) from Fulani settlement. These manure were taken to ASTC, Vom, Jos, Plateau State for curing and analysis. While the NPK (15:15:15) at 300 $kgha^{-1}$was sourced from Plateau Agricultural Development Program (PADP) in Jos, Plateau State, Nigeria. The seeds were sown into the seed boxes in the screen house nursery and watered for four weeks before transplanting to the field. Weeding was carried out three times before maturity of the plant. The fruits were picked from the plants periodically as it matures.

Data collection and Analysis: Data were collected from five randomly tagged plants from each plot on;

Germination Percentage: A seed was considered as germinated when the radicle penetrated out from the seed coat and clearly appeared visually. The daily germination count was continued until no more seeds had been germinated. This was calculated using the equation below

$$Germination\ Percentage = (Number\ of\ Germinated\ Seeds / Number\ of\ seeds\ used) * 100\%$$

Plant height: This was measured from the base to the tip of the last leaf of the plant using meter rule in centimeter (cm).

Number of leaves: This was done by counting the leaves on the tagged plants

Number of branches: The number of branches was also counted on the plants that were tagged

Stem girth: A Vanier caliper was used to measure the stem girth of the eggplant tagged in centimeter (cm)

Days to 50% flowering: This was carried out by counting the number of days for the tagged plants to produce 50% flowering

Number of fruits/plant: The fruits on each tagged plant were counted and result extrapolated

Fruit weight: A digital weighting balance was used to measure the weight of the fruit harvested in grams (g) and

Total Yield: This was calculated using the formula

$$Total\,Yield = (FW * 10{,}000)/Plot\,Size$$

Where FW = Fruit Weight in Kilogram (kg), 10,000 = 1 hectare, Plot size = 3x3 ($9m^2$)

Characters measured were analyzed using XLSTAT 18 statistical package and where significance was declared, means were separated using Turkey's test at 5% probability level.

RESULTS AND DISCUSSION

The result of the soil physical and chemical properties of the experimental site is presented in Table 1. The result showed that the soil was sandy loam textural class with 837g/kg sand, 101g/kg silt, and 62g/kg clay. The pH value of the soil is 5.78, indicating acidity. Organic matter content and total nitrogen are low. The exchangeable cations and cation exchangeable capacity, and total nitrogen were relatively low, indicating that the soil is low in fertility. The result is in agreement with the findings of research conducted by Agriculture, Forestry and Fisheries Department (2011) who stated that eggplant grows best with a soil pH of 5.5 to 6.5. Eggplant is usually grown in light or sandy loam soils that provide good drainage and favourable soil temperatures. The chemical composition of poultry droppings and cow dung is presented in Table 2. The result reveals that the composition of poultry manure is higher than those of cow dung.

Effects of Organic Manure on the Growth Characters of Eggplant Varieties

The efficacy of organic manure on the growth characters of eggplant varieties is presented in Table 3. The germination percentage of eggplant was found to be statistically similar on the application of poultry droppings and cow dung. The application of NPK (15:15:15) fertilizer at 300kg/ha significantly ($p<0.001$) affect the germination percentage of eggplant producing 78.22% germination. The plant height of eggplant was significantly affected by organic manure application. Poultry manure was found to produce the tallest plant (103.89 cm), followed by cow dung (101.11cm) while the control (NPK fertilizer) produced the shortest plant (92.33 cm). Aminifard *et al.,* (2010) reported similar results indicates that manure application increased plant height at vegetative stage. The application of poultry manure produced more leaves (128.67) as against cow dung (114.67) and NPK fertilizer (107.33). The findings are in line with those of Cardoso *et al*., (2009), who found that manure increases eggplant aboveground characters better than the mineral fertilizer. Similarly, organic manure significantly influenced the number of branches of eggplant. Higher number of branches (13.67) was recorded at the application of poultry manure with cow dung and NPK fertilizer producing the least number of branches respectively. Stem girth was not statistically influenced by the application of both poultry droppings and cow dung but was significantly influenced on the control treatment. Farmyard and poultry manures increased plant development (measured in terms of shoot height, number of branches, leaves, and nodules) and reduced nematode gall formation, according to Devi and Hassan (2002). Varietal difference significantly influenced the germination percentage of eggplant. Higher germination percentage was recorded for *Solanum melongena* L. (76.22%) followed by *Solanum gilo* L. (73.44%) and *Solanum eathiopicum* L. had the least germination percentage (71.00%). Similarly, *Solanum gilo* L. performed better than *Solanum melongena*L. and *Solanum eathiopicum* L.on growth (plant height, number of leaves and number of branches) characteristics. In comparison to White green striped and light green cultivars, the Dark green cultivar developed the most branches. This could be because the cultivar's genetic make-up combines to take advantage of favorable agro-ecological variables for rapid development and branching. The tallest plants produced at 100kgNPK ha^{-1} with *Solanum gilo* cultivar were in agreement with the findings of Jayasinghe *et al.* (2016). No significant varietal influence was observed on stem girth for all the varieties.

Efficacy of Organic Manure on the Yield Characters of Eggplant Varieties

The efficacy of organic manure on the yield and yield characters of eggplant varieties is presented in Table 4. The yield and yield characters of eggplant was significantly ($p<0.001$) affected by the application of organic manure. Application of poultry manure took lesser number of days (48.55) to reach 50% flowering, produced more number of fruits/plant (26.33), produced heavier fruits/plant (570.00g) and recorded the highest total yield (28.00 t/ha) of eggplant as against the application of cow dung and NPK fertilizer (control).According to Adil *et. al*,. (2015) mean values showed that the more days to flowering were noted in control treatment. While plants grown under organic regimes took minimum number of days to flower which was at par with the plants grown under inorganic regimes. This result is also in line with the findings of Ambre and Comadug (2010) who found that early flowering in organic fertilizer treatment were observed in egg plant. Poultry manure gave significantly the highest number of fruits per plant while NPK gave the lowest number of fruits. Similarly, according to (Dominic *et al*., 2014) the likely impacts of organic manures in improving soil chemical and physical properties were attributed to the greater fruit yields obtained from manure applications (poultry manure). The result from Table 4 reveals that *Solanum eathiopicum* L. variety took lesser number of days to attain 50% flowering as against the other two varieties (*Solanum melongena* L and *Solanum gilo* L.). Varietal difference between *Solanum melongena* L., *Solanum gilo* L. and *Solanum eathiopicum* L. was measured on number of fruits/plant, fruit weight/plant and total yield. *Solanum gilo* L. consistently produced the highest number of fruits/plant (25.22), fruit weight/plant (543.33g) and total yield (30.55 t/ha).These differences might be as a result of the genetic makeup of the different varieties. According to Adil *et al*., (2015) Cultivar planted were at par with each other took the least days to attain 50% flowering. The early flowering in cultivar might be due to genetic variations, which play an important role in flowering. The induction of early flowering in organic regime by all cultivars may be due to the better nutritional status of plants, which increased the production of photosynthates (carbohydrates) needed for flower induction. All cultivars had larger fruit diameters in the organic regime, possibly because organic fertilizers improved the available nutritional status of the soil, resulting in more vigorous plants and higher leaf production (Adil *et al.*, 2015). According to Jayasinghe *et al.,* (2016) cultivar had no significant effect on total yield per hectare.

CONCLUSION

The results obtained from this experiment indicate that organic manure significantly affect the growth and yield of egg. The application of poultry droppings at the rate of 10 tha^{-1} produced the highest growth and yield characters of egg plant. Varietal difference also plays a significant role in influencing the growth and yield characters of eggplant. *Solanum gilo,* performed better than the other two varieties. No interaction between organic manure and variety was observed on the yield of eggplant. Therefore, organic manure in the form of poultry droppings at the rate of 10 t/ha and *Solanum gilo* should be used by farmers who embark on large scale production of eggplant in the study area. However, further studies may be needed to verify whether this rate of application is capable of maximizing yields.

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Table 1: Physical and Chemical Properties of Soil at the Experimental Site

Soil composition	Value
Physical composition	
Sand (g kg^{-1})	837
Silt (g kg^{-1})	101
Clay (g kg^{-1})	62
Textural class (USD)	Sandy Loam
Chemical composition	
Soil pH	5.78
Organic carbon (%)	1.61
Available P (mg kg^{-1})	5.8
Total Nitrogen (%)	0.47
Exchangeable Cations ($Cmolkg^{-1}$)	
Calcium	5.60
Magnesium	10.7
Sodium	90
Potassium	7.98
Cation Exchange Capacity ($Cmolkg^{-1}$)	3.59

Source: Field Work 2020, as Analysed at Agricultural Services and Training Center KASSA/VOM.

Table 2: Chemical Composition of Poultry Dropping and Cow Dung

Property	Poultry Droppings	Cow Dung
Total N (%)	2.40	0.85
Total P (%)	1.56	0.12
Total K (%)	1.40	1.49
Ca (%)	0.86	1.57
Mg (%)	0.42	0.51

Table 3: Effects of Organic Manure on the Growth Characters of Eggplant (*Solanum spp* L.*)*Varieties in JOS

Treatment	Germination Percentage (%)	Plant Height (cm)	Number of Leaves	Number of Branches	Stem Girth (cm)
Organic Manure					
Poultry Manure (10t/ha)	70.89^{b}	103.89^{a}	128.67^{a}	13.67^{a}	6.47^{a}
Cow Dung (10t/ha)	71.55^{b}	101.11^{b}	114.67^{b}	11.44^{b}	6.33^{a}
NPK (300kg/ha)	78.22^{a}	92.33^{c}	107.33^{c}	10.00^{c}	5.51^{b}
P – value	0.000***	0.000***	0.000***	0.000***	0.001**
Variety					
Solanum melongena L.	76.22^{a}	97.22^{b}	116.78^{b}	11.44^{b}	6.27
Solanum gilo L.	73.44^{ab}	105.78^{a}	120.67^{a}	12.78^{a}	6.09
Solanum eathiopicum L.	71.00^{b}	94.33^{c}	113.22^{c}	10.89^{b}	5.96
P – value	0.003**	0.000***	0.000***	0.000***	0.396^{NS}
Interaction					
O * V	NS	NS	NS	0.007**	NS

Table 4: Effects of Organic Manure on the Yield Characters of Eggplant (*Solanum spp* L.)in JOS

Treatment	Days to 50% Flowering	Number of Fruits/Plant	Fruit Weight/Plant (g)	Total Yield (t/ha)
Organic Manure				
Poultry Manure (10t/ha)	48.55^{c}	26.33^{a}	570.00^{a}	28.00^{a}
Cow Dung (10t/ha)	52.33^{b}	24.67^{b}	495.44^{b}	26.44^{b}
NPK (300kg/ha)	55.44^{a}	19.11^{c}	471.11^{c}	24.00^{c}
P – value	0.000***	0.000***	0.000***	0.000***
Variety				
Solanum melongena L.	52.22^{a}	22.66^{b}	510.00^{b}	25.11^{b}
Solanum gilo L.	52.89^{a}	25.22^{a}	543.33^{a}	30.55^{a}
Solanum eathiopicum L.	51.22^{b}	22.22^{b}	483.22^{c}	22.78^{c}
P – value	0.001**	0.000***	0.000***	0.000***
Interaction				
O * V	NS	NS	0.000***	NS

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EFFECTS OF SOIL AMENDMENT AND INTERCROPPING ON TOTAL SOLUBLE SOLIDS (^{0}BRIX), TITRATABLE ACIDITY AND pH OF TWO TOMATO VARIETIES

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ABSTRACT
Tomato is an important vegetable condiment used for stew and other recipes in Nigeria. It is one of the most protective foods, low in calories and has been associated with decreased risk of some cancer types. The experiment was carried out in National Horticultural Research Institute (NIHORT), Ibadan, in South Western Nigeria. The experiments were design as 2x2x5 factorial arranged in split-split plots with the main effects comprising of cropping system (sole and intercropped tomato), the sub-plots made up of two tomato varieties (Uc82B and Ibadan local) and the sub-sub plots consisted of five soil amendments (0, 60, and 120 kg N/ha NPK 15-15-15 and 10 and 20 tons/ha poultry manure). The soil was slightly acidic in 20011 to near neutral in 2012, poor in essential plant nutrients and low in organic matter. The nutrients composition of the poultry manure show an appreciable amount of plant nutrients which may be adequate to ameliorate the deficiency of the native soil fertility. The tomato was intercropped with maize. The results reveal that the cropping systems had no significant effect on the total soluble solids (^{0}Brix), but application of 10 t/ha PM resulted in significantly higher value especially in Ibadan local. The titratable acidity was not significantly influenced by the variety, while application of 120 kg N/ha NPK resulted in the highest values. The application of 20 t/ha PM resulted in significantly highest pH and the least pH value was obtained with the application of 120kgN/ha NPK.

Keywords: *Uc82B, Ibadan local, cropping system, NPK 15-15-15, poultry manure*.

INTRODUCTION

Tomato is commonly grown in intercropping in South Western Nigeria, this ensure good land use efficiency among other advantages. Varying rates of organic fertilizers are used by farmers because the native fertility status of most Nigeria agricultural soils is low and could not support suitable crop production over a long period (Agboola and Omueti, 1982). The soils therefore require fertilizer application to be able to supply the needed nutrient for optimum profitable cropping. Using poultry manure is in support of global agitation for organic fertilization as it has long been recognized as perhaps the most desirable of the natural fertilizer sources. It supplies essential plant nutrients and serves as a soil amendment by adding organic matter (Sloan *et al.,* 2003; Ewulo, 2005). Whereas the use of chemical fertilizer by farmers has not been sustainable due to its scarcity, high cost, nutrient imbalance and degradation of soil physical and chemical properties. Saliba-Colombani *et al.* (2001) illustrated that total sugars (primarily reducing sugars) content of tomato are positively correlated with pH and titratable acidity. Non-volatile compounds such as sugar, titratable acidity and soluble solids play a great role in determining the flavor of the tomato fruits. Hence, a field study was conducted to evaluate the treatments effects on these major physico-chemical properties: total titratable acid (TTA) and total soluble solids (^{0}Brix) and pH of the tomato fruits.

MATERIALS AND METHODS

General Treatments and Experimental Design: The study was carried out at the National Horticultural Research Institute (NIHORT), Jericho, Idi-Ishin, Ibadan, located in the rainforest Savanna transition zone and falls approximately on latitude 7^0 30' N and longitude 3^0 50'E. It is at altitude 168m above sea level.

Soil and Poultry Manure Analysis and Soil Amendment Application: Soil and poultry manure analyses were carried out for the two years under consideration using the standard analytical laboratory procedure of IITA (IITA, 1994). Cured poultry manure was thoroughly homogenized and subsamples were milled and sieved (<4 mm). N was determined by Kjedahl method, P by colorimeter, K by flame photometer and Ca and Mg were determined on Atomic Absorption Spectrophotometer (AAS). Incorporation of organic manure into soil involved digging the poultry manure into the soil using garden fork two weeks before planting. The inorganic fertilizer was applied by ring placement into drills 5 cm deep and 7.5 cm away from the plant and covered with soil at 3 weeks after planting (WAT). The inorganic fertilizer was NPK 15-15-15, and was applied at rate of 0, 400kg and 800kg/ha while poultry manure was applied at rate of 10 and 20t/ha.

Total Soluble Solids (^{0}brix), Titratable Acidity and pH: Ripe fruits of tomato from the randomly selected plants were harvested, counted and weighed two times a week. Tomato juice was extracted from a 10g sample, followed by centrifugation (10,000g, 10 min), at 4^0C. The supernatant was recovered for pH, values of pH were measured with a digital pH meter; (PHS-25, Precision scientific Instrument Co., Ltd., Shanghai, China). Buffers of pH 4.0 and 7.0 were used to standardize the equipment. Titratable acidity was determined by titration with 0.1 N NaOH until pH 8.1 was reached and reported as g acid/100g fresh weight (FW). Total soluble solids content was determined at 20^0C with a refractometer and reported as ^{0}Brix (adapted from AOAC, 1990). All assays for the physicochemical analysis were performed in triplicate.

Data Analysis: Data were subjected to analysis of variance using GenStat Discovery Edition 4 (2011). Significant means separated where appropriate by the least significant difference at 5% probability level ($LSD_{0.05}$).

RESULTS

Chemical and Physical Characteristics of Soil and Nutrients Composition of the Evaluated Poultry Manure: The soil was slightly acidic in 20011 to near neutral in 2012 (Table 1). The soils were also poor in essential plant nutrients and low in organic matter. Both were loamy sand in texture. The nutrients composition of the poultry manure evaluated in the present study (Table 2) show that the manure contained appreciable amount of plant nutrients which may be adequate to ameliorate the deficiency of the native soil fertility in the two years of the evaluation.

Effects of cropping system, soil amendment application and variety on chemical properties of tomato fruits (total soluble solids (^{0}Brix), titratable acidity and pH): ***Results of the Analyses Of Variance for Total Soluble Solids (^{0}Brix), Titratable Acidity and pH of Tomato Fruit :*** The results of the analyses of variance revealed that cropping systems and variety have no significant effects on total soluble solids (^{0}Brix) and titratable acidity, while the application of soil amendment has highly significant ($p < 0.05$) effects on the parameters (Table 3 and 4). Nevertheless, most primary and secondary interactive effects of the three factors were highly significant for these chemical properties of tomato. The pH was significantly affected by the three factors under consideration. All the evaluated factors had highly significant effects on pH, and these effects were also qualified by various significant primary and secondary interactive effects in 2011 (Table 3), while in 2012 (Table 4), there were no significant interactive effects of cropping system x variety and soil amendment x variety on the pH. The results further show that in 2011 (Table 5) cropping system has no significant effects on the total soluble solids (^{0}Brix), whereas sole cropping significantly increased titratable acidity and pH over the intercropped tomato. Application of various forms and rates of soil amendment resulted in significant variations of the parameters in the two years of evaluation, with 120 kg N/ha NPK resulting in the highest values and 0 kg N/ha showing the lowest values. Uc82B showed higher total soluble solid (^{0}Brix) and pH compare to Ibadan local, while variety has no significant effects on the titratable acidity of tomato fruit. The results obtained in 2012 (Table 6), also revealed that sole cropping resulted in significantly lower total soluble solids and higher titratable acidity, while cropping system had no significant effect on the pH. The results also show that the application of different forms and rates of soil amendment resulted in significant variations in the measured chemical properties of tomato fruit, with the application of 120 kg N/ha NPK resulting in highest values of total soluble solids and titratable acidity and 0 kg N/ha and 20t/ha PM showing the lowest values for total soluble solids and titratable acidity respectively. The highest pH was obtained with the application of 20 t/ha PM and 120 kg N/ha the lowest.

The results of the significant primary interaction effects of cropping system and soil amendment on titratable acidity for the two cropping seasons presented in Table 7, show that in 2011, the application of 20 t/ha PM, 0 and 60kg N/ha NPK fertilizer resulted in similar titratable acidity values in both sole and intercropping systems, while the application of 10 t/ha PM and 120 kg N/ha NPK fertilizer resulted in significantly higher titratable acidity with sole planting of tomato. Similar results in 2012, revealed that the application of 10 t/ha PM and 120 kg N/ha NPK fertilizer showed similar titratable acidity values in the two cropping systems. However, the application of 0 and 60 kg N/ha NPK fertilizer resulted in higher titratable acidity values with sole cropping, while the application of 120 kg N/ha NPK fertilizer showed significantly higher titratable acidity in the intercropped tomato.

The results of the significant cropping system x variety effects on titratable acidity obtained in 2012 and presented in Table 8, show that while Ibadan local tomato had significantly higher titratable acidity value under sole cropping, the value of the parameter was significantly higher with Uc82B tomato variety under the intercropping system. The results of the secondary interaction effects of cropping system, soil amendment application and variety on total soluble solids, titratable acidity and pH obtained in 2011 (Table 9) show that when tomatoes were planted as sole crop, the application of 20 t/ha PM, 0 and 120 kg N/ha NPK fertilizer resulted in no significant differences between the two tomato varieties, while the application of 10 t/ha PM resulted in significantly higher total soluble solids value than in Uc82B and vice versa with the application of 60 kg N/ha NPK fertilizer. However, when they were planted as intercrops with maize, the two varieties showed similar TSS values with the application of 0, 60 and 120 kg N/ha NPK fertilizer, while the application of 10 and 20 t/ha PM showed significantly higher TSS values in Uc82B tomato variety.

Similar results for titratable acidity revealed that tomato varieties showed similar titratable acidity values with the applications of 10t/ha, 0 and 60 kg N/ha NPK fertilizer, while the application of 20 t/ha PM resulted in significantly higher value in Ibadan local than in Uc82B, and vice versa with the application of 120 kg N/ha NPK fertilizer. However, under intercropping system, application of 10 t/ha PM, 0 and 60 kg N/ha NPK fertilizer resulted in significantly higher titratable acidity values in Ibadan local , while the parameter was significantly higher in Uc82B than in Ibadan local with the application of 20 t/ha PM. The results for the pH show that under sole cropping of tomato, the application of all forms and rates of soil amendments resulted in significant differences between the two tomato varieties, to the advantages of Ibadan local with the applications of 0 and 120 kg N/ha NPK fertilizer and to the advantages of Uc82B when 10 and 20 t/ha PM and 60 kg N/ha NPK fertilizer were applied. However, when tomatoes were intercropped with maize, the varieties showed similar pH values with the application of 20 t/ha PM, 0 and 120 kg N/ha NPK fertilizer, while the application of 10 t/ha PM and 60 kg N/ha NPK fertilizer resulted in significantly higher pH values in Ibadan local.

The results of similar secondary interactions of cropping system, soil amendment application and variety on t these parameters in 2012 (Table 10) show that with the sole cropping of tomato, the application of 10 t/ha PM resulted in similar TSS values in the two varieties, while the application of 0 and 60 kg N/ha NPK resulted in significantly higher TSS values in Uc82B and the parameter was significantly higher in Ibadan local with the application of 20 t/ha and 120 kg N/ha NPK fertilizer. However, when the tomatoes were intercropped with maize, TSS values were significantly higher in Uc82B with the application of 0, 60 and 120 kg N/ha NPK fertilizer, while the application of PM at 10 and 20 t/ha resulted in similar TSS values in the two varieties. The pH values was significantly higher in Uc82B with the application of 10 t/ha PM, 0 and 120 kg N/ha NPK fertilizer and vice versa with the application of 20 t/ha PM under the sole cropping system. However, under intercropping, the application of only 60 kg N/ha NPK resulted in significant difference in pH of the tomato varieties to the advantage of Uc82B, while the application of other soil amendments resulted in similar pH values in the two varieties.

DISCUSSION

Effects on total soluble solids: Similar to present study, the value of TSS was found to be lowest under inorganically fertilized plots, while the highest value of TSS was recorded under poultry manure at 10.0 t/ ha by Yadava *et al*. (2012). Kumaran *et al*. (1988) and Lumpkin (2005) also reported increase in total soluble solids in organically grown crops. However, Kapoulas *et al*. (2011) observed that tomato fruits from conventional system contained more total sugar, in average of all cultivars in comparison with organically produced fruits.

Effects on titratable acidity: In the present study, variety has no significant effects on the titratable acidity of tomato fruits, but there were some evidence, although not statistically significant, for higher levels of titratable acidity in Uc82B. However, George *et al.* (2004) and Tittonell *et al.* (2001) found that larger fruits had better titratable acidity due to variability in fruit weight. Titratable acidity was highest when plants were fertilized using inorganic fertilizer compared to all other fertilizer treatments. In contrast, Yadava *et al.* (2012) found that among other qualities of tomato fruits, acidity was found to be superior under organic system and the values of all these parameters were found to be lowest under inorganically fertilized plots.

***Effects on pH*:** Cropping system effect on tomato fruits pH was not consistent; there was a significant effect in 2011 as against 2012. The highest pH was obtained with the application of 20 t/ha PM while the lowest pH was observed with the application of 120 kg N/ha NPK. Fruits of the cultivar Uc82B, which were firmer and with thicker mesocarps had higher pH values. This was consistent with the earlier reports of Oko-Ibom and Asiegbu (2007) who reported that firm fruited tomato cultivars had higher pH values, because of the lesser locular area, which normally contains most of the fruit acids. Specifically, low pH (about 4.4) and excellent red colour are important quality requirements for processing tomatoes (Villareal, 1980). The result obtained from this study, can be compared with the research work by Al-Yahyai *et al.* (2010), in which the differences in fruit pH was pronounced among all the parameters and was highest under organic fertilizer and lowest under inorganic NPK treatment.

CONCLUSION

It can be concluded that cropping systems and variety have no effects on Total Soluble Solids (^{0}Brix) and Titratable acidity, while the application of Poultry manure and NPK15-15-15 has highly significant effects on the them, because Titratable acidity was highest when plants were fertilized using inorganic fertilizer, while the highest TSS was with organic fertilizer (20ton/ha poultry manure) for both Ibadan local and UC82b. The pH was affected by the three factors under consideration.

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Table 1: Chemical and Physical Characteristics of Soil

Parameters	2011	2012
pH	5.7	6.5
Total N (gkg-^{1})	0.30	0.65
Available P (mgkg-^{1})	8.09	12.5
Exchangeable K(cmol)	0.23	0.13
Exchangeable Ca ,,	0.12	1.23
Exchangeable Mg ,,	0.16	0.48
Exchangeable Na ,,	0.12	0.17
Exchangeable H^{++}Al ,,	0.2	0.2
ECEC(c mol)	0.83	2.21
Organic Carbon (%)	0.61	1.59
Organic matter	1.05	2.79
Sand (g/kg)	830	806
Silt (g/kg)	110	154
Clay (g/kg)	60	40
Textural class	Loamy Sand	Loamy Sand

Table 2: Nutrients Composition of the Evaluated Poultry Manure

Parameters	2011	2012
pH	6.2	6.4
Total N (gkg-^{1})	2.92	2.90
Total P (mgkg-^{1})	1.65	1.55
Total K (cmol)	1.80	1.83
Ca ,,	3.55	2.57
Mg ,,	0.55	0.43

Table 3: ANOVA Table showing mean square from the analyses of variance for total soluble solids (^{0}Brix), titratable acidity and pH of tomato fruit in 2011

Source of variation	d.f.	Total soluble solids (^{0}Brix)	Titratable acidity	pH
Cropping System (CS)	1	6.04Ns	0.18Ns	0.40**
Soil Amendment (SA)	4	13.52***	0.41***	0.16***
CS x SA	4	0.21**	0.01Ns	0.01*
Variety (VAR)	1	15.4Ns	0.03Ns	0.02**
CS x VAR	1	0.01Ns	0.07***	0.11***
SA x VAR	4	0.71***	0.02*	0.01*
CS x SA x VAR	4	0.264***	0.06***	0.02***

*, ** and *** denote effects significant at 5, 1 and 0.1 percent probability level, respectively
Ns denotes effects not significant

Table 4: ANOVA Table showing mean squares from the analyses of variance for Total soluble salt (^{0}Brix), Titratable acidity and pH in 2012

Source of variation	d.f.	Total soluble solids (^{0}Brix)	Titratable acidity	pH
Cropping System (CS)	1	6.46Ns	0.2Ns	0.05**
Soil Amendment (SA)	4	6.28***	0.42***	0.31***
CS x SA	4	0.07Ns	0.07***	0.03***
Variety (VAR)	1	0.19Ns	0.01ns	0.23***
CS x VAR	1	2.32***	0.31***	0.01Ns
SA x VAR	4	2.72**	0.02*	0.002Ns
CS x SA x VAR	4	0.67***	0.004Ns	0.04***

*, ** and *** denote effects significant at 5, 1 and 0.1 percent probability level, respectively
Ns denotes effects not significant

Table 5: Main effects of cropping system, soil amendment application and variety on total soluble solids (^{0}Brix), titratable acidity and pH of tomato fruit in 2011

Treatments	Total soluble solids (^{0}Brix)	Titratable acidity	pH
Cropping system			
Sole	5.37	0.85	4.42
Intercrop	5.32	0.74	4.26
$LSD_{(0.05)}$	Ns	0.1	0.08
Variety			
Ib. local	4.84	0.82	4.32
Uc82B	5.86	0.77	4.36
$LSD_{(0.05)}$	0.07	Ns	0.02
Fertilizer			
0Kg	4.16	0.77	4.28
10t/ha PM	4.99	0.68	4.38
20t/ha PM	5.82	0.59	4.51
60kgN/ha NPK	4.86	0.87	4.35
120kgN/ha NPK	6.93	1.06	4.20
$LSD_{(0.05)}$	0.14	0.0 7	0.04

Least Significant Difference at 5 percent probability level ($LSD_{0.05}$), Ns= not significant. PM=Poultry Manure

Table 6: Main effects of cropping system, soil amendment application and variety on total soluble solids (^{0}Brix), titratable acidity and pH of tomato fruit in 2012

Treatments	Total soluble solids (^{0}Brix)	Titratable acidity	pH
Cropping system			
Sole	4.02	0.77	4.36
Intercrop	4.68	0.66	4.35
$LSD_{(0.05)}$	0.43	0.05	Ns
Variety			
Ib. local	4.29	0.71	4.27
Uc82B	4.40	0.72	4.40
$LSD_{(0.05)}$	Ns	Ns	0.04
Fertilizer			
0kg	3.56	0.68	4.34
10t/ha PM	3.77	0.59	4.40
20t/ha PM	4.68	0.52	4.57
60kgN/ha NPK	4.51	0.79	4.23
120kgN/ha N P K	5.30	1.05	4.16
$LSD_{(0.05)}$	0.18	0.06	0.04

Least Significant Difference at 5 percent probability level ($LSD_{0.05}$), Ns= not significant, PM= Poultry Manure

Table 7: Interactive effects of cropping system and soil amendment application on titratable acidity of tomato fruit.

		Titratable Acidity (%)	
Soil amendment	Cropping system	2011	2012
0 kg/ha N	Sole crop	0.70	0.70
	Intercrop	0.67	0.67
10 t/ha PM	Sole crop	0.67	0.58
	Intercrop	0.51	0.60
20 t/ha PM	Sole crop	0.51	0.46
	Intercrop	0.53	0.57
60 kg N/ha NPK	Sole crop	0.82	0.85
	Intercrop	0.77	0.74
120 kg N/ha NPK	Sole crop	1.17	0.98
	Intercrop	0.82	1.02
$LSD_{0.05}$		0.07	0.08

Least Significant Difference at 5 percent probability level ($LSD_{0.05}$), PM= Poultry Manure

Table 8: Effects of cropping system and variety on titratable acidity in 2012

Cropping System	Variety	Titratable acidity(%)
Sole	Ib. local	0.84
	Uc82B	0.71
Intercrop	Ib. local	0.59
	Uc82B	0.73
$LSD_{0.05}$		0.04

Least Significant Difference at 5 percent probability level ($LSD_{0.05}$)

Table 9: Interactive effects of cropping system soil amendment application and variety on total soluble solids, titratable acidity and pH of tomato fruit in 2011

Cropping system	Fertilizer	Variety	Total soluble solids (^{0}Brix)	Titratable acidity(%)	pH
Sole	0Kg	Ib. local	3.88	0.65	4.20
		Uc82B	4.76	0.74	4.47
	10t/ha PM	Ib. local	4.03	0.60	4.37
		Uc82B	6.29	0.74	4.57
	20t/ha PM	Ib. local	5.38	0.63	4.57
		Uc82B	6.14	0.45	4.67
	60kgN/ha NPK	Ib. local	4.38	0.81	4.37
		Uc82B	5.13	0.77	4.50
	120kgN/ha N P K	Ib. local	6.63	0.95	4.30
		Uc82B	7.13	1.09	4.23
Intercrop	0Kg	Ib. local	3.63	0.95	4.25
		Uc82B	3.63	0.74	4.20
	10t/ha PM	Ib. local	4.13	0.81	4.30
		Uc82B	5.49	0.60	4.27
	20t/ha PM	Ib. local	5.13	0.56	4.43
		Uc82B	6.63	0.70	4.37
	60kgN/ha NPK	Ib. local	4.63	1.11	4.30
		Uc82B	5.29	0.81	4.20
	120kgN/ha N P K	Ib. local	6.63	1.10	4.13
		Uc82B	7.33	1.12	4.15
$LSD_{(0.05)}$			0.76	0.12	0.07

Least Significant Difference at 5 percent probability level ($LSD_{0.05}$), PM= Poultry Manure

Table 10: Interactive effects of cropping system, soil amendment application and variety on total soluble solids, titratable acidity and pH in tomato fruit in 2012

Cropping system	Fertilizer	Variety	Total soluble solids (^{0}Brix)	Titratable acidity(%)	pH
Sole	0Kg	Ib. local	2.80	0.81	4.27
		Uc82B	3.61	0.57	4.43
	10t/ha PM	Ib. local	3.38	0.74	4.27
		Uc82B	3.38	0.6	4.50
	20t/ha PM	Ib. local	5.53	0.50	4.37
		Uc82B	3.39	0.52	4.63
	60kgN/ha NPK	Ib. local	3.96	0.96	4.22
		Uc82B	4.40	0.69	4.13
	120kgN/ha N P K	Ib. local	5.13	1.2	4.03
		Uc82B	4.61	1.13	4.20
Intercrop	0Kg	Ib. local	3.14	0.6	4.23
		Uc82B	4.68	0.75	4.28
	10t/ha PM	Ib. local	4.29	0.42	4.40
		Uc82B	3.73	0.59	4.43
	20t/ha PM	Ib. local	5.12	0.43	4.60
		Uc82B	4.65	0.63	4.67
	60kgN/ha NPK	Ib. local	4.42	0.74	4.15
		Uc82B	5.25	0.8	4.43
	120kgN/ha N P K	Ib. local	5.14	0.74	4.17
		Uc82B	6.32	0.91	4.23
LSD			0.43	Ns	0.09

Least Significant Difference at 5 percent probability level ($LSD_{0.05}$), Ns= not significant, PM= Poultry Manure

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ANALYSIS OF THE EFFECT OF CLIMATE CHANGE ON THE PRODUCTION OF OKRA IN ENUGU STATE, NIGERIA: 1999-2014

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ABSTRACT
Climate change has positive and negative effects on crop production in Nigeria. The study analysed the effect of climate change on the production of okra in Enugu state, Nigeria (1999-2014) using secondary data collected from Enugu state Agricultural Development Programme (ENADEP) and Nigeria Meteorological Agency (NIMET) Akanu-Ibiam International Airport for the period of sixteen years. Specifically, the study determined trends of okra yields, trends of climate variables, onset and cessation of rainfall, and effect of climate change on okra yields in the study area. Results indicated an increasing trend of okra yields in the area. Rainfall and evaporation rates decreased within the period under investigation as well as relative humidity within the same period as seen from their negative intercepts. The least and highest rainfall was seen in 2001 and 2003 respectively. Though there was an increase in okra yields, but yields increased with a decrease in rainfall as observed from the trend analysis. Similarly, onset and cessation of rainfall was witnessed in the months of April and November respectively. Also the Double log results with the R^2 values of 0.774 indicated that seventy-seven percent (77%) of the fluctuations in the yields of okra was accounted for by the explanatory variables included in the model. The coefficients of Rainfall amount (0.288), relative humidity (0.257) and evaporation rates (0.273) were positively related to the yields of okra in the area, hence, the positive influence of abiotic factor in enhancing crop yields, whereas temperature maximum was negatively related to yields of okra. Therefore, climate change in the form of changes in its elements was significantly influencing the production of okra in the study area. The study recommends planting of resistant and quick maturing varieties especially in the midst of climate change.

Keywords: *Okra, Meteorology, Rainfall, Cessation of Rainfall, Climate Change.*

INTRODUCTION

Okra fruit (*Abelmoschus esculentus*) is a vegetable crop commonly grown by most rural farmers in sub-Saharan Africa. Okra is often referred to as "finger licks" due to its draw nature (Douglas, 2001). According to Law-Ogbomo *et. al.*, (2013) okra fruit is rich in vitamins and minerals and is grown widely in gardens for home use with few for markets. In Nigeria, okra rank third among fruit vegetables compared to tomato and pepper in terms of consumption and production. The world production is estimated at 6 million tonnes per year and India followed by Nigeria and Sudan as the world largest producers (Ekunwe, Alufohai, and Adolue, 2017; Varmudy, 2011). Currently, India is the largest okra producer in the world with 6,126,000 tonnes production per year. Nigeria comes second with 2,033,129 tonnes yearly production and with 304,712 tonnes of production per year, Sudan is the third largest producer of okra (AtlasBig.com, 2022).

The immature pods of Okra are used as boiled vegetable while in dried form, used as soup thickener as it contains vitamins, calcium, potassium and other minerals (Ijoyah and Dzer, 2012). Over 60% of okra grown in Nigeria are produced under intercropping system and the intercropping of okra with arable crops by most smallholder farmers is a common copping techniques for poverty reduction in Nigeria (Ibeawuchi, 2007). This intercropping may allow complementary interactions in crops that have greater system resilience, reduce insect-pest incidence and deliver environmental benefits such as greater soil and water conservation potential (Gupta, 2004; Ekunwe, *et al*. 2017). Despite the nutritive values of okra, its production is very low in the country even in Enugu state. Farmers depend on natural fertility of the soil and utilises the resources of family and hired labour in land preparation and weed control to ensure maximum yields per hectare (Nwaobiala and Ogbonna, 2014). However, production has not kept pace with population growth and has not been sustainable due to climate change and over dependence on rain-fed agriculture (Law-Ogbomo, *et al.* 2013). Consequently, low yield of okra and its rapid deterioration are due to poor storage and preservation technology hence, a widening gap between the supply and demand of the product in Nigeria (IITA, 1993). As such there is a "glut" in supply at the harvest period, and loom in scarcity during the off-seasons.

Climate change in the form of erratic rainfall patterns and unpredictable high temperature spells consequently reduce crop productivity (Ijoyah and Dzer, 2012). Unless measures are undertaken to mitigate the effects of climate change, okra production and food security in the country will be under threat and will jeopardize the future of the fruit vegetable growers. Okra is generally sensitive to environmental extremes, and thus high temperatures and limited soil moisture are the major causes of low yields and will be further magnified by climate change (Varmudy, 2011). Temperature limits the range and production of many crops. In the tropics, high temperature conditions are often prevalent during the growing season and, with a changing climate, crops will be subjected to increased temperature stress (Udoh, *et al*. 2005). Analysis of climate fluctuation in the tropics indicated that temperatures are rising and its severity will increase in the coming decades. High temperature stress disrupts the biochemical reactions fundamental for normal cell function in plants (Ijoyah and Dzer, 2012). It primarily affects the photosynthetic functions of higher plants. High temperatures can cause significant losses in okra productivity due to reduced fruit set, and lower quality fruits (Katung and Kashina, 2005). In okra, high temperature exposure at the pre-anthesis stage did not affect pistil or stamen viability, but high post-pollination temperatures inhibited fruit set, suggesting that fertilization is sensitive to high temperature stress (Ijoyah and Dzer, 2012). Symptoms causing fruit set failure at high temperatures in okra; includes bud drop, abnormal flower development, poor pollen production, ovule abortion and poor viability and other reproductive abnormalities (Eke, *et al*. 2008). In addition, significant inhibition of photosynthesis occurs at temperatures above optimum, resulting in considerable loss of potential productivity (Agbola 2007).

Unpredictable drought is the single most important factor affecting world food security and the catalyst of the great famines of the past (CGIAR, 2003). In combination with elevated temperatures, decreased precipitation could lead to increase in evapo-transpiration, and severe crop water-stress conditions. Rainfall amount and distribution greatly influences the yield and quality of okra; drought conditions drastically reduce okra productivity (Ifeanyi-obi *et al*. 2012). Drought stress causes an increase of solute concentration in the environment (soil), leading to an osmotic flow of water out of plant cells. This leads to an increase of the solute concentration in plant cells, thereby lowering the water potential and disrupting membranes and cell processes such as photosynthesis. The timing, intensity, and duration of drought spells determine the magnitude of the effect of drought.

Okra production occurs in both dry and wet seasons in the tropics. However, production is often limited during the rainy season due to excessive moisture brought about by heavy rainfall (Lee, *et al.* 1990). Most fruit vegetables especially okra is highly sensitive to flooding and damage to okra by flooding is due to the reduction of oxygen in the root zone which inhibits aerobic processes (Schipper, 2000). Flooded okra plants accumulate endogenous ethylene that causes damage to the plants. Low oxygen levels stimulate an increased production of organic chemicals that deleteriously affect the growth and development of okra plant in the roots due to water-logged conditions. The severity of flooding symptoms increases with rising temperatures; rapid wilting and death of okra plants is usually observed following a short period of flooding at high temperatures (Ijoyah and Dzer, 2012) Production of okra is often limited during the rainy season due to excessive moisture brought about by heavy rainfall (Makinde, *et al*. 2011). Okra is highly sensitive to flooding and damage to okra by flooding is due to the reduction of oxygen in the root zone which inhibits aerobic processes. Farmers depend on natural fertility of the soil to ensure maximum yields per hectare. Farmers utilises the resources of family and hired labour for weed control. However, the possible solutions to mitigate climate challenge problems in okra production include: a. in locating okra farms, areas that are prone to flooding should be avoided; b. farm yard manure which may be a waste material in certain climes may be accessed and used to improve soil fertility; c. use of herbicide is becoming very popular in crop production (Obiazi and Onyibe, 2021), it is recommended that butachlor should be one of the pre-emergence herbicides considered for weed management in okra production in Asaba in the rain forest ecology of Nigeria (Obiazi, 2021). Okra production is also affected by the changing climatic scenario, which arise from extreme events that are difficult to predict. More erratic rainfall patterns and unpredictable high temperature spells will consequently reduce crop productivity (Adejuwon, 2005). Climate change is projected to increase the global temperatures, causes variations in rainfall, increase the frequency of extreme events such as heat stress, droughts, floods and land degradation, hence, this study, on the analysis of the effect of climate change on the production of okra in Enugu State.

MATERIAL AND METHODS

Study Area

Enugu State is in the South-east geo-graphical zone of Nigeria. The state has a population of 3,267,837 and a population density of 262 people per square kilometre. It accounts for 2.3% of Nigeria's total population (NPC, 2006). It shares boarders with Abia and Imo States in the South, Ebonyi and Benue States in the East and Northeast respectively, Kogi and Anambra states in the North West and West respectively. Enugu State covers an area of 7,660.2 square kilometres. It lies at latitude $6^0 30'$ North and longitude $7^0 30'$ East. Enugu is located in a tropical rain forest zone with a derived savannah. The city has a tropical savannah climate. Enugu's climate is humid and this humidity is at its highest between the months of March and November. The average annual rainfall in Enugu is around 2,000 millimetres, which arrives intermittently and becomes very heavy during the rainy season. Other weather conditions affecting the city include Harmattan, a dusty trade wind lasting a few weeks in the months of December and January. Like the rest of Nigeria, Enugu is hot all year round (Clayton, 1999; Minahan, 2002).

Data Collection: The data used for the study were sourced from Enugu Agricultural Development Programme reports on agricultural production survey, where data on agronomic parameters (yields of okra) was collected from 1999-2014. Similarly, data on climate variables (rainfall, temperature, relative humidity, and evaporation rate) were collected from Nigeria Meteorological Agency (NIMET), Akanu-Ibiam International Airport Enugu.

Data Analysis : The data for the study were analysed using E-view and SPSS version 17.0. The line graph is used to examine the relationship between the yields of the crop for the period under study as well as the climate variability pattern. However, Cobb-Douglas model that relate yields in tons per hectare to meteorological data were used to analyse its impact on the yields of okra in the study area. The Cobb-Douglas equation was implicitly stated as:

$Y = f(R, MT, EP, RH)$ --I

The explicit and stochastic form of the model was also stated as:

Cobb-Douglas Functional Form

$\log Y_{it} = \beta_o + \beta_1 \log R_t + \beta_2 \log Rh_t + \beta_3 \log Ep_t + \beta_4 \log T_t + et$ ------------------------------------- II

Where:

Y = Yields of okra (t/ha),
R = Annual average of rainfall (mm),
Rh = Annual average of relative humidity (%),
Ep = Annual average of evaporation rate (mm),
T = Annual average of Temperature (^oC),
et = Random disturbances,
i = 1, 2, 3, ----- n periods observed,
t = 1999 – 2014
β_o, = Intercept,
$\beta_{1-}\beta_4$ = Parameter estimates

RESULTS AND DISCUSSION

The descriptive results on the trends of okra yields ('000mt), rainfall, temperature, relative humidity, evaporation rates and their linear trend lines with equations as well as the onset and cessation of wet seasons were presented in Figure 1, 2, and 3. Also the Cobb-Douglas results of the impact of climate element variability patterns on the yields of okra using rainfall, temperature, relative humidity, and evaporation rate as a proxy for climate change from 1999-2014 was presented in Table 1. Figure 1, the lowest yield of okra was recorded in 1999 (5.9mt) and the highest yields of 12.87mt in 2012. The yields of okra increased at an increasing rate, but drastically declined from 2004 to 2006. But a steady increment was witnessed from 2007 to 2012 when the highest yield was recorded as earlier stated. Throughout the periods, the yields of okra fluctuated relative to the variability in climate element. The depressions in the line graph of okra yields would be attributed to the years of extreme events of rainfall and other climate element variability. From the point of view of linear trends analysis, the yields of okra increased within the period under investigation as revealed by the positive intercept and coefficient of the yield equation. The R Squared value of 0.878 of the equation as seen in the graph indicated that eighty-eight percent fluctuation in the yields of okra in the period under investigation. This fluctuation in the yields of okra as observed from the trend analysis might be attributed to the impact of climate change on the yields of okra within the period of this investigation, as such the yields of okra have not kept pace with population increase and demand and supply in the study area and the unequivocal food insecurity in the country. This result is in-line with the finding of Oguntade *et al.* (2012) who reported that okra production has not been sustainable due to climate change and over dependence on rain-fed agriculture. Consequently, okra yields declined due to non-resilient of production, hence, there is a widening gap between the supply and demand of the product.

Figure 2 refers, temperature maximum varied within 32^0C and 33^0C within the period. The lowest temperature was recorded in the years with 32^0C maximum temperature and highest temperature in the years with 33^0C maximum temperature as seen in the temperature line graph. The linear trend line indicated that temperature increased within the period of this study as seen the positive coefficient and intercept of the trend equation. The depressed and undulated line graph is rainfall. Rainfall was lowest in 2001 and highest in 2003. The undulated nature of the graph showed the degree of variation in rainfall patterns in the study area. From trend line equation, rainfall fluctuated in the area within the period under review as manifested in the negative coefficient and intercept of its trend equation. Relative humidity increased within the period as seen in the positive trend equation of the graph. The least relative humidity was recorded in 2002 with 69% and the highest relative humidity was recorded in 2012 with the value of 75.5%. The least evaporation rate was recorded in 2014 with 3.8mm and the highest rate of evaporation was recorded in 2005 with 6.2mm within the period of this study. Evaporation rate decreased as seen in the negative sign of the linear trend equation while relative humidity increases as seen in the positive sign of the linear trend equation. From the above, it was observed that climate elements fluctuated within the period of this study. The onset and cessation of wet season in the area was determined using moisture budget, which is a technique that related rainfall amount at monthly averages to evaporation rate at monthly averages all measured in millimetres (mm). The onset and cessation were determined at the point of interception of the two lines i.e. precipitation equals evaporation rate (PE=ER) which is always at the beginning and at the end of the year. From Figure 3, onset of wet season occurred in the month of May and cessation was seen in the month of November. Therefore, onset and cessation of rainfall was in the months of May and November respectively.However, where evaporation line is greater than rainfall line graph implied a drought condition, otherwise it is wet season i.e. within January and April as well as the months of November to December were the months of drought, while May to October were months of rainy season. The two peaks at the months of July and September indicated the popular bimodal rainfall pattern of Southeast, Nigeria and the August drought condition always known as “August break” shown by the sharp depression in the month of August.

Impact of Climate Change on Okra Yields in the Study Area: The relationship on the impact of climate change on the yields of okra was presented in Table 1 where temperature, rainfall, relative humidity and evaporation rates were used as the explanatory variables to the yields of okra. Table 1, the R^2 value of 0.774 implied that seventy-seven percent of the fluctuations in the yields of okra was accounted for by the explanatory variables included in the model. The F-ratio of 12.464 which was significant at 1% probability showed that the coefficients of the explanatory variables were statistically different from zero. Also the Durbin-Watson value of 1.894 that was approximately 2.00 showed the absence of auto-correlation. Specifically, temperature (-0.066) which was statistically negative and significant at 5% implied that temperature had adverse impacts on the yields of okra in the study area especially in the midst of climate change. This is in-agreement with the finding of Adejuwon, (2005) who reported that more erratic rainfall patterns and extreme events of high temperature spells would consequently reduce the productivity of okra. Rainfall (0.288) was positively related to the yields of okra. This indicated that rainfall influences the yields and productivity of okra in the study area. This result corroborated with Agbola (2007) who reported that rainfall and other climatic variables does not have adverse significant effects on the yield of fruit vegetables rather soil fertility, use of fertilizer, type of seedlings and seeds that determine the variations in crop yields. The result was also consistent with Ifeanyi-obi *et al* (2012) who asserted that rainfall amount and distribution greatly influences the yield and quality of okra. Also, relative humidity (0.257) and evaporation rate (0.273) were positively related to output of okra in the area. This also corroborated with the findings of Sowunmi *et al* (2010) who reported that climate change in relation to rainfall, relative humidity and evaporation rates does not have significant detrimental impact on the yield of fruit vegetables rather soil fertility, use of fertilizer, type of seedlings and seeds that determine the variations in crop yields.

Summary : The study investigated the impact of climate change on the yields of okra in Enugu state, Nigeria using secondary data collected for sixteen years from Nigeria Meteorological Agency, Akanu-Ibiam International Airport, Enugu and Enugu state Agricultural Development Programme where data on rainfall, temperature, relative humidity, evaporation rate and okra yields were collected respectively. Data collected were analysed using descriptive statistics and Cobb-Douglass production function. Results showed that okra yields increased within the period of the study. Also rainfall and evaporation rates decreased within the area, while temperature increased significantly in the area. Similarly, the study identified that onset and cessation of wet season were in the month of May and November respectively. From R Square (0.774), seventy-seven per cent of the variations in okra yields were accounted for by the explanatory variables, while rainfall, relative humidity, and evaporation rates were positively related to okra yields. However, temperature had adversely impacted on the yields of okra in the area.

CONCLUSION

Based on the major findings, okra yields increased within the period of the study. Rainfall and evaporation rates decreased within the periods under review, while temperature increased significantly in the study area within the periods.

RECOMMENDATION

Farmers are encouraged to change the time of planting relative to onset and cessation of wet season. Use of drought resistant varieties of okra should be encouraged. Climate change policy should be incorporated in the current agricultural transformation policy of the Federal Government of Nigeria. Irrigation agriculture should be introduced in the area to cushion the negative impact of high temperature experienced in the area.

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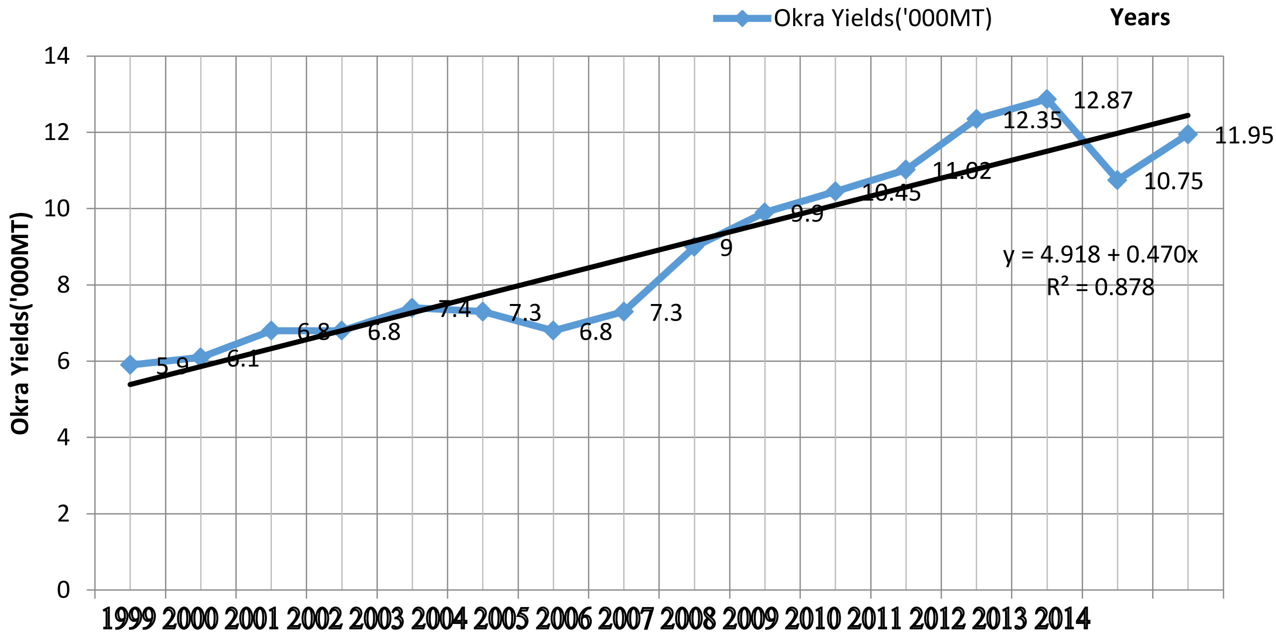
Table 1: Cobb-Douglas Results of the Relationship between Okra Yields and Climate Variables: 1999-2014

Explanatory variable	Coefficients	t-values
Temperature (^{o}C)	-0.066	-3.208**
Rainfall (mm)	0.288	7.967***
Relative Humidity (%)	0.257	2.839**
Evaporation rate (mm)	0.273	5.782***
Constant	3.123	9.081***
F-ratio	12.464	***
R^2	0.774	
R^2 Adjusted	0.751	
Durbin-Watson	1.894	

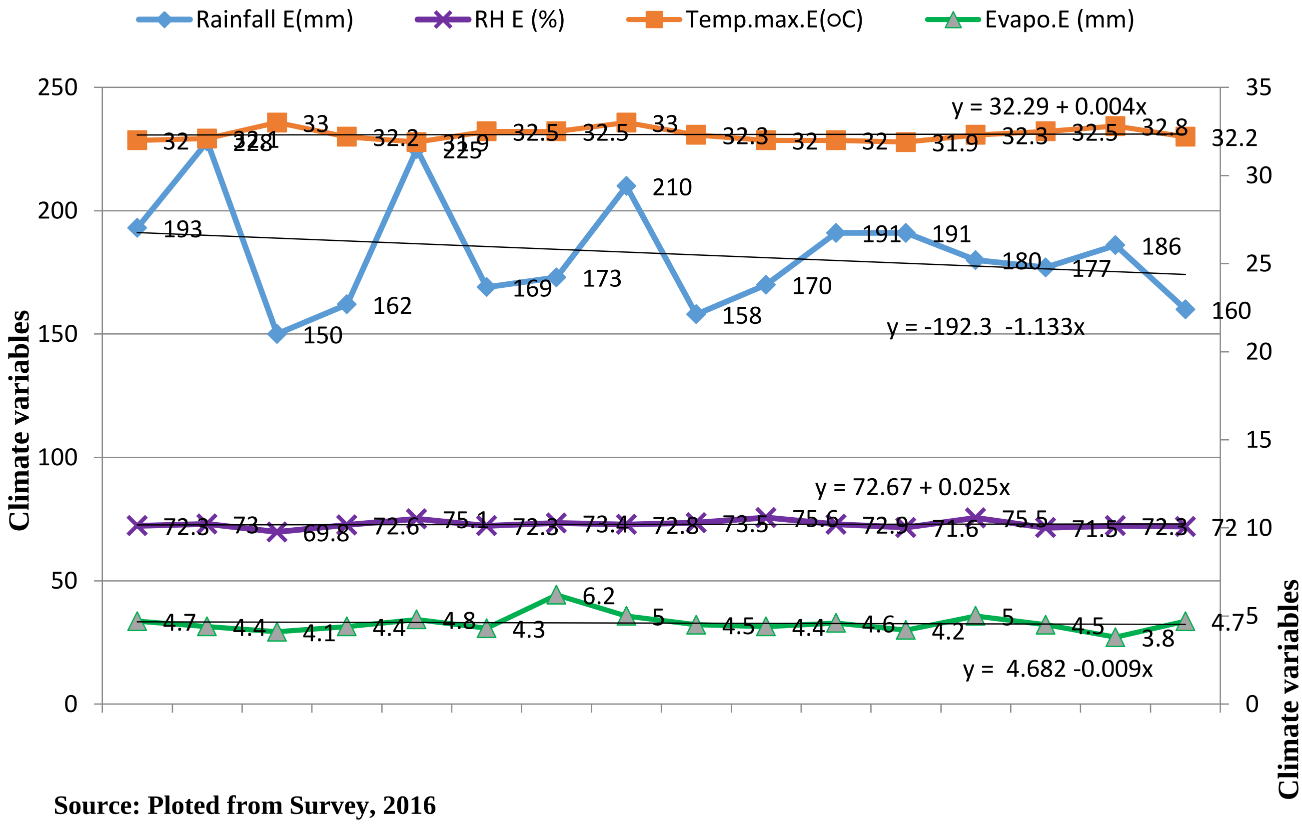
Source: Computed from Survey, 2016. ** and *** significant at 5% and 1%, respectively.

Figure 1: Trends of Okra yield in Enugu State, 1999-2014



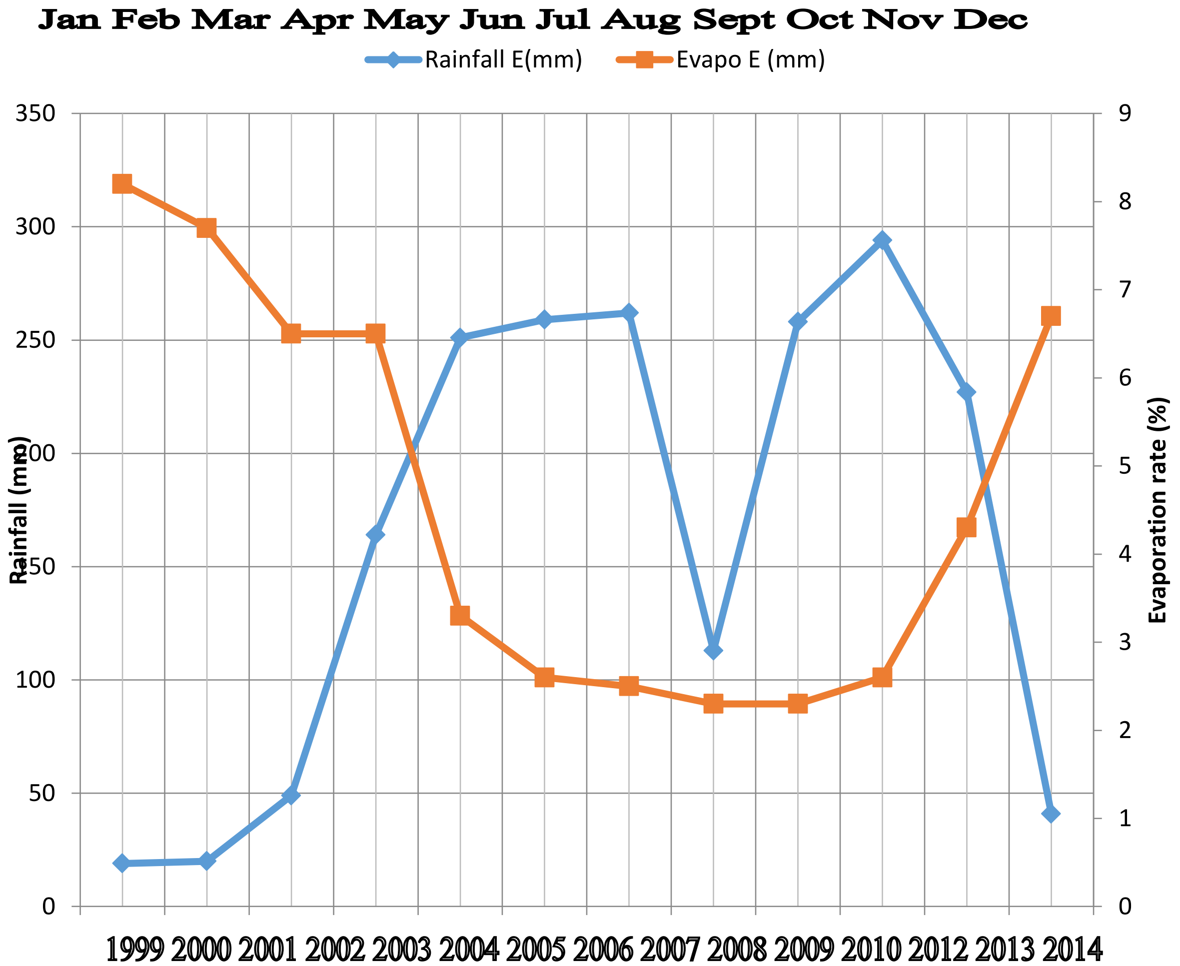
Source: Ploted from Survey, 2016

Figure 2: Trends of climate variables in Enugu: 1999-2014 **Years**



Source: Ploted from Survey, 2016

Figure 3: Determination of Onset and Cessation of Rainfall Using Moisture



Source: Ploted from Survey, 2016

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EFFECTS OF NUTRIENTS SOURCES ON THE GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L.) IN DADIN-KOWA, GOMBE STATE, NIGERIA

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ABSTRACT
Field experiment was conducted at the Teaching and Training Farm, Hinna, Federal College of Horticultural Technology, Dadinkowa. The aim of the research was to determine the effects of nutrients sources on the growth and yield of Okra. The experiment consisted of three levels of poultry manure and control (0, 4, 6 and 8 tha^{-1}) and three levels of N.P.K (20:10:10) fertilizer (100, 150 and 200 $kgha^{-1}$) which were combined factorially and laid out in a Randomized Complete Block Design replicated three times. Data was collected on plant height, number of leafs, leaf area, at 2, 4, 6, 8 and 10 weeks after planting etc. Based on the findings of this study, plant height, number of leaves, leaf area, number of fruit and fruit diameter had no significant difference.

Key words: *Okra, Leaf area, Poultry manure, Plant height*

INTRODUCTION

Okra, *Abelmoschus esculentus* L. Moench is a popular vegetable in tropical and sub-tropical countries of the world grown for its pod (Folorunso and Ojeniyi, 2003). It is a member of the hibiscus family, Malvaceae and has the typical floral characteristics of that family. Originating from Africa, it is now widely distributed in the tropics including Nigeria (National Research Council, 2006). It is an important vegetable crop occupying a land area of 277,000 hectares with a production of 731,000 metric tons worldwide and productivity of 2.63 th^{a-1}in Nigeria (FAO, 2006). Okra is valued for its edible green pods (fruits), a capsule that contains many seeds. However, its leaves are also eaten as a vegetable. Okra seeds are used as a non-caffeinated substitute for coffee and also as a source of seed oil (FAO, 2006). Okra is said to be of economic importance because of its nutritional value that has the potential to improve food security (FAO, 2006). The use of organic amendments applied to soil not only enhances its nutrient status but also reduces the incidence of pest (Adilakshi *et al.,* 2007). Improvement of soil fertility through the application of fertilizers has become an essential factor that enables the world to feed billions of people of its population (Brady and Weil, 1999). Soil fertility is usually maintained by the application of organic and inorganic fertilizers (Okigbo, 1985), and there is also an improvement in the physical and biological properties of the soils (Okwuagwu *et al.,* 2003). The use of inorganic fertilizers can improve crop yields, soil pH, total nutrient content and nutrient availability (Akande *et al.,* 2010); most especially in the tropics where soils are adversely affected by sub optimal soil fertility and erosion causing deterioration of the nutrient status and changes in population of soil organisms (Economic Commission for Africa, 2001). But its use is constrained by acidity, scarcity, nutrient imbalance and it is no longer within the reach of poor-resource farmers due to its high cost. When excessively used, it also has a depressing effect on yield. This causes a reduction in number of fruits, delays and reduces fruit setting (John *et al.,* 2004). The use of organic manures as a means of maintaining and increasing soil fertility has been advocated (Alasiri and Ogunkeye, 1999). Some of these materials have also been found to control pathogens (Muhammed *et al.,* 2001). Animal manures, when efficiently and effectively used, ensure sustainable crop productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil thus ensuring longer residual effects; improve root development and higher crop yields (Sharma and Mittra, 1991).

Poultry manure's relative resistance to microbial degradation is essential for establishing and maintaining optimum soil physical condition and is important for plant growth. It is also very cheap and effective as a good source of nitrogen for sustainable crop production (Dauda *et al.*, 2008).

MATERIAL AND METHODS

Site description

The experiment was conducted at the Teaching and Research Farm Hinna, Federal College of Horticulture, Dadin-kowa. Yamaltu Deba Local Government Area, Gombe State, Nigeria. Located on Latitude 11^0 -3- 'N longitude 10^0 2' and altitude 240 above sea level. It receives an annual rainfall of 980 -1100 mm and temperature ranges between 24^0C – 35^oCand the soil type of the area is loamy.

Treatments and experimental design

The experiment consisted of three levels of poultry manure and control (0, 4, 6 and 8 tha^{-1}) and three levels of N.P.K (20:10:10) fertilizer (100, 150 and 200 $kgha^{-1}$) and fitted in to a Randomized Complete Block Design (RCBD) replicated three times. The experimental area was cleared manually and delineated in to plots sizes of 2 x 3m. Data was collected on plant height using measuring tape , number of leafs by counting, leaf area, fruit length and weight, at 2, 4, 6, 8 and 10 weeks after planting. The collected data were subjected to analysis of variance (ANOVA) and means were compared using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effects of Poultry Manure and NPK on Plant Height of Okra (cm)

From the results recorded Table1 the treatments had no significant different on plant height of okra but poultry manure recorded the overall tallest plant height. This is in contrast to the works of (Giwa, Ojeniyi 2004, Ojeniyi, 2000) whose discover that poultry manure gave better plant height of Okra Plant compared to in organic fertilizers.

Number of Leaves of Okra

From these findings, it has been discovered that number of leaves of okra in Table 2 did not significantly varied ($P < 0.05$) from 2 - 6^{th} WAS with the application of poultry manure and NPK. Poultry manure at 8WAS significantly varied. Application of 6 tha^{-1} poultry manure at 8WAS recorded highest number of leaves of okra with a value of 15.00. Similarly, application of 150 $kgha^{-1}$NPK and 4 tha^{-1} Poultry manure were statistically similar with number of leaves value of 14.70. Control (without poultry manure and NPK) produces the lowest number of leaves. The highest number of leaves recorded due to application of 6 tha^{-1} poultry manure agreed with the work of (John *et al.*, 2004) who reported that, Poultry manure contains essential nutrients which are associated with high photosynthetic activities that promote root and vegetative growth of Okra.

Leaf Area of Okra (cm)

From the experiment, results showed significant effects only at 8WAS. Application of 8 tha^{-1} poultry manure recorded tallest LA of 375.1cm (Table 3). Control produce the shortest leave area. These findings are Similar to the work of John (1992) who reported that, application of poultry manure had nitrogen content that increase leave area which invariable increase sunlight interception for a highest rate of Photosynthesis.

Number of Fruits and Fruits Diameter of Okra (cm)

The results of number of fruit and fruit diameter in Table 4 revealed non-significant difference ($P < 0.05$) at 8 and 10WAS. Application of 4 tha^{-1} gave the highest number of fruit of 6.6 at 10WAS followed by 8 $tha^{-1}$with 6.00 numbers of fruits of okra. While application of 100 $kgha^{-1}$produce the lowest number of okra fruits of 1.6 .For the fruit diameter, application of 8 tha^{-1} produce highest okra fruit diameter of 9.1 at 8WAS (Table 4). Whereas application of 100 $kgha^{-1}$ NPK produce lowest fruit diameter compare to other treatments. The results is in line with findings of (Anon, 2006) who earlier reported that, application of poultry manure helps to improve the soil which aid in making soil better environment for plant growth and yield.

Fruit length and fruit weight of Okra

Results presented in Table 5 did not significantly varied by different nutrient sources applied on fruit length and fruit weight of okra. Except that, application of 8 tha^{-1} poultry manure recorded highest fruit length of 12.1 cm and fruit weight of 40.8 Kg 10WAS. Application of 100 Kg/ha of NPK fertilizer recorded the least fruit length of 4.5 cm and fruit weight of 0.5 Kg 10WAS. The highest fruit length and weight recorded were in line with the findings of (Deksis *et al.*, 2008) who observed that, poultry manure provide plant which promote growth and yield of Okra, similarly to the finding of Garg and bahla (2008), who reported the importance of poultry manure on the performance of vegetative growth as it promote plant growth and development of Okra plant.

Yield per Plot and Yield/hectare of Okra

The results of yield per plot and yield per hectare presented in Table 6 significantly varied by application of different nutrient sources on okra. Application of 8 tha^{-1} poultry manure gave highest yield per plot with a value of 8.1 Kg while control recorded the least value of 3.3 Kg/m^2 (Table 6). Similarly, on yield per hectare, application of poultry manure at 8tha^{-1} recorded the highest value of 40.8tha^{-1} while control recorded the least yield per hectare of 8.33tha^{-1}(Table 6). Many researchers worked on organic and inorganic fertilizers on the growth and yield of okra. (Giwa and Ojeniyi, 2004) reported that, organic manure gave better excellent soil amendment providing both organic matter and nitrogen and is in agreement with the work of (Olatunji and Uboh, 2012) who also reported an increased in okra and tomato yield when poultry manure was used on the effect of organic and in organic fertilizers on the growth and yield of okra and tomato. Anon (2006) stated that application of poultry manure help to improve the soil which aid in making soil better environment for plant growth and yield.

CONCLUSION AND RECOMMENDATION

The results concluded from the present investigation was that, application of poultry manure and inorganic fertilizer had no significant effect on parameters measured on Okra growth at FCH Dadinkowa Teaching and Training Farm Hinna. Hence further research to be conducted in the study area.

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Table 1: Effects of Poultry Manure and NPK on Plant Height of Okra (cm)

Treatments/ Weeks after sowing	2WAS	4WAS	6WAS	8WAS
T1 = Control	11.2	16.5	26.5	34.1
T2= 100 Kgha^{-1}	10.0	20.0	29.1	33.6
T3 = 150 Kgha^{-1}	11.3	20.5	34.1	38.0
T4 = 200 Kgha^{-1}	10.9	16.2	28.3	32.3
T5 = 4 tha^{-1}	10.7	17.6	27.4	35.1
T6 = 6 tha^{-1}	10.7	17.4	29.2	32.3
T7 = 8 tha^{-1}	11.8	18.5	32.5	38.1
SE±	1.09	2.72	7.16	7.55
P< F	NS	NS	NS	NS

Figures in the same row followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT.

Table 2: Effects of Poultry Manure and NPK on Number of Leaves of Okra

Treatments/ Weeks after sowing	2WAS	4WAS	6WAS	8WAS
T1 = Control	5.7	8.0	9.1	14.3^{ab}
T2= 100 Kgha^{-1}	5.7	8.4	9.0	12.5^{c}
T3 = 150 Kgha^{-1}	6.0	8.4	10.0	14.7^{a}
T4 = 200 Kgha^{-1}	6.1	8.4	8.3	12.7^{bc}
T5 = 4 tha^{-1}	6.0	8.4	9.1	14.7^{a}
T6 = 6 tha^{-1}	5.7	8.2	10.4	15.0^{a}
T7 = 8 tha^{-1}	6.0	9.0	10.0	13.7^{abc}
SE±	0.64	1.20	0.93	0.76
P< F	NS	NS	NS	*

Figures in the same row followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT.

Table 3: Effects of Poultry Manure and NPK on Leave Area (cm)

Treatments/ weeks After sowing	2WAS	4WAS	6WAS	8WAS
T1 = Control	21.5	47.8	112.2	221.4
T2= 100 Kgha^{-1}	24.39	42.9	108.4	236.2
T3 = 150 Kg/ha^{-1}	31.8	50.7	181.1	291.4
T4 = 200 Kgha^{-1}	34.2	54.7	128.3	248.3
T5 = 4 tha^{-1}	21.5	37.9	113.2	321.3
T6 = 6 tha^{-1}	32.5	55.6	137.3	322.4
T7 = 8 tha^{-1}	40.8	71.5	202.4	375.1
SE±	11.36	23.69	58.23	70.5
P< F	NS	NS	NS	NS

Figures in the same row followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT.

Table 4: Effects of Poultry Manure and NPK on number of Fruits and Fruits Diameter of okra (cm)

Treatments/ Weeks after sowing	Number of Fruit 8WAS	Number of Fruit 10WAS	Fruit Diameter (cm) 8WAS	Fruit Diameter (cm) 10WAS
T1 = Control	2.5	6.3	7.2	8.2
T2= 100 Kgha^{-1}	1.6	5.0	5.1	7.5
T3 = 150 Kgha^{-1}	3.3	4.0	8.3	8.7
T4 = 200 Kgha^{-1}	2.6	5.7	6.1	7.8
T5 = 4 tha^{-1}	3.0	6.6	8.1	9.7
T6 = 6 tha^{-1}	2.5	5.0	6.5	8.4
T7 = 8 tha^{-1}	3.9	6.0	9.1	9.0
SE±	1.27	1.32	2.55	1.66
P< F	NS	NS	NS	NS

Figures in the same row followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

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Table 5: Effects of Poultry Manure and NPK on Fruit Length and Fruit Weight of Okra

Treatments/ weeks After sowing	Fruit Length (cm) 8WAS	Fruit Length (cm) 10WAS	Fruit Weight (Kg) 8WAS	Fruit Weight (Kg) 10WAS
T1 = Control	6.5	8.8	0.6	34.1
T2= 100 Kgha^{-1}	4.5	10.0	0.5	24.9
T3 = 150 Kgha^{-1}	7.2	9.8	0.6	38.0
T4 = 200 Kgha^{-1}	5.5	8.7	1.6	31.8
T5 = 4 tha^{-1}	6.8	9.9	0.8	34.2
T6 = 6 tha^{-1}	7.2	8.0	0.6	32.5
T7 = 8 tha^{-1}	8.1	12.1	1.0	40.8
SE±	2.48	2.45	0.57	11.36
P< F	NS	NS	NS	NS

Figures in the same row followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT.

Table 6: Effects of Poultry Manure and NPK on Yield per plot and yield/hectare of Okra

Treatments	Yield per Plot $Kg/6m^2$	Yield per Hectare tha^{-1}
T1 = Control	3.3^{b}	8.3^{b}
T2= 100 $Kgha^{-1}$	4.8^{ab}	12.3^{ab}
T3 = 150 $Kgha^{-1}$	6.6^{ab}	14.0^{ab}
T4 = 200 $Kgha^{-1}$	6.0^{ab}	15.0^{ab}
T5 = 4 tha^{-1}	6.5^{ab}	16.3^{a}
T6 = 6 tha^{-1}	5.7^{ab}	14.0^{ab}
T7 = 8 tha^{-1}	8.1^{a}	20.0^{a}
SE±	1.51	3.30
P< F	*	*

Figures in the same row followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT.

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ICT DEVICES, APPLICATIONS AND THEIR BARRIERS IN THE HORTICULTURAL SECTOR IN NIGERIA

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ABSTRACT

The strategic application of Information and communication technologies (ICT) to the agricultural sector, offers a greater opportunity for economic growth and poverty alleviation. This paper reviewed ICT devices applications and barriers to the horticultural sector of Nigeria. The review showed that Phyto-monitoring technique, e-Data Bank, Plant-Plus DSS, Computer-Aided Design (CAD) software, List Servers, Geographic Information System (GIS) were ICT devices that supported horticultural development for economic sustainability. Likewise, the review identified inadequate and unstable power supply, high cost of hardware and software, lack of financial assistance, inadequate databases, poor infrastructure and inadequate training on ICT devices impeded ICT integration in the horticultural sector of the country. It was concluded that the government should improve the horticultural sector through consistent policies and implementation, holistic adaptation strategy and proper funding.

Keywords: *ICT, Integration, Sustainable Technology, Horticultural sector*

INTRODUCTION

The application of information and communication technologies (ICT) are increasing day by day among different communities for obtaining the information about related issues, problems and their solutions (Chhachhar *et al.*, 2014). ICT, as described by Food and Agricultural Organization cited in Lawal-Adebowale, (2017) refers to the technologies that facilitate collection, gathering, processing, storage, retrieval, dissemination, and implementation of data and information using microelectronics, optics, and telecommunication computers. Other devices include radios, telephone (mobile or fixed), video, television, DVD, audio players etc. (Maigoro *et al.,* 2013; Lawal-Adebowale, 2017). As averred by Singh, (2002) horticulture is the branch of agriculture concerned with intensely cultured plants directly used by people for food, medicinal purposes or for aesthetic gratification. A more precise definition can be given as "the cultivation, processing and sale of fruits, nuts, vegetables, ornamental plants, and flowers as well as many additional services" (Acquaah, 2009; Rahman, 2018). It also includes plant conservation, landscape restoration, soil management, landscape and garden design, construction and maintenance.

According to Chhachhar *et al.* (2014) and Sheyin *et al.* (2017) effective distribution of ICT can increase agricultural attractiveness by production, transaction costs, raising production, efficiencies and farmers' incomes, by providing more information and value to stakeholders. ICT can be used for distance learning programs and help the farmer for learning new approaches and technologies for the use of agriculture development in developing countries. Such kind of technologies can provide information on weather, prices, and profitable income. The application of ICT in agriculture development had been widely studied by individual researchers and corporate bodies (Sideridis *et al.,* 2010; Fawole*et al.,* 2012; Okasha *et al.*, 2013; Chhachhar*et al.,* 2014;Saidu*et al.,* 2017; Rahman, 2018; Taragola *et al.*,2009) . For instance, Chhachhar *et al.* (2014) research in remote areas of developing countries yielded positive results when they discovered that mobile phones, radio and television used by farmers reduced communication gap with buyers of market goods. While Saidu *et al.* (2017), observed that despite thepotential benefits of ICT in agricultural technology development in developing countries there are challenges that hinders the successful implementation. Recommendations such as good and affordable internet connectivity, good ICT infrastructure, and adequate ICT skills, were made.

Communication devices enable people around the world to contact one another to use information instantly, and to communicate from remote areas. There are lots of difficulties facing horticulturist which can be solved by providing them with adequate access to quality information which many researchers have generated (Taiwo and Amoo, 2021). ICT play important roles in addressing these challenges and enhancing the standard of living of the rural farmers. Improved agricultural production is the major weapon in the fight against world hunger, improving rural livelihood and increasing economic growth. The world development report of the World Bank (2008) argued that the growth in the agricultural sector contributes proportionally more to poverty reduction than growth in any other economic sector.

However, there are little or no known studies to assess ICT application and barriers in the horticultural sector of Nigeria. This review therefore intends to identify the gap that exists in the usage of ICT devices and the barriers in the horticultural sector. The objective of this review is to examine various linkages of Information technologies to the horticultural sector in other to achieve maximum productivity by the horticulturist.

METHODOLOGY

The methodology used in this review involves collection of data from secondary sources. It is a literature review study with the main sources of data and information from documented sources such as books, journals, bulletins, official documents, reports, conference proceedings/workshop papers etc. The data from these sources are discussed to bring out a clear picture of the issue in focus. The opinions and conclusions formed from this systematic process can be accepted as reliable and valid.

RESULTS AND DISCUSSIONS

ICT Devices that support Horticultural Development

ICT devices that support horticultural development as enumerated by many researchers such as Nokoe, (2001), Van der Waals *et al., 9*2003), Gurovich *et al., (*2006), Taragola*et al., (*2009), Okasha*et al.,* (2013), Musale *et al.,* (2013), Gisgeography.com (2019*)* can be categorized under the following headings.

Computer-Aided Design (CAD) software: These programs aid designers in developing the urban design of sites particularly without affecting the other aspects of the design. Clients can choose or describe their requirements while the computer based model may be used to fine tune such requirements. The programs are Land CAD, Real time Landscaping Pro, Landscape deck patio designer 12, 3D Home Architect and Landscape Design Deluxe, 3D Landscape Design for Everyone, Earth capes, and 3D garden composer etc. The benefits of (CAD) are: saves time, increases productivity, improves accuracy**,** better quality and ease of understanding

The Phyto-monitoring Technique: was developed for early and objective detection of crop stress such as water stress. Phyto-monitoring was originally developed by Russian and Israeli scientists and combine modern microelectronics, computer and data transmission technologies. This technology enables real-time plant water status assessment in a nondestructive way. It is a combination of hardware (plant growth-related and environmental sensors, data loggers and data transmission units), software and application techniques (measurement protocols and data interpretation).The system is capable of warning the farmer of upcoming problems and can be used effectively to reduce crop damage in severe climatic conditions. The benefits of Phyto monitoring system are introduced as follows: Reduced inspection outage frequency, reduced forced outage frequency, reduced spillage of water**,** reduced maintenance hours and reduced man power and High yield.

The PLANT-Plus system: was developed in the Netherlands as a DSS for the control of late blight on potatoes in Europe. The framework has since been expanded and modified to include DSS for various diseases on potatoes, carrots and other crops. The system requires information input on the spread and size of the fungus and environmental data. The system assists growers in deciding the most appropriate time to apply fungicides in a cost effective and environmentally acceptable manner. An alternative model that has also been used is the *ADVANTAGE DSV* for the control of the same fungus in carrots.

Geographic Information System (GIS): is a computer system/tool for mapping and analyzing things that exist and evens happening on earth. The components of a GIS are the hardware (computers, digitizers, plotters etc.).Software (data input tools, database management system, query tools, graphical user interface), and possibly the Data. Data include maps (base maps, environmental maps, reference maps). An example of GIS for decision making may be given for tomato production, and indicating suitable areas (based on soil, rainfall etc.) for evaluation in Nigeria. The benefits include: Cost savings resulting from greater efficiency**,** better decision making**,** improved communication**,** better geographic information record keeping and managing geographically.

Internet, List Servers: The exchange of information is much easier due to internet accessibility. Once an individual subscribes to a 'listserv', he/she is immediately accessible in some way to a wide array of professionals and experts who are in the group. The Internet has several list servers covering a variety of topics and disciplines. Example HORTI-NET caters for those interested in horticulture research related issues, development and issues specific to India. The Horticultural Research Institute of Nigeria and the Horticultural Society can take lead role in this aspect. The benefits of List Servers include: Relationship building and authentic, remote community, expertise on-demand, knowledge archiving and **b**uilding a shared history / consciousness.

Databases: a database is an organized collection of data stored and accessed electronically from a computer system i.e. a place where the data is stored. The major components of the Database are**:** Hardware **(**I/O devices, storage devices**),** Software (DBMS software, application programs), Data, Procedure, and Database Access Language **(**It is used to access the data to and from the database**).**

The e-Data Bank: is primarily to disseminate information to farmers and comprised the crop related information, weather and soil information, growth progress monitoring, farmer's data and experts' consultation. The benefits of the developed model include data management and readiness, reduced rural-urban drift, motivation of both farmers and researchers to get involved in agriculture, improved security, reduced technical issues and improvement of the overall economy.

According to Singh *et al* (2015) Agriculture Information System (AIS) is a computer based information system which contains all the interrelated information which could really help Horticulturists (farmers) in managing information and policy decision making. The ICT devices that help facilitating farming activities encompassed applications like radio, television, cellular phones, computers, tablets and networking, hardware and software, satellite systems (Munyua and Adera 2009; Pande and Deshmukh, 2015). In the same way, (Yimer, 2015; Munyua and Adera 2009) reports that radio is extensively used to inform users on agricultural topics, including new and upgraded farming techniques, production management, and market information and many more. This shows that farmers may take advantage of using radio in the absence of technology especially rural farmers. The Internet and web-based applications are extensively used in sharing and dissemination of agricultural knowledge, marketing of goods and services.

The mobile phone has reduced the gap among traders and farmers and same time farmers directly communicate with buyers and customers to find the good price of their product. Famers before going to market simply contact one of the best buyers who purchase production in good price. According to Grameen (2007) the uses of mobile phones among farmers have played positive impact in their income and productivity because before travel communicate with buyers and sell their product in good price. The development about agriculture in developing countries mostly depends on the use of information and communication technologies which can connect the different communities of people. The radio and television have played a very important role in enhancing the capacity of farmers by broadcasting different agricultural related programs. Similarly Television disseminates scientific and agricultural knowledge among farmers and provides latest information with the discussion of agriculture experts (Chhachhar *et al*.,2014).

Barriers to the use of ICT in Horticulture

ICT is extremely dynamic, changing dramatically with time and little political input. The presence of specific barriers can create difficulties that prevent farmers from reaping the benefits of the systems

Inadequate Training and ICT Support Facilities: Access to the internet and telecommunications are mostly limited to urban areas in many developing countries while the rural areas remain beyond the ambit of new technology**.** It was further argued by Saidu *et* *al.,* (2017) that poor implementation in support of ICT is among the key impediments to wider usage by small-scale and rural farmers. In addition, lack of customized ICT applications, increase of sophisticated software with enhanced human capital requirements, lack of harmonization with production, market and essential ongoing end-user extension training that will enhance farmers and lack of basic skills of using ICT facilities in agriculture. "Lack of training" is important in most countries, regardless of the level of development (Taragola and Gelb, 2005). Singh *et al*. (2014) reported some existing issues to include inadequate accessibility of ICT services to rural farmers, lack of basic skills of using ICT facilities in agriculture, inability of government to deliver adequate ICT knowledge to farmers. On the other hand, a study by Agu (2013), specifically focuses on the problems faced by women in agriculture like access to land, access/weak extension services, access to credit, lack of supportive policies, access/no adoption of new agricultural technologies, and restricted access to training and education. These issues continue to persist because information that could help the farmers adjust and minimize their problems were either absent or not sufficient (Abdulrahman et al., 2017).

Inadequate Database: Authors such as Kale *et al.,* (2015), Tolulope*et al.,* (2015)cited in Saidu*et al.,* (2017) suggest the harmonization of the basic and scientific research knowledge database and farmers' knowledge database adopted biologically and socially over a period of time. This would aid faster dissemination of agricultural information and knowledge among the various stakeholders in the sector. In addition, outdated curriculum of agriculture is still being used in Nigerian educational institution which is not in conformity with global trends. There is need to in-cooperate agricultural curriculum into schools and to create massive awareness via mass media, especially Nollywood industry. It was revealed that the key challenges to ICT implementation were lack of customized ICT applications, increase of sophisticated software with enhanced human capital requirements, lack of harmonization with production, market and essential ongoing end-user extension training that will enhance farmers. The authors were able to analyzed impediments of ICT adoption in agriculture. The shortcoming of this review is the use of old data which could not reflect the present situation. The results would have been useful if current data are used, thus findings are not reliable as they fail to represent the contemporary situation. Owing to the fact that ICT is extremely dynamic, changing dramatically with time and little political input.

Low Power Supply: Inadequate, and unstable power supply, cost of hardware and software are high with respect of average rural dwellers in most developing countries. In addition, Saidu*et al.,* (2017) reports that lack of ICT proficiency by end user is one of the factors militating against adopting ICT in horticulture.

Lack of Financial Support: is a major stumbling block for many farmers to expand production or diversify into new high value enterprises.

Poor infrastructure and marketing facilities: poor communications and unavailability of facilities from major suppliers hinders farmers' access to ICT devices. This argument corresponds with findings of Lawal-Adebowale, (2017) and Saidu*et al.,* (2017) who put forward that these are also main constraints of ICT adoption in horticulture. Moreover, challenges hampering the use of ICTs in ARIs have been listed to include inadequate computers and the supporting technological infrastructure, and low coordination of agricultural stakeholders due to institutional diversity and department disintegration. Most of the horticultural growers use the PC for business administration (Word, Excel, etc.).

Summary: The review has demonstrated that ICT devices which support horticultural development for economic sustainability include the use of Phyto-monitoring,e-Data Bank,PLANT-PlusDSS, Computer-Aided Design (CAD) software, List Servers etc. for improved productivity and High yield.

CONCLUSION

Collectively, the study outlined the critical roles of ICT integration in the horticultural sector of Nigeria centering on sustainable technology transfer. The review mainly focuses on integration of ICT devices in horticultural sector, benefits and some specific barriers. This review has identified the use of Phyto-monitoring technique,e-Data Bank,PLANT-PlusDSS, Computer-Aided Design (CAD) software, List Servers, Geographic Information System (GIS) as ICT devices that support horticultural development for economic sustainability. However, Inadequate, and unstable power supply, high cost of hardware and software, lack of financial assistance, inadequate databases, poor infrastructure and inadequate training on ICT devices impede ICT integration in the horticultural sector of the country. Relevant suggestions were given by various researchers to overcome challenges militating against successful implementation of ICT in horticultural sector but were found to be insufficient. The Government of Nigeria should therefore advance the horticultural sector through consistent policy making and implementation, holistic adaptation strategy and proper funding.

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RESPONSE OF TWO ACCESSIONS OF BAOBAB (*Adansonia digitata* L.*)* TO POULTRY MANURE RATES AT THE NURSERY STAGE AND EARLY GROWTH UNDER FIELD CONDITIONS

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ABSTRACT
Nursery experiment is meant to predict field performance of crops. Nursery and field experiments were conducted at the Department of Crop Science, University of Nigeria, Nsukka to determine the repsonse of two accessions of Baobab sourced from Odo-Ere and Okolok, Kogi State, Nigeria to six poultry manure (PM) rates (0, 10, 20, 30, 40 and 50 t ha^{-1}) in the nursery and three PM rates (0, 15, and 30 t ha^{-1}) in the field, as factorial experiments in completely randomized design (CRD) and randomized complete block design (RCBD) with six and three replicates, respectively. Data were collected on plant height, number of leaves, stem diameter, number of branches both in the nursey and field while data on number of bifurcated leaves was recorded only in the nursery. Analysis of variance showed existence of variation between the two accessions of Baobab with respect to some growth attributes. Notably, Odo-Ere accession gave higher number of leaves (29.8 and 101.9), thicker stem (5.9 and 7.0 cm) at 2 MAT in both experiments and more bifurcated leaves at 2, 3, 4 and 5 months in the nursery with respective values of 1.6, 3.5, 4.1 and 4.7. Application of PM significantly enhanced growth of Baobab in both experiments. In the nursey, application of 50 t ha^{-1} of PM increased plant height (95.3 cm), number of leaves (97.2), number of bifurcated leaves (95.7), stem diameter (10.8 cm) and number of branches (8.1) at 7 months. Field evaluation revealed that PM rate beyond 15 t ha^{-1} had inverse effects on Baobab growth. Accession x PM interaction was not significant. A near-linear response pattern of the two accessions to PM in the nursery and in the field suggest the superlative impact that external nutrient input could have on the Baobab plant.

Keywords: *Accessions, baobab, poultry manure rates, growth*

INTRODUCTION

Baobab **(***Adansonia digitata* L.**)** belongs to the Malvaceae family. It is an indigenous tree crop known as Baobab tree in English, Igi Ose in Yoruba, Ose in Igbo, and Kuka in Hausa. Baobab is found throughout the drier regions of Africa (Melissa, 2019). It is a deciduous, massive and majestic tree up to 25 m high which may live for hundreds of years (Gebauer *et al.,* 2002). The trunk is up to 10 m in diameter, often buttressed; usually tapering or cylindrical and abruptly bottle-shaped. Branches are large and distributed irregularly. The leaves are alternate and foliate. *Adansonia digitata* is a multipurpose and widely used species in the savanna with numerous medicinal and non-medicinal applications in Africa and every part of it has been reported to be useful (Rabi'u and Murtala, 2013). In 2009, the European Commission authorized the importation of Baobab fruit pulp as a novel food (Buchmann *et al.,* 2010) and it was approved by the Food and Drug Administration as a food ingredient in the United States of America (Addy, 2009). In Nigeria, Baobab leaves have been a major component in traditional diets of the rural population (Husseini *et al.,* 2016). The young leaves are used for soup in form of slurry sauce comparable to Okra used for eating starchy balls made from cassava, yam and millet. The leaves can also be dried and processed into powder which is used to prepare delicious vegetable soup during the dry season. The flower is eaten raw and the seeds provide flour which is very rich in vitamin B and protein (Rabi'u, *et al.,* 2013). Several studies have revealed that Baobab leaf contains vitamin, phytochemical, proximate and mineral contents. Abiona *et al.* (2015) observed that Baobab leaf is rich in vitamin C (14.98 mg/100g). Ogbaga *et al.* (2017) reported that the sun-dried leaves contain 0.09% of cardiac glycosides, 0.25% of saponin and 0.12% of flavonoids. Enoch *et al.* (2020) reported that Baobab leaf contains protein (38.18%), fat (3.50%), ash (11.0%), crude fibre (1.0%), magnesium (1.260 mg/l), iron (3.640 mg/l), calcium (0.780 mg/l), potassium (4.118 mg/l) and phosphorus (0.162 mg/l).

Despite the numerous importance of Baobab tree, its cultivation is threatened due to lack of information required for nursery and field establishments. Field evaluation of crops involves a large expanse of land and could be expensive (Ndukwe and Baiyeri, 2020). However, evaluation of crop varieties in the nursery is thought to predict the field performance. Ndukwe and Baiyeri (2020) revealed that growth and yield performances of two passion fruit genotypes were relatively similar in both pot and field experiments. Investigating into nutritional requirement of Baobab accessions in the nursery as well as in the field can provide useful information that will encourage the cultivation of the plant species in order to remedy food insecurity, improve the diet of the people and encourage the cultivation of the crop thereby preventing it from going into extinction. However, there is limited information regarding soil amendment for indigenous leafy vegetables like Baobab in the nursery and in the field. Therefore, the objective of this present work was to determine the response of two accessions of Baobab (*Adansonia digitata* L.*)* to different rates of poultry manure at the nursery and early growth stages.

MATERIALS AND METHODS

Experimental site: The experiments were conducted at the Department of Crop Science Teaching and Research Farm, Faculty of Agriculture, University of Nigeria, Nsukka (07^0 29' N, 06^0 51' E and 400 m above sea level). Nsukka is characterized by lowland humid tropical conditions with bimodal annual rainfall distribution that ranges between 1,155 and 1,955 mm with a shift in the second peak of rainfall from September to October, a mean annual temperature of 29 to 31^0 C and a relative humidity that ranges from 69 to 79% (Uguru *et al.,* 2011).

Collection of Baobab germplasm and soil sample: Germplasm were collected in July, 2019. Seeds were extracted (see Figure 1) from the pods of two accessions of Baobab sourced from the wild at Odo-Ere and Okoloke, Yagba West LGA of Kogi State, North Central Nigeria. The extracted seeds were first planted in the pre-nursery (Figure 2). After emergence, the seedlings were transplanted to the main nursery late 2019 as shown in Figure 3 and later transplanted to the field (Figure 4) in May, 2020 at the onset of rain. Before planting, 15 representative soil samples were randomly taken with the use of soil auger at different parts of the field. These were thoroughly mixed together to form a composite soil sample. It was air dried, sieved through a 2-mm sieve and used for the determination of bulk density and particle size as described by Carter (1993). Total porosity was calculated from the values of bulk density and particle density. Organic matter was determined by the Walkley and Black's dichromate wet oxidation method (Nelson and Sommers, 1982). Total N was determined by Micro-Kjeldahl digestion method. Available P was determined by Bray-1 extraction followed by Molybdenum blue colorimetric (Bray and Kurtz, 1945). The exchangeable bases (K^+, Ca^{2+} and Mg^{2+}) were extracted by Ethylene Diamine Tetra Acetic Acid (EDTA) titration method (Jackson, 1962). Soil pH was determined in 1:2 soil-water ratio using digital electronic pH meter.

Pre-nursery, nursery operations and experimental design: At the pre-nursery stage, extracted seeds from both accessions were planted in plastic containers filled with cured sawdust and kept under a tunnel. Regular watering was done to accelerate emergence. A month after seedling emergence, 36 uniformly sized seedlings per accession were transplanted into the nursery where polyethylene bag of size 48 x 38.5 cm were used for each seedling. The polyethylene bags were doubled for reinforcement and then filled with 12.0 kg soil. The seedlings were arranged as a 2 x 6 factorial in CRD with six replications. The factors were two accessions of Baobab (Odo-Ere and Okoloke) and six PM application rates (0, 10, 20, 30, 40 and 50 t ha^{-1}). Poultry manure was applied at the required quantity one month after transplanting to the nursery.

Required quantity for each PM rate was calculated as follows:

$$\frac{\text{PM rate (kg) x weight of potting medium (kg)}}{\text{2,242,000 (furrow slice per ha)}}$$

Experimental design and field layout: The field experiment was laid out as a factorial design in RCBD using single row plots of three plants in three replicates. The factors were two accessions of Baobab (Odo-Ere and Okoloke) and three PM application (0, 15 and 30 t ha^{-1}). The experiment was carried out between August 2019 and February 2021. In the field, the plants were spaced 3 m x 2 m (inter-row x intra). An alleyway of 3.0 m separated each block. Planting holes, each 35 cm^3 were dug according to the marked plant spacing and treatment allocation. Poultry manure was applied in split doses with 40% of the required quantity applied as first dose in June, 2020, and 60% applied as second dose in September, 2020. Glyphosate was applied at the rate of 3 L ha^{-1} at 4 weeks interval to control weeds.

Data collection: Monthly data were collected on plot basis on plant height as the distance from the ground level to the apex measured in cm with the use of measuring tape, number of leaves, stem girth as the circumference measured at 10 cm above ground level using measuring tape, and number of branches, at both the nursery and field. Additionally, number of bifurcated leaves was collected only at the nursery. Bifurcation of leave is a developmental process in which Baobab leaves change from ovate to palmate.

Statistical analysis: Data were subjected to analysis of variance (ANOVA) following the procedure for factorial experiment in CRD and RCBD using GenStat statistical software. Means were separated using the least significant difference (LSD) at 5% probability level.

RESULTS

Physicochemical properties of soil of the experimental site and the poultry manure

The physicochemical properties of the soil from the experimental site are presented in Table 1. The total nitrogen was very low (0.098%) and the available phosphorus (12.59 ppm) was medium. The potassium content was 0.10 cmol/kg. The cation exchange capacity was 10.80 cmol/kg, the base saturation was 51.48%. Organic carbon and organic matter were 1.857 and 3.201%, respectively, indicating that the soil was low in fertility. The soil is sandy loam. The PM utilized was very high in organic matter (85.12%), nitrogen (1.315%), potassium (0.18%) and sodium (0.0155%). The pH of the PM in water was strongly alkaline (8.5).

Main effects of accession and poultry manure rates on plant height of Baobab

Results of ANOVA revealed significant ($p < 0.05$) variation between the accessions for plant height at 2MAT to the nursery but there were no significant differences for plant height in the other months (Table 2). Higher plant height (20.1 cm) was attributed to accession from The Odo-Ere accession grew taller at 20.1 cm than the Okoloke accession that recorded 16.0 cm in the nursery at 2MAT. Plant height was not significantly ($p > 0.05$) influenced by PM rates at 1MAT in the nursery, but varied significantly ($p < 0.05$) at all other months (Table 2). Application of 50 t ha^{-1} of PM gave the highest plant height at 3, 4, 5, 6 and 7MAT with respective values of 31.0, 46.3, 56.6, 74.6 and 95.3 cm. Plants treated without PM application gave the least height of 17.4, 19.8, 20.6, 23.8 and 27.5 cm, respectively. There were no significant differences ($p > 0.05$) among the accessions for plant height at 2, 5, 6 and 7MATexcept at 3 and 4MAT to the field (Table 3). Accession from Okoloke had the highest plant height of 93.4 and 125.5 cm at 3 and 4MAT relative to 87.3 and 113.7 cm observed in Odo-Ere accession. As shown in Table 3, PM had no significant ($p > 0.05$) effect on plant height of Baobab at 2MAT to the field, but significant differences ($P < 0.05$) were observed at 3, 4, 5, 6 and 7MAT. Plant height (98.6, 144.1, 180.8, 228.1 and 233.3 cm) increased with the application of 15 t ha^{-1} of PM at 3, 4, 5, 6 and 7MATF, respectively in comparison with other rates while the least plant height was recorded in the control plots with respective values of 80.2, 83.8, 97.2, 109.5 and 113.5 cm. Accession x PM rate interaction on the growth of Baobab in the nursery and in the field were not significant.

Main effect of accession and poultry manure rates on number of leaves of Baobab

Table 4 showed that accession significantly ($p < 0.05$) influenced number of leaves of Baobab seedling at 2MATN but did not differ at 3, 4, 5, 6 and 7MATN. Higher number of leaves (29.8) was obtained in accession from Odo-Ere at 2MATN in comparison with 12.6 recorded in Okoloke accession. Poultry manure had no significant ($p > 0.05$) effect on number of leaves at 2MATN while number of leaves differed at 3, 4, 5, 6 and 7MATN (Table 4). At 3MATN, application of 40 t ha^{-1} of PM had more number of leaves of 22.2. Number of leaves (32.0, 41.2, 78.8 and 97.2) was highest with the application of 50 t ha^{-1} of PM at 4, 5, 6 and 7MATN, respectively while the least values (9.4, 7.2, 12.7, 20.3 and 23.0) were obtained from plants that received no PM at 3, 4, 5, 6 and 7MATN, respectively. Results showed that number of leaves only varied significantly ($p < 0.05$) between the accessions at 2MATF but all other months were statistically similar (Table 5). Accession from Odo-Ere produced more number of leaves (101.9) at 2MATF relative to 88.0 recorded in accession from Okoloke. The results in Table 5 also indicated that PM had significant ($p < 0.05$) impact on number of leaves of Baobab at 2, 3, 4, 5 and 6MATF except at 7MATF. Application of 15 t ha^{-1} of PM had positive influence on number of leaves with respective values of 101.7, 139.1, 392.0, 519.0 and 588.0 at 2, 3, 4, 5 and 6MATF. A decline in number of leaves was observed on further application of PM

Main effect of accession and poultry manure rates on stem diameter of Baobab

In Table 6, stem diameter was only significantly ($p < 0.05$) influenced by accession at 5MATN. Odo-Ere accession had broader stem (5.9 cm) at 5MATN compared to 5.3 cm recorded in Okoloke accession. Poultry manure significantly ($p < 0.05$) affected stem diameter across the months with the application of 50 t ha^{-1} of PM possessing the broadest stem (6.9, 9.3 and 10.8 cm) at 5, 6 and 7MATN, respectively while plants grown without PM gave the least girth of 3.3, 4.3 and 4.9, respectively (Table 6). Results in Table 7 indicated that stem diameter were significantly ($p < 0.05$) different between the accessions at 2, 4, 5 and 7MATF but did not vary significantly at 3 and 6MATF. The thickest stem (7.0 cm) was obtained in Odo-Ere accession at 2MATF when compared with 6.0 cm recorded in accession from Okoloke. Stem diameter however, was wider in accession collected from Okoloke at 4, 5 and 7MATF with 13.1, 19.8 and 31.5 cm, respectively in comparison with 11.3, 17.8 and 26.7 cm obtained in accession from Odo-Ere. Application of PM significantly ($p< 0.05$) influenced stem diameter of Baobab across the months as shown in Table 7. It resulted that soil amendment using PM at 15 t ha^{-1} was superior in stem diameter across the months with 6.9, 8.5, 15.5, 23.9, 32.1 and 38.0 cm, respectively when compared with other PM rates. Plants grown without PM application had the tinniest stem (5.9, 7.0, 7.9, 11.1, 12.0 and 12.3 cm, respectively).

Main effect of accession and poultry manure rates on number of branches of Baobab

Number of branches was significantly ($p < 0.05$) influenced by accession only at 3MATN, all other months did not statistically vary (Table 8). At 3MATN, Okoloke accession gave greater number of branches (1.1) compared to 0.5 obtained from Odo-Ere accession. Poultry manure has no significant ($p > 0.05$) effect on number of branches at 3MATN but differed statistically at 4, 5, 6 and 7MATN (Table 8). At 4MATN, application of 50 t ha^{-1} of PM gave more number of branches (2.2) which was statistically similar to 2.1 recorded in 40 t ha^{-1} of PM while at 5MATN, 50 and 40 t ha^{-1} of PM had the greatest number of branches of 3.4. Number of branches (6.0) was highest at 6MATN when PM was applied at 50 t ha^{-1} but did not vary statistically from the values (5.9) obtained in the application of 40 t ha^{-1} of PM. At 7MATN, 50 t ha^{-1} of PM had more branches (8.1) while plants in the control plots gave the least at 3, 4, 5 and 6MATN with respective value of 0.3, 0.7, 1.2 and 1.5. Table 9 revealed that the main effect of accession on number of branches was non-significant ($p > 0.05$) at 2, 3, 4, 5 and 7MATF but accession significantly influenced number of branches at 6MATF. Accession from Okoloke had higher number of branches (55.6) at 6MATF when compared with 42.0 obtained from Odo-Ere accession. There was no significant ($p > 0.05$) influence of PM on number of branches at 2MATF, but poultry manure rates varied significantly on number of branches of Baobab at 3, 4, 5, 6 and 7MATF. Highest number of branches (22.6) was recorded in plants treated with 15 t ha^{-1} of PM at 3MATF, number of branches at 4 and 5MATF also followed the same trend with 36.1 and 42.2 respectively. However, number of branches (65.0 and 69.4) was highest when PM was applied at 30 t ha^{-1} at 6 and 7MATF. These values were statistical similar to the values (61.1 and 66.0) obtained when PM was applied at 15 t ha^{-1}. Plants grown without PM application gave the least values (12.4, 12. 9, 19.0, 20.3 and 23.2) at 3, 4, 5, 6 and 7MATF, respectively.

Main effect of accession and poultry manure rates on number of bifurcated leaves of Baobab

Data in Table 10 revealed that accession showed significant ($p < 0.05$) difference on number of bifurcated leaves at 2, 3, 4 and 5MATN but did not vary at 6 and 7MATN. Number of bifurcated leaves (3.5, 11.0, 14.6 and 25.4) were higher in Odo-Ere accession at 2, 3, 4 and 5MATN relative to the values 0.8, 5.0, 8.5 and 16.4 obtained from Okoloke accession, respectively. Poultry manure had no significant ($p>0.05$) effect on number of bifurcated leaves at 2, 3 and 6MATN but varied at 4, 5 and 7MATN with 50 t ha^{-1} of PM having more bifurcated leaves (19.8, 37.8 and 95.7) than other PM rates. Plants with no PM application gave the least of 2.7, 4.7 and 15.4, respectively.

DISCUSSION

Effect of accession on growth and number of bifurcated leaves of Baobab in the nursery: The result from this current study indicated that variation existed between the accessions with respect to growth parameters measured. Odo-Ere accession significantly produced taller plants, more number of leaves and broader stem diameter. Accession sourced from Okoloke significantly had more number of branches. The differences observed in growth of Baobab in this experiment could be due to the genetic makeup of the accessions. This conforms with the result of Maforikan *et al.* (2018) who reported that genetic variation among the individual and within the different population are likely to influence seedling growth in Baobab from Benin. Results of Baiyeri *et al.* (2015) showed accessional differences in seedling emergence, early growth and leaf proximate composition of *M. oleifera* in Nsukka which could probably be due to variations in the genetic potentials of the accessions. Nwofia and Okwu (2015) reported genotypic variation in early seedling growth of five *Carica papaya* morphotypes from Umudike. Observation from Suthar *et al*. (2019) revealed significant genotypic differences in seedlings growth and biomass production in 15 guar accessions in Texas. Accession from Odo-Ere had more bifurcated leaves in the nursery. The result obtained in this study could be connected to the genetic potential of this accession which aids leaf development from obcordate to palmate and enable the leaves to harvest more light for photosynthesis resulting in higher height, thicker stem and increased number of leaves.

Effect of accession on growth of Baobab in the field: The effect of accession on growth of Baobab showed significant differences in some attributes evaluated. From the results, it was evident that enough variability existed between the two accessions to warrant selection. Accession from Okoloke produced taller plants at 3 and 4 MAT and had more number of branches at 6 MAT. On the other hand, accession from Odo-Ere had higher number of leaves and widest stem at 2 MAT but at 4 and 5 MAT, Okoloke accession recorded thicker stem. The variability observed in growth traits in this current study may be linked to the genetic makeup of the accessions. Previous report of Stevens *et al.* (2018) established the existence of accessional differences in growth and yield of *Moringa oleifera* in Nigeria. The study by Nwankwo *et al.* (2020) also observed genetic differences in growth and yield of two genotypes of passion fruit evaluated in Jos, Nigeria. The result is also in consonance with the earlier report of Ibeh *et al*. (2019) who reported that yield potentials of okra are determined by the genetic makeup of the individual crop plant.

The effect of poultry manure on the growth and number of bifurcated leaves of Baobab in the nursery: The application of PM increased the growth of Baobab compared to the plants in the control plots. The consistent poor performance of Baobab grown with no PM reveals that Baobab plants were highly responsive to PM. This observation agrees with earlier reports of Baiyeri and Tenkouano (2007); Ndukwe *et al.* (2011); Aba, *et al.* (2011); Baiyeri *et al.* (2015) that animal manure is a valuable source of crop nutrients and organic matter, which can improve the soil biophysical conditions making the soil more productive and sustainable for plant growth. Significant increase in growth of Baobab was associated with the application of 50 t ha^{-1} of PM which is the highest rate. This observation could be due to the sufficient amount of nutrient supplied to the seedlings in the nursery since the plants depends solely on the nutrient given which was found to favour vegetative growth in the plants. The results obtained in this work corroborates the findings of Baiyeri *et al.* (2015) who found that application of highest rate of organic manure at 20 t ha^{-1} increased growth parameters in *Moringa oleifera* grown as pot plant in Nsukka. The result also agreed with the report of Husseini *et al.* (2016) who observed that organic manure provided enough nutrients that perhaps contributed to the high leaf yield of Baobab seedling in the nursery from Ghana. The finding contradicts the report of Mukhtar (2016) who found that *A. digitata* seedlings do not require much manure or nutrient for optimum growth. The increase in number of bifurcated leaves as the PM rate increased indicated that the PM provided adequate nutrients for Baobab growth and development. Palmately and many deep green leaves signifies vigorous plants, which photosynthesizes efficiently. These photosynthetically active leaves could produce more photo-assimilates thereby enhancing biomass yield of the Baobab seedlings. Any crop management strategies, such as fertilizer application, that will improve the plant's vigour especially at the juvenile stage, may eventually translate into higher yield (Baiyeri *et al.*, 2009; Ndukwe and Baiyeri, 2020).

The effect of poultry manure on growth parameters of Baobab in the field: The effect of PM rates on growth of Baobab differed significantly. Plant height, number of leaves, stem girth and number of branches significantly increased with the application of 15 t ha^{-1} of PM, further application of PM beyond this rate led to a decline in growth attributes of Baobab. The decline in growth of Baobab obtained at 30 t ha^{-1} of PM implies that sufficient quantities of nutrient elements were supplied by the 15 t ha^{-1} of PM to complement the inherent nutrient in the soil. Optimum nutrient supply results in the production of high quality and better nutritious plants (Baiyeri *et al.,* 2009; Abubakari *et al.,* 2015). As reported by Adebayo *et al.* (2011) when manure is available in adequate amounts, plants tend to grow at their optimal potential. Earlier reports from Baiyeri (2002) observed that the number of fruits per bunch of plantain is influenced by plant nutrition. Another work Olubode and Fawusi (1998) reported positive effects of organic manure on pawpaw growth and yield. Results also showed that plots amended with poultry manure performed better compared to the control. The higher values of the morphological traits obtained with poultry manure application suggests that Baobab plants are highly responsive to manure application. Poultry manure, the richest of the animal manures, is a valuable source of nutrients and organic matter, particularly nitrogen and potassium (Ani and Baiyeri, 2008). Organic soil amendment is very essential in the sustainability of crop production systems since it forms important sources of nitrogen and carbon (Liang *et al.,* 2012; Rinaldi *et al.,* 2014) and it is also very critical in moderating soil pH (Abubakari *et al.,* 2015).

CONCLUSION

It was hypothesized that response of Baobab accession to PM in relation to growth could predict the performance of Baobab in the field. It was evident that the two accessions had similar responses in the nursery and in the field. Therefore, nursery experiment can be used to predict field performance of Baobab. In the nursey, 50 t ha^{-1} of PM enhanced better growth suggesting that Baobab require high dosage of nutrients in nursey for early growth and development since the plants are solely dependent on the nutrient supplied. However, field evaluation revealed that PM rate beyond 15 t ha^{-1} had reduced growth indicating that this rate was the optimum.

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Table 1: Physicochemical properties of soil of the experimental site (prior transplanting) and the poultry manure sample used in the study

Mechanical properties	Soil Particle size	Poultry manure
Clay (%)	17	-
Silt (%)	9	-
Fine sand (%)	35	-
Coarse sand (%)	39	-
Textural class	Sandy loam	
Chemical properties		
pH in water	4.8	8.5
pH in KCl	3.8	8.1
Organic carbon (%)	1.857	58.905
Organic matter (%)	3.201	85.12
Total nitrogen (%)	0.098	1.315
Phosphorus (ppm)	12.59	0.52 (%)
Exchangeable base		
Sodium (Na+) cmol/kg	0.06	0.0155 (%)
Calcium (Ca^2+) cmol/kg	4.20	6.8 (%)
Potassium (K+) cmol/kg	0.10	0.18 (%)
Magnesium (mg^2+) cmol/kg	1.20	5.12 (%)
CEC	10.80	-
Base saturation (%)	51.48	-
Exchangeable acidity in me/ 100 g soil		
Aluminium (Al3+)	0.80	-
Hydrogen (H+)	2.40	-

Source: Faculty of Agriculture, University of Nigeria, Nsukka, laboratory.

Table 2: Main effect of accession and poultry manure rates on plant height of Baobab tree at 2, 3, 4, 5, 6 and 7 months after transplanting to the nursery

	Plant height in months after manure transplanting					
Accessions	2	3	4	5	6	7
Odo-Ere	20.1	27.4	35.6	41.3	53.9	65.0
Okoloke	16.0	24.1	31.7	36.8	50.9	65.2
LSD (0.05)	3.9	4.9	5.0	4.6	6.9	8.9
Manure (t ha^{-1})						
0	14.9	17.4	19.8	20.6	23.8	27.5
10	17.3	21.7	25.4	28.5	37.0	47.0
20	18.2	24.5	29.2	33.5	46.3	58.6
30	18.6	30.3	38.3	44.0	65.3	82.0
40	19.6	29.4	43.8	51.1	67.6	80.2
50	19.8	31.0	46.3	56.6	74.6	95.3
LSD (0.05)	6.9	8.5	8.7	8.9	12.0	15.6

Table 3: Main effect of accession and poultry manure on plant height (cm) of Baobab tree at 2, 3, 4, 5, 6 and 7 months after transplanting to the field

	Plant height in months after transplanting					
Accession	2	3	4	5	6	7
Odo-Ere	73.8	87.3	113.7	146.0	180.7	185.6
Okoloke	72.8	93.4	125.5	150.0	183.2	197.4
LSD (0.05)	2.5	3.2	11.5	10.3	11.9	13.7
Manure rates (t ha^{-1})						
0	72.1	80.2	83.8	97.2	109.5	113.5
15	73.9	98.6	144.1	180.8	228.1	233.3
30	73.9	92.3	130.9	165.9	208.3	227.6
LSD (0.05)	3.0	3.9	14.1	12.6	14.6	16.8

Table 4: Main effect of accession and poultry manure rates on number of leaves of Baobab tree at 2, 3, 4, 5, 6 and 7 months after transplanting to the nursery

	Number of leaves in months after transplanting					
Accession	2	3	4	5	6	7
Odo-Ere	29.8	19.4	21.8	29.7	53.4	61.0
Okoloke	12.6	16.2	20.6	26.3	49.4	53.0
LSD (0.05)	8.4	4.4	5.5	5.4	12.1	16.4
Manure (t ha^{-1})						
0	13.2	9.4	7.2	12.7	20.3	23.0
10	23.2	15.8	15.4	21.0	32.2	39.7
20	24.8	17.7	19.8	24.0	41.4	43.6
30	20.5	19.4	22.8	28.9	60.3	70.8
40	23.7	22.2	30.0	40.3	75.7	67.8
50	21.8	22.1	32.0	41.2	78.8	97.2
LSD (0.05)	14.5	7.7	9.6	9.5	21.1	28.4

Table 5: Main effect of accession and poultry manure on number of leaves of Baobab tree at 2, 3, 4, 5, 6 and 7 months after transplanting to the field

	Number of leaves in months after transplanting					
Accession	2	3	4	5	6	7
Odo-Ere	101.9	130.5	273.0	371.0	390.0	391.0
Okoloke	88.0	122.1	283.0	397.0	455.0	488.0
LSD (0.05)	14.4	22.6	61.8	62.5	70.9	126.5
Manure rates (t ha^{-1})						
0	81.9	106.7	132.0	173.0	176.0	140.0
15	101.7	139.1	392.0	519.0	588.0	628.0
30	101.4	133	310.0	460.0	502.0	551.0
LSD (0.05)	17.6	27.6	75.7	76.5	86.8	154.9

Table 6: Main effect of accession and poultry manure rates on stem diameter of Baobab tree at 5, 6 and 7 months after transplanting to the nursery

	Stem diameter in months after transplanting		
Accessions	5	6	7
Odo-Ere	5.9	7.4	8.4
Okoloke	5.3	6.9	8.2
LSD (0.05)	0.6	0.7	0.9
Manure (t ha^{-1})			
0	3.3	4.3	4.9
10	5.5	6.4	7.6
20	5.6	6.5	7.6
30	6.4	8.1	9.7
40	6.1	8.2	9.2
50	6.9	9.3	10.8
LSD (0.05)	1.1	1.4	1.7

Table 7: Main effect of accession and poultry manure on stem diameter (cm) of Baobab tree at 2, 3, 4, 5, 6 and 7 months after transplanting to the field

	Stem diameter in months after transplanting					
Accession	2	3	4	5	6	7
Odo-Ere	7.0	7.9	11.3	17.8	24.4	26.7
Okoloke	6.0	7.5	13.1	19.8	25.5	31.5
LSD (0.05)	0.7	0.9	1.3	1.3	3.7	3.0
Manure rates (t ha^{-1})						
0	5.9	7.0	7.9	11.1	12.0	12.3
15	6.9	8.5	15.5	23.9	32.1	38.0
30	6.8	7.6	13.2	21.4	30.7	36.9
LSD (0.05)	0.9	1.1	1.6	1.6	4.5	3.6

Table 8: Main effect of accession and poultry manure rates on number of branches of Baobab tree at 3, 4, 5, 6 and 7 months after transplanting to the nursery

	Number of branches in months after transplanting				
Accessions	3	4	5	6	7
Odo-Ere	0.5	1.1	1.8	3.1	4.8
Okoloke	1.1	1.6	2.3	4.3	5.3
LSD (0.05)	0.5	0.6	0.7	1.3	1.6
Manure (t ha^{-1})					
0	0.0	0.3	0.7	1.2	1.5
10	1.0	1.4	1.6	2.1	3.8
20	0.9	1.3	1.3	2.9	4.2
30	0.8	1.0	1.7	4.1	5.6
40	1.1	2.1	3.4	5.9	7.0
50	0.8	2.2	3.4	6.0	8.1
LSD (0.05)	0.9	1.2	1.3	2.3	2.9

Table 9: Main effect of accession and poultry manure on number of branches of Baobab tree at 2, 3, 4, 5, 6 and 7 months after transplanting to the field

	Number of branches in months after transplanting					
Accession	2	3	4	5	6	7
Odo-Ere	10.1	17.0	22.9	31.7	42.0	46.3
Okoloke	8.1	18.0	29.3	34.2	55.6	59.4
LSD (0.05)	3.0	8.9	10.3	6.9	15.2	15.4
Manure rates (t ha^{-1})						
0	8.5	12.4	12.9	19.0	20.3	23.2
15	10.0	22.6	36.1	42.2	61.1	66.0
30	8.9	17.6	29.4	37.7	65.0	69.4
LSD (0.05)	3.7	7.4	12.7	18.4	18.6	18.90

Table 10: Main effect of accession and poultry manure rates on number of bifurcated leaves of Baobab tree at 2, 3, 4, 5, 6 and 7 months after transplanting to the nursery

	Number of bifurcated leaves in months after transplanting					
Accession	2	3	4	5	6	7
Odo-Ere	3.5	11.0	14.6	25.4	75.0	58.2
Okoloke	0.8	5.0	8.5	16.4	40.0	49.4
LSD (0.05)	1.6	3.5	4.1	4.7	52.1	16.1
Manure (t ha^{-1})						
0	0.4	3.0	2.7	4.7	9.0	15.4
10	2.3	5.9	6.0	11.0	96.0	32.8
20	3.3	9.4	11.2	16.4	36.0	42.1
30	1.7	9.1	13.3	21.7	57.0	69.5
40	3.3	9.7	16.3	33.8	70.0	67.2
50	2.5	10.9	19.8	37.8	77.0	95.7
LSD (0.05)	2.7	5.9	7.1	8.1	90.2	27.9

Figure 1: Baobab seed extraction

Figure 2: Emergence of seedlings in the pre-nursery

Figure 3: Baobab at one month after transplanting to the nursery

Figure 4: Baobab plants pruned after six months of transplanting

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YIELD RESPONSE OF GREEN AMARANTH TO THE RESIDUAL FERTILIZERS PREVIOUSLY APPLIED TO CARROT GENOTYPES (*Daucus carota* L.) IN NSUKKA, SOUTHEAST NIGERIA

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ABSTRACT
The study was carried out at the Teaching and Research Farm of University of Nigeria, Nsukka to determine the residual effects of previously applied fertilizers to three genotypes of carrot on the performance of the succeeding crop, green amaranth. The treatments were 0 t/ha (control), 20 t/ha poultry manure (PM), 20 t/ha pig manure (PiM), 10 t/ha PM + 200 kg/ha NPK 15:15:15 and 10 t/ha PiM + 200 kg/ha NPK 15:15:15 previously applied to three genotypes of carrot, Safety Touchon France genotype plot 1 (P1), Carotte Touchon AM genotype plot 2 (P2) and Carotte Touchon ETS genotype plot 3 (P3). The experiment was laid out as split-plot in Randomized Complete Block Design with four replications. The plants transplanted to P1 had the highest non-significant mean values of 38.1g, 101.2, 26.5g per plot for foliage (leaves, stalks, and stems) weight, number of leaves and fresh leaf weight respectively while P3 produced the least non-significant yield values. Amaranth plants grown in P2 best expressed whole plant biomass, number of harvested plants and survival rate. The residual fertilizers significantly ($p \geq 0.05$) influenced whole plant biomass, foliage weight, and number of leaves of green Amaranth. The interaction of Carotte Touchon AM genotype plot and 10t/ha PM + 200kg/ha NPK 15: 15:15 gave the highest values 8.0, 92.2g, 131.8, 37.7g and 66.7 % for all parameters measured except in foliage weight. The study showed that previously applied fertilizers sustained crop establishment and yield of green amaranth.

Keywords: *Green amaranth; Residual Fertilizers; Biomass, Yield Response*.

INTRODUCTION

Amaranth (Amaranthus spp.) simply called 'green' in Nigeria is an annual erect vegetable crop of dietary importance belonging to the family Amaranthaceae (Grubben, 1976; Rai and Yadav, 2005). The amaranth is a versatile crop, which serves as a nutritious food for man and feed for livestock. Amaranth is grown for its leafy vegetables and grains, which are rich sources of fibre, vitamins, minerals, water and protein (Teutonico and Knorr, 1985; Grubben and Denton, 2004; Rai and Yadav, 2005). The high demand of vegetables has stimulated the production of amaranth not only in Africa but also in other parts of the world where it is still considered a minor crop (Grubben and Denton, 2004; Cai et al., 2004; Corke *et al.*, 2016). According to Olorode (1984), amaranth is widely grown in Nigeria alone or in mixture with other crops. Amaranth has the ability to grow fast producing high biomass and grain yield (Palada and Crossman, 1999; Corke *et al*., 2016). The amaranth crop can also greatly tolerate soil stress conditions (Arendt and Zannini, 2013; Corke *et al*., 2016).

The exhaustion of soil nutrients is one of the constraints to crop production in humid tropical regions such as the southeastern Nigeria with the likelihood to fluctuate under climate change leading to degraded soils and decreasing crop yields (Osundare, 2008). The humid tropics are characterized by high temperature and moisture regimes, which lead to the rapid breakdown of applied fertilizers (London, 2019). Fertilizer application is one of the major farm practices that affect the physical and chemical properties of the soil (Tankou, 2004). Lombini *et al*. (1991) reported that for an effective soil fertility management strategy for a crop, complementary incorporation of organic manure and the routine inputs of synthetic fertilizers are necessary. The benefits of the combined use of inorganic and organic fertilizers comprise of increased fertility, improved physical and chemical aspects of the soil and increased crop yield (Huang and Lin, 2001; Zhang and Fang, 2007).

The fundamental basis for sustainable crop production is soil conservation, improvement of its characteristics, high crop yields and the maintenance of soil fertility with minimum ecological deterioration at cheap cost especially to resource deprived farmers. Short duration crop such as amaranth can be repeatedly planted on harvested plots to utilize residual nutrients.

Residual effect described as the response of plants to fertilizers after its first season of application is of benefit to farmers as it improves soil quality and productivity (Rowell, 1994; Ginting *et al*., 2003). Also, Gomez (1992) stated that residual effect of fertilizer is the effect on the present crop by fertilizer applied to previous crop. Crop yield assessment of the residual effect of applied fertilizers is of benefit to farmers as it aims at reducing repeated fertilizer application, hence sustaining the soil productivity. In order to fully exploit the potential of applied inputs and limit the frequent use of fertilizers, it is necessary to establish one more planting on the same plot of land. Therefore, this study was designed to evaluate the residual effect of fertilizers applied to the preceding crop (Carrot) on the yield of green amaranth.

MATERIALS AND METHODS

Experimental site: Field study was conducted in 2019 planting season at the Teaching and Research Farm, Department of Crop Science, University of Nigeria, Nsukka. Nsukka is located in the derived savanna zone at latitude $6^0$52'N, and longitude $07^0$24'E, with an altitude of 447.26 m above sea level.

Climatic Condition of the Experimental site: Nsukka has a humid tropical climate; with a mean rainfall of 1400 mm per annum distributed over six months (April - September). The monthly minimum temperature ranges from 19°C – 23°C while the monthly maximum temperature ranges from 27°C – 34°C. The relative humidity varies from 37% - 63% (UNN Meteorological station, 2019).

Soil Conditions of the Experimental site: The soil of the experimental site had a sandy clay loam texture and pH of 4.8. The soil organic carbon was 1.5% while available phosphorus and total nitrogen were 30.8 mg/kg and 0.14%, respectively. Exchangeable calcium was 2.2 cmol/kg, exchangeable potassium was 1.40 mg/kg and exchangeable magnesium was 0.13 mg/kg (As determined by Soil Science laboratory, University of Nigeria, Nsukka).

Nursery Operations

The seedlings were raised in seedbeds. The nursery was located in a flat area, with fertile soil and near a water source but not in shaded area. The seeds were mixed with sand at a ratio of 1: 2 and sow at a depth of 0.5 cm in rows. The seedbeds were watered first and then sown. Seeds were covered with a thin layer of soil, followed by careful watering. The spacing was 20 x 20 cm. The seedlings were ready to be transplanted after 4 weeks when they had four true leaves and height of 15 cm.

Field layout and Preparation

The field area on which Amaranth succeeded carrot was an area of 50m x 25m, which was ploughed, harrowed and ridged. The field was divided into 3.0m x 1.5m plots and ridges of 1.5m long with spacing of 1m x 50cm. The appropriate rate of organic and inorganic fertilizers for the preceding crop was thoroughly mixed with the soil in each ridge.

Cropping history of the experimental site: Carrot was planted in June as the first crop and harvested in September. After the harvest of carrot, the land was minimally slashed and ridges were raised. The Green amaranth was transplanted after four weeks to the field to evaluate the residual effect of the applied treatments on the second crop planting.

Other agronomic practices

Weeds were controlled by hand picking and hoeing every two weeks. Earthen up was carried out when necessary. Insect pests were managed by picking. Harvesting was done five weeks after transplanting.

Experimental Design: The study evaluated the residual effect of five fertilizer treatments previously applied to plots of carrot genotypes Safety Touchon France (P1), Carotte Touchon AM (P2) and Carotte Touchon ETS (P3) on green amaranth in the field. The experiment was laid out as split plot in a Randomized Complete Block Design replicated four times. The main plot consisted carrot genotype plots of the previous cropping while the sub-plots comprised the fertilizer treatments. The three carrot genotype plots formed the main plot treatments while the fertilizers which included control (no amendment) (F1), 20 t/ha poultry manure (F2), 20 t/ha pig manure (F3), 10 t/ha poultry manure + 200 kg/ha N: P: K 15:15:15 (F4), 10 t/ha pig manure + 200 kg/ha N: P: K 15:15:15 (F5) were the sub plot treatments. .

Data Collection:

Data were collected after harvest on the following growth and yield parameters:

Survival rate of green amaranth plants (%) harvested five weeks after transplanting was calculated using the formula:

$$\frac{\text{Number of harvested plants x 100}}{\text{Number transplanted}}$$

Number of harvested plants: The datum was collected by counting the number of plants harvested.

Whole Plant biomass (g): The plants were uprooted and plants was measured using weighing scale.

Foliage weight (g): This is the above ground weight (the leaves, stem and stalk weight), which were collected using weighing scale.

Leaves weight (g): The leaves were separated from the stalks and weighed using weighing scale

Number of leaves: The leaves of the harvested plants were separated from the stalks. This was collected by counting the number of leaves picked from the stalks.

Data Analysis: All data were subjected to Analysis of Variance (ANOVA) according to the procedure outlined for a Split-plot Design Experiment in Randomized Complete Block Design (RCBD) using GENSTAT 10.3 discovery edition (GENSTAT, 2012) software while the detection of differences among treatment means for significance was done using Fisher's Least Significant Difference (F-LSD) at 5% probability level.

RESULTS

Residual effect of fertilizer levels applied to carrot genotypes on the yield and yield components of succeeding Amaranth crop: The yield and yield components of Amaranth as presented in Table 1, were significantly ($p<0.05$) influenced by fertilizer levels except number of plants harvested and survival rate.

The fertilizer rate 10 t/ha PM + 200 kg/ha NPK 15:15:15 had highest mean values on whole plant biomass, foliage weight, number of leaves and weight of leaves of Amaranth plants harvested. It was followed successively by 20t/ha poultry while 10 t/ha Pig M + 200 kg/ha NPK 15:15:15 gave the least mean values.

Residual effect of carrot genotype plots on the Yield and yield components of succeeding crop, Amaranth taken at harvest: Plots on which carrot genotypes were previously grown had non-significant ($p > 0.05$) effect on the growth and yield components of Amaranth (Figure 1 and 2). Although, Safety Touchon France plot (P1) recorded the highest foliage weight (38.1g), number of leaves (101.2) and weight of leaves (26.5g) of Amaranth plants. The Carotte Touchon AM Plot (P2) gave the highest values on number of harvested plants (7.7), whole plant biomass (56.4 g) and survival rate (63.8%) per plot. Carotte Touchon ETS plot (P3) Plot recorded the lowest mean values on all parameters.

Residual effect of the interaction of fertilizers and genotype plots on the Yield and yield components of Amaranth taken at harvest: The interaction of fertilizer levels and genotype plots had non-significant ($p > 0.05$) effect on the growth and yield components of Amaranth (Table 2).

The combined effect of the plot Carotte Touchon AM and the application of 10 t/ha PM + 200 kg/ha NPK 15:15:15 gave the highest values on number of plants harvested (8.0), whole plant biomass yield (92.2 g), number of leaves (131.8), weight of leaves (37.7 g) and survival rate (66.7 %) . The least values on whole plant biomass yield and foliage weight were recorded by the interaction of the Carotte Touchon AM plot and 10 t/ha Pig M + 200 kg/ha NPK 15:15:15 (F5). While the least number of plants harvested, number of leaves, weight of leaves and survival rate values were expressed by Carotte Touchon ETS plot x 10 t/ha Pig M + 200 kg/ha NPK 15:15:15.

DISCUSSION

The growth and yield components of green Amaranth were significantly influenced by fertilizer levels except the number of harvested plants and survival rate of the transplanted plants. The result showed that fertilizers supplied enough nutrients to Amaranth plants, which ensured growth and yield more than the control treatment plot.

Generally, the integrated fertilizer management treatment had significant ($p< 0.005$) residual effect on the transplanted amaranth plants. The 10 t/ha PM+200 kg/ha NPK 15:15:15 treatment significantly expressed the highest yield traits of amaranth plant (Table 1). The demonstrated outcome of the amaranth crop under this fertilizer level may be attributed to the amount of the organic fertilizer (10 t/ha Poultry manure) that was combined with substantial amount of 200kg/ha NPK 15:15:15 inorganic fertilizer.

The result also showed that 20t/ha PM successively followed 10t/haPM+200kg/ha NPK 15:15:15 in performance. These results are in harmony with the findings of Eghball and Gilley (2004) and Isitehale and Osemwota (2010) who observed a significant greater biomass and increase in plant weight as influenced by residual effect of manure application when compared to the control treatment (no fertilizer application). This reconfirmed the role of fertilizer in promoting vegetative growth in leafy vegetables and hence the previously applied fertilizers sustained the growth of transplanted green amaranth plants (Tijani-Eniola *et al*., 2000). The result showed that the control performed poorly in terms of yield but sustained the survival rate of the transplanted plants when compared to other treatments. Warren *et al.* (1992) suggested that residual effect can be evaluated in the same year and to make allowance for the predictable fluctuations in yields between seasons, results can be expressed as the response of residual, either over control (kg/ha N) or as percentage of the control yield. The subplots on which the preceding crop was harvested did not increase the yield of the succeeding crop. However, the amaranth plants on safety Touch on France produced higher foliage weight, number of leaves and the leaves weight. Amaranth plants harvested from Carotte touch on AM had the greatest biomass production. Residual effect can vary from year to year under the influence of weather conditions and other factors (Loks *et al*., 2014). It has been reported that an annual crop rarely takes up more than 60% of the nutrients applied to it as fertilizer, as a result the use of the nutrient residues by succeeding crops are essential (Loks *et al*., 2014). The overall interaction results showed that there was no significant residual effect of fertilizer plots and genotypes plots on Amaranth crops. The result however, showed that the Carotte Touchon AM and 10 t/ha PM + 200 kg/ha NPK 15:15:15 plots had the highest yielding amaranth crops of the parameters measured (number of plants harvested, whole plant biomass yield, number of leaves, weight of leaves survival rate). This suggests that fertilizers applied to carrot at the given rate left sufficient residual nutrients to meet the demand of the following Amaranth crops (Singh *et al*., 1997).

CONCLUSION

The previously applied fertilizer had sufficient residual effect to support and sustain the growth and yield of Amaranthus. Therefore, complementary application of organic and inorganic fertilizers in humid tropical agro ecological zone of Nigeria is recommended. Also, subsequent planting of crops particularly short duration crops on previously cultivated plots is advised.

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Table 1: Residual effect of fertilizer levels applied to carrot genotypes on the yield (g) and yield components of succeeding Amaranth crop

Effects	Growth and Yield Components					
	NPH	WPB(g)	FW (g)	NL	LW(g)	SR (%)
Fertilizers						
Control	7.6	46.8	28.1	83.2	22.1	63.2
20t/ha PM	7.4	61.2	43.1	110.6	28.0	61.8
20t/haPigM	7.3	46.1	30.2	91.8	19.2	60.4
10t/haPM+200kg/ha NPK 15:15:15	7.5	82.9	58.9	124.7	36.2	62.5
10t/haPigM+200kg/ha NPK 15:15:15	7.1	32.2	19.0	73.2	13.3	59.0
$LSD_{(0.05)}$	NS	3.0	1.0	27.9	13.0	NS

PM: Poultry manure, Pig M: pig manure, N: P: K 15:15:15, NPH: Number of plants harvested, WPB (g): Whole Plant Biomass in gram, FW (g): Foliage Weight in gram, NL: Number of leaves, LW (g): Leaves Weight in gram, SR (%): Survival Rate in percentag

Table 2: Residual effect of the interaction of fertilizer levels and Genotype plots on the Growth and yield components of Green Amaranth.

Genotype Plots	Fertilizers	NPH	WPB(g)	FW(g)	NL	LW(g)	SR (%)
Safety Touchon France	Control, 0t/ha	7.8	44.5	27.8	80.2	21.5	64.6
	20t/ha PM	7.8	84.7	59.3	126.3	39.8	64.6
	20t/haPigM	7.0	45.5	34.0	100.8	22.2	58.3
	10t/haPM + 200kg/ha NPK	7.5	68.7	48.8	114.0	33.7	62.5
	10t/haPigM + 200kg/ha NPK	7.5	33.7	20.5	84.5	15.5	62.5
Carotte Touchon AM	Control, 0t/ha	7.5	56.5	33.5	91.8	25.5	62.5
	20t/ha PM	7.5	53.5	36.0	104.8	22.0	62.5
	20t/haPigM	7.5	51.5	32.5	94.5	20.5	62.5
	10t/haPM + 200kg/ha NPK	8.0	92.2	62.5	131.8	37.7	66.7
	10t/haPigM + 200kg/ha NPK	7.8	28.2	17.0	70.5	12.5	64.6
Carotte Touchon ETS	Control, 0t/ha	7.5	39.5	23.0	77.8	19.2	62.5
	20t/ha PM	7.0	45.5	34.0	100.8	22.2	58.3
	20t/haPigM	7.3	41.2	24.0	80.0	15.0	60.4
	10t/haPM + 200kg/ha NPK	7.0	87.7	65.5	128.2	37.2	58.3
	10t/haPigM + 200kg/ha NPK	6.0	34.7	19.5	64.5	12.0	50.0
$LSD_{(0.05)}$		NS	NS	NS	NS	NS	NS

PM: Poultry manure, Pig M: pig manure, N: P: K 15:15:15, NPH: Number of plants harvested, WPB (g): Whole Plant Biomass in gram, FW (g): Foliage Weight in gram, NL: Number of leaves, LW (g): Leaves Weight in gram, SR (%): Survival Rate in percentage.

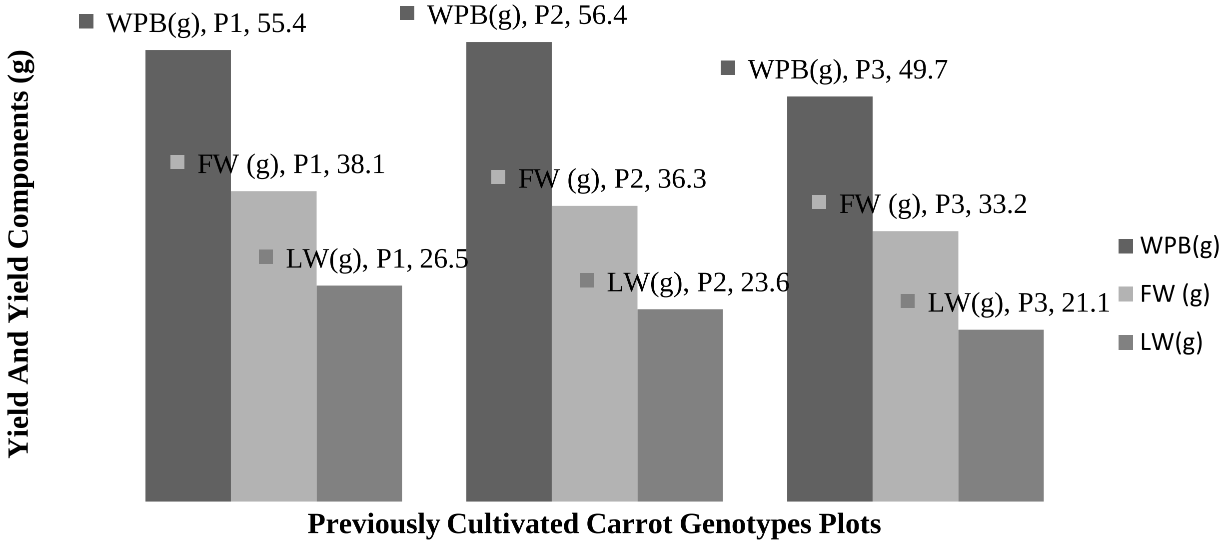

Figure 1: Residual effect of carrot genotype plots on the yield and yield components of succeeding Amaranth crop taken at harvest

WPB (g): Whole Plant Biomass; FW (g): Foliage Weight; LW (g): Leaves weight
P1: Safety Touchon Plot (1); P2: CarotteTouchon AM Plot (2); P3: CarotteTouchon ETS Plot (3)

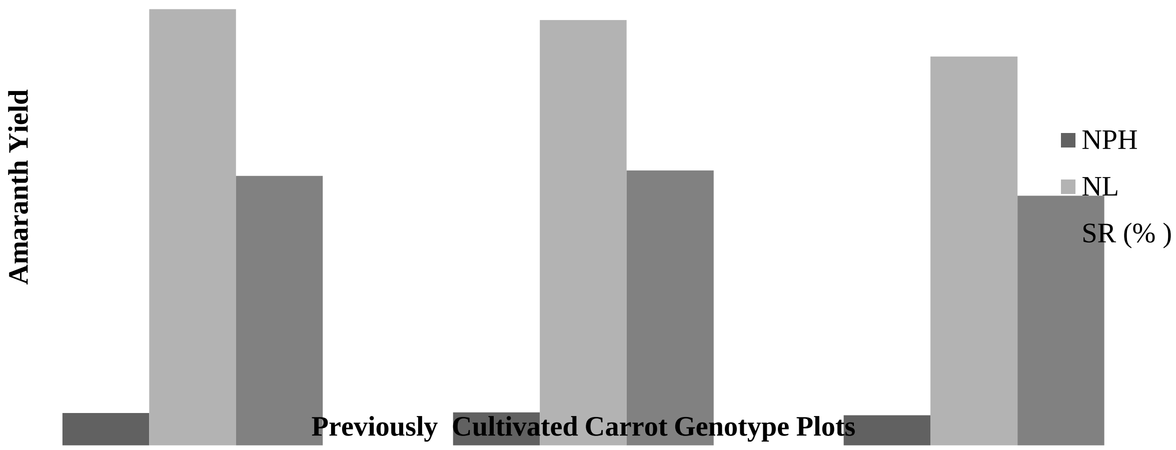

Figure 2: Residual effect of carrot genotype plots on the yield of succeeding Amaranth crop taken at harvest

NPH: Number of plants harvested
NL: Number of Leaves
SR (%): Survival rate of transplanted plants in percentage
P1: Safety Touchon Plot (1)
P2: CarotteTouchon AM Plot (2)
P3: CarotteTouchon ETS Plot (3)

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VARIATIONS IN THE GROWTH AND YIELD OF LETTUCE [*LACTUCA SATIVA* L.] WITH ORGANIC AND INORGANIC FERTILIZER COMBINATIONS DURING TWO CROPPING CYCLES IN AN ULTISOL OF SOUTHEASTERN NIGERIA

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ABSTRACT
Lettuce production is constrained by poor soil fertility among other factors. Thus, organic (poultry manure – PM) and inorganic fertilizers (NPK) were evaluated singly or in combinations on the growth and yield of the crop. Fertilizer treatments were: Control, 300 kg NPK 20-10-10, 300 kg NPK 15-15-15, 300 kg NPK 20-10-10 + 5t/ha PM, 300 kg NPK 15-15-15 + 5t/ha PM, 150 kg NPK 20-10-10 + 10t/ha PM, 150 kg NPK 15-15-15 + 10t/ha PM and 20t/ha PM. A second cycle experiment utilized 50% of the initial fertilizer dosage. Growth and yield data measured were subjected to analysis of variance and significant treatment means were separated using Fisher's Least Significant Difference (F-LSD) at 5% probability level. Data on number of leaves, leaf area and vigor index measured during six weeks after treatment application were significantly ($P < 0.05\%$) influenced by the fertilizer treatments during the two cropping cycles. Survival count varied significantly only in the second cycle planting. Similarly, whole plant biomass yield, and below and above ground biomass yields distinctly varied with fertilizer treatments in the two cropping cycles. In all cases, 20 t/ha PM or 150 kg/ha NPK 20:10:10 + 10 t/ha PM outperformed all other treatments in the first cropping cycle. The second cropping cycle revealed that the highest biomass yield was obtained in plots that received 10 t/ha PM, and 75 kg/ha NPK 20:10:10 + 5 t/ha PM. Under the growing conditions in Nsukka, application of 20 t/ha PM or 150 kg/ha NPK 20:10:10 + 10 t/ha PM is recommendable for production of lettuce.

Keywords: *Productivity of lettuce; Integrated Fertilizer Management; Cropping Cycle*

INTRODUCTION:

Lettuce (*Lactuca sativa* L) is popularly consumed as salad; it belongs to the Asteraceae family, and is found in different variety, sizes and shapes. Lettuce is grown globally as a commercial vegetable; its significance and importance as a salad vegetable crop has made lettuce gained attention globally. Its production assures sustainable environment. However, certain climatic and soil requirements of lettuce production impede the overall production of lettuce in some parts of the world such as southeastern Nigeria. Most soils in the region are low in native fertility and are highly acidic, requiring external nutrient inputs to make the soils productive. Because of these limitations, addition of nutrients to the soil through either organic or inorganic sources generally improves the soil productive potential thereby enhancing the agronomic and physiological performances of any vegetable (Hossain and Ryu, 2017). The use of inorganic fertilizers commercially and for conventional farming is still in existence because of its quick-to-release nutrient feature, affordability and ability to be absorbed readily by plant (Islam *et al*., 2018). But the essential elements necessary for increase in growth and yield of lettuce are also implicated for soil and environment degradation (Purbajanti *et al.*, 2019). The mineral contents provided by these inorganic fertilizers to plants often leads to increase in toxicity level of certain trace element in fresh vegetables, but organic fertilizers curb the toxic compounds produced by inorganic fertilizers in crops, thus enhancing the quality of vegetables consumed by humans (Masarirambi *et al*., 2010). The application of manure to soils has increased tremendously owing to the beneficial functions that organic matter adds to cultivated lands (Silva *et al.*, 2010).

The overall productivity of lettuce under a particular rate of organic fertilizers is not yet ascertained, as its rate of application is dependent on the climate, cultivar and soil (Batista *et al*., 2012; Figueiredo *et al*., 2012). In southeastern Nigeria, especially the experimental site at Nsukka, the soil is an ultisol and typically acidic and poor in native fertility. Crop performance is however not limited only by the nutrient level of the soil, rather some other factors are considered, example is the physical-chemical-biological properties of the soil (Bell and Dell, 2008). Villas Boase *et al.* (2004) stated that organic based compounds significantly increased the fresh weight of lettuce. A recent report has also shown that there is a linear relationship between increasing fertilizer application and productivity of lettuce (Okafor *et. al.*, 2020). Similarly, Baiyeri *et al*. (2016) reported that the growth, yield and nutritional quality of 'Nsukka Yellow' pepper was exponentially increased by application of increasing rate of poultry manure. Thus, external provision of nutrient to plant is ideal to achieve increase in growth and yield. Available publications elsewhere have shown the beneficial effect of organic and inorganic fertilizers on the increase in growth and yield of (Shahbazi, 2005; Islam *et al.*, 2012). In this study, we aimed at bridging the knowledge gap in fertilizer requirement regarding lettuce production in southeastern Nigeria. Thus, organic, inorganic fertilizers and their combinations were evaluated during two cropping cycles in an ultisol of southeastern Nigeria.

MATERIALS AND METHODS:

Two experiments were conducted between June and November 2021 at the Teaching and Research Farmland, Department of Crop Science, University of Nigeria, Nsukka. Nsukka is located in the derived savanna zone at latitude $6^0$52'N, and longitude $07^0$24'E, with an altitude of 447.26 m above sea level. Rainfall distribution pattern is bimodal with peaks in July and September and a short break in mid August. The soil of the experiment is reddish-brown clay loamy utisol belonging to the Nsukka series. Nsukka has derived savanna vegetation with mean annual minimum and maximum temperature of 25 and 32^0C, respectively (Ekwu and Mbah, 2001; Uguru *et al*., 2011).

Nursery and nursery management: Lettuce seed was sourced from AgroHortiponics seed company, Lagos. Nursery growth medium prepared in the ratio 3:2:1 of topsoil: poultry manure: river sand, respectively and cured for about 6 weeks was used to raise the seedlings. Sowing was by spot placement of about 3 seeds per nursery bags and was watered regularly. A semi-growth chamber was constructed with palm fonts and about 90% of the seedlings sprouted on the second day after planting, following the development of the 3rd leaf after 4 days.

Experimental Design: The two experiments were conducted as randomized completely block design. Experiment one (first cycle) had 8 treatments (Control; 300 kg/ha NPK 20:10:10; 300 kg/ha NPK 15:15:15; 300 kg/ha NPK 20:10:10 + 5 t/ha Poultry manure (PM); 300 kg/ha NPK 15:15:15 + 5 t/ha PM; 150 kg/ha NPK 20:10:10 + 10 t/ha PM; 150 kg/ha NPK 15:15:15 + 10 t/ha PM and 20 t/ha PM). The experiment two (second cycle) had 9 treatments (Control; 150 kg/ha NPK 20:10:10; 150 kg/ha NPK 15:15:15; 150 kg/ha NPK 20:10:10 + 2.5 t /ha Poultry manure (PM); 150 kg/ha NPK 15:15:15 + 2.5 t/ha PM; 75 kg/ha NPK 20:10:10 + 5 t/ha PM; 75 kg/ha NPK 15:15:15 + 5 t/ha PM; 10 t/ha PM and 20 t/ha PM); it was conducted as a follow experiment of the first, whereby the same plots in cycle one was used for the corresponding treatment in cycle two. But half dose of the treatments in cycle one was used in cycle two. Each treatment in both experiments was replicated four times. The land was cleared, 32 and 36 sunken beds were raised and tilled for experiment one and two respectively. Dimension of each bed was 0.7 x 0.7 m with 1m between the beds. Beds were watered prior to transplanting of seedling.

Transplanting of seedlings: The seedlings were transplanted to the field at two weeks after emergence, when they attained 4 to 5 leaves per plant. Each plot had 9 plants transplanted to it. The transplants were watered immediately to ensure firmness and aggregation of soil at the transplants base.

Application of fertilizer: Where applicable and appropriate poultry manure was applied one week before transplanting whereas the inorganic fertilizer dosages were assigned and applied one week after transplanting. Fertilizer dosage following plot size was calculated from the treatments and applied accordingly. Application of inorganic fertilizer was done once and was by side placement at 2 cm away from the plant. The plants were irrigated during the periods of no rainfall and the plots were weeded as at when necessary.

Data collection: Growth data were collected on weekly basis. Data collection commenced on the 3rd week after transplanting and lasted till harvest. Data collected included: Number of leaves; length and breadth of the two youngest fully expanded leaves, survival count measured by directly counting the number of plants that survived per plot; vigor index was estimated by visual subjective measures defined as:

1. Few small yellowish leaves
2. Few medium size yellowish leaves
3. Many small yellowish green leaves
4. Many big but light green leave
5. Many big and greenish leaves

Yield parameters were whole plant biomass, above ground biomass and below ground biomass.

Data Analysis: All the data obtained were subjected to analysis of variance (ANOVA) according to the procedures outlined for randomized completely block design. Treatments were compared using the Fisher's Least Significant difference (F-LSD) at 5% probability level. Statistical analysis was done using GENSTAT 12th Discovery edition.

RESULTS:

First crop cycle: Fertilizer treatment significantly ($p < 0.05$) influenced area of the last two fully expanded leaves during the period 3 – 6 weeks after transplanting (Table 1). During this period 20 t/ha poultry manure (PM) and 150 kg/ha NPK 20:10:10 + 10 t/ha PM consistently produced the widest leaves. In most cases, 300 kg/ha NPK 20:10:10 + 5 t/ha PM ranked third in performance (Table 1). Number of leaves per plant almost followed similar trend with leaf area, but 20 t/ha PM consistently produced the highest number of leaves. Table 2 indicated non-significant treatment effect on survival counts but vigor index was best for plants that received 20 t/ha poultry manure (PM) and 150 kg/ha NPK 20:10:10 + 10 t/ha PM. Whole plant biomass yield per plot and the proportion of biomass partitioned to the above or below ground responded to the applied fertilizer (Table 3). Similar to earlier trends in growth parameters, whole plant biomass yield [WPBY] was significantly higher for plants that received 20 t/ha PM and 10 t/ha PM + 150 kg/ha NPK 20:10:10. Biomass distribution followed the same trend (Table 3). In all cases of growth and yield of lettuce NPK 20:10:10 outperformed NPK 15:15:15. Also, supplementations of either NPK with PM enhanced growth performance of lettuce.

Second crop cycle: Same plots as in the first cycle experiment were utilized but fertilizer treatments were halved. An additional treatment of 20 t/ha PM was included as a positive control; thus, there were nine treatments as against the eight in the first cycle experiment. Leaf area was highest in 20 t/ha PM followed by 10 t/ha PM and 75 kg/ha NPK 20:10:10 + 5 t/ha PM (Table 4). The number of leaves per plant followed the same trend. Survival counts at the 5th and 6th weeks after transplanting varied significantly with fertilizer treatment (Table 5). Survival was highest in plots that received 10 t/ha PM. Vigor index was consistently the best in this same plot that received 10 t/ha PM. In all cases of parameters measured Control had the poorest values except in survival counts. NPK (either 20:10:10 or 15:15:15) fertilizer similarly recorded poor parameters similar to the unfertilized plot. WPBY of second cycle cropping, and biomass distribution to above or belowground responded to fertilizer treatment. The highest biomass yield per plot was obtained in plots that received 10 t/ha PM, and 75 kg/ha NPK 20:10:10 + 5 t/ha PM. Biomass distribution was inconsistent but the Control was expectedly the poorest.

DISCUSSION

Growth and yield response pattern to the applied fertilizer treatment was similar across the two cropping cycles suggesting reliability and predictability of the fertilizer dosage. In all cases, 20 t/ha PM or 150 kg/ha NPK 20:10:10 + 10 t/ha PM outperformed all other treatments in the first cropping cycle. The same trend was obtained in the second cropping cycle (where half of the dosages in the first cycle were used). The positive Control in the second cropping cycle (20 t/ha PM) did not perform as much as the plot that had residual effects plus application of 10 t/ha PM. Supplementation of inorganic fertilizer with organic (PM) manure demonstrated high level of synergy by boosting both growth and yield of the two cropping cycles. Notably, organic manure enhances soil biophysical ecosystem enabling better hydraulic functionality of the soil (Aba *et al*., 2011). In all cases, NPK 20:10:10 outperformed NPK 15:15:15 probably supporting the idea of high nitrogen demands by leafy vegetable crops such as lettuce (Horque *et.al.*, 2010; Agba, 2018; Shahbazi, 2005; Maryam and Baser, 2007). Under the growing conditions in Nsukka, application of 20 t/ha PM or 150 kg/ha NPK 20:10:10 + 10 t/ha PM is recommendable for production of lettuce.

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Table 1: Effect of organic and inorganic fertilizer combinations on leaf area and number of leaves of lettuce

	Weeks after transplanting			
Treatment/Parameters	3	4	5	6
Leaf area (cm^2)				
Control	103.8	177	158	185
300kg NPK 20-10-10	118.8	233	237	302
300kg NPK 15-15-15	89.3	171	171	201
300kg NPK 20-10-10 + 5t/ha PM	211.4	346	419	428
300kg NPK 15-15-15 + 5t/ha PM	201.1	303	277	366
150kg NPK 20-10-10 + 10t/ha PM	217.3	452	495	570
150kg NPK 15-15-15 + 10t/ha PM	190.8	313	310	393
20t/ha PM	324.8	425	527	526
F-LSD	71.85	115.9	156.4	194.2
Number of leaves				
Control	6.8	9.5	10.0	15.6
300kg NPK 20-10-10	7.5	11.6	14.3	20.1
300kg NPK 15-15-15	6.5	9.1	11.3	15.9
300kg NPK 20-10-10 + 5t/ha PM	8.8	12.8	16.3	24.3
300kg NPK 15-15-15 + 5t/ha PM	9.0	12.4	16.8	23.9
150kg NPK 20-10-10 + 10t/ha PM	8.6	13.5	16.1	24.5
150kg NPK 15-15-15 + 10t/ha PM	8.6	12.3	16.3	22.6
20t/ha PM	11.6	17.9	18.8	25.0
F-LSD	1.6	3.0	5.1	4.9

PM: Poultry manure

Table 2: Effect of organic and inorganic fertilizer combinations on Survival count and growth vigor index of lettuce

	Weeks after transplanting			
Treatment/Parameters	3	4	5	6
Survival Count (%)				
Control	97.8	97.8	97.8	97.8
300kg NPK 20-10-10	97.8	97.8	97.8	97.8
300kg NPK 15-15-15	100.0	100.0	100.0	100.0
300kg NPK 20-10-10 + 5t/ha PM	100.0	100.0	100.0	100.0
300kg NPK 15-15-15 + 5t/ha PM	100.0	100.0	100.0	100.0
150kg NPK 20-10-10 + 10t/ha PM	97.8	97.8	97.8	97.8
150kg NPK 15-15-15 + 10t/ha PM	94.4	94.4	94.4	94.4
20t/ha PM	97.8	97.8	97.8	97.8
F-LSD	NS	NS	NS	NS
Vigor Index				
Control	1.8	1.8	2.5	3.0
300kg NPK 20-10-10	2.0	2.5	3.5	3.8
300kg NPK 15-15-15	2.3	2.3	2.3	3.0
300kg NPK 20-10-10 + 5t/ha PM	3.8	3.8	4.5	4.5
300kg NPK 15-15-15 + 5t/ha PM	3.8	3.8	4.0	4.0
150kg NPK 20-10-10 + 10t/ha PM	4.0	4.5	5.0	5.0
150kg NPK 15-15-15 + 10t/ha PM	3.5	3.8	4.0	4.3
20t/ha PM	4.8	5.0	5.0	5.0
F-LSD	1.2	1.2	1.0	1.1

PM: Poultry manure

Table 3: Yield components of lettuce as influenced by organic and inorganic fertilizer combinations

Treatment	AGB(g)	BGB(g)	%AGB	%BGB	WPBY(g)
Control	83	3.83	94.1	5.87	459
300kg NPK 20-10-10	185	5.42	96.2	3.78	982
300kg NPK 15-15-15	86	4.75	87.82	12.18	526
300kg NPK 20-10-10 + 5t/ha PM	319	8.83	96.4	3.61	2050
300kg NPK 15-15-15 + 5t/ha PM	202	7.42	96.0	4.02	1276
150kg NPK 20-10-10 + 10t/ha PM	368	9.83	97.4	2.62	2460
150kg NPK 15-15-15 + 10t/ha PM	165	7.08	95.0	4.96	1110
20t/ha PM	369	11.92	96.6	3.44	2673
F-$LSD_{0.05}$	146.2	483	NS	NS	1082.8

WPB: Whole plant biomass yield; AGB: Above ground biomass; BGB: Below ground biomass;
PM: Poultry manure

Table 4: Growth responses of lettuce as influenced by fertilizer treatment in a second cycle experiment: leaf area (cm) and number of leaves

	Weeks after transplanting			
Treatment/Parameters	3	4	5	6
Leaf area (cm^2)				
Control	38	66	92	171
150kg NPK 20-10-10	56	103	156	188
150kg NPK 15-15-15	48	75	101	144
150kg NPK 20-10-10 2.5 t/ha PM	127	215	318	388
150kg NPK 15-15-15 2.5 t/ha PM	88	178	264	350
75kg NPK 20-10-10 5 t/ha PM	135	205	333	437
75kg NPK 15-15-15 5 t/ha PM	101	175	287	403
10 t/ha PM	186	287	380	485
20 t/ha PM	230	318	435	528
F-$LSD_{(0.05)}$	96.8	105.0	143.3	95.1
Number of leaves				
Control	6.4	7.8	9.1	13.5
150kg NPK 20-10-10	6.3	8.5	11.4	15.5
150kg NPK 15-15-15	6.4	7.8	9.8	13.8
150kg NPK 20-10-10 2.5 t/ha PM	7.4	11.6	17.0	21.3
150kg NPK 15-15-15 2.5 t/ha PM	7.1	10.1	14.6	21.5
75kg NPK 20-10-10 5 t/ha PM	8.0	11.4	18.1	24.5
75kg NPK 15-15-15 5 t/ha PM	6.8	10.3	14.6	20.9
10 t/ha PM	8.9	13.8	20.5	28.1
20 t/ha PM	10.4	15.8	20.9	25.3
F-$LSD_{(0.05)}$	NS	4.3	5.1	7.3

PM: Poultry manure

Table 5: Growth responses of lettuce as influenced by fertilizer treatment in a second cycle experiment: Survival count and Vigor index

	Weeks after transplanting			
Treatment/Parameters	3	4	5	6
Survival Count				
Control	7.0	7.0	7.0	7.0
150kg NPK 20-10-10	6.0	5.3	5.3	4.8
150kg NPK 15-15-15	8.5	7.0	8.0	7.5
150kg NPK 20-10-10 2.5 t/ha PM	7.3	7.3	7.3	7.3
150kg NPK 15-15-15 2.5 t/ha PM	5.8	5.8	5.8	6.0
75kg NPK 20-10-10 5 t/ha PM	7.5	7.5	7.5	7.5
75kg NPK 15-15-15 5 t/ha PM	6.8	6.8	6.8	6.8
10 t/ha PM	8.0	8.0	8.0	8.0
20 t/ha PM	5.3	5.3	5.3	5.3
F-LSD$_{(0.05)}$	1.7	NS	1.9	1.9
Vigor Index				
Control	2.3	2.3	2.5	2.5
150kg NPK 20-10-10	2.3	2.3	2.5	2.5
150kg NPK 15-15-15	2.3	2.3	2.3	2.3
150kg NPK 20-10-10 2.5 t/ha PM	3.8	4.0	3.8	4.3
150kg NPK 15-15-15 2.5 t/ha PM	3.5	3.5	3.5	3.5
75kg NPK 20-10-10 5 t/ha PM	4.3	4.3	3.5	4.3
75kg NPK 15-15-15 5 t/ha PM	3.5	3.5	3.3	3.5
10 t/ha PM	4.8	4.8	4.8	4.8
20 t/ha PM	4.3	4.3	4.8	4.8
F-LSD$_{(0.05)}$	1.1	1.0	0.9	1.0

PM: Poultry manure

Table 6: Yield components (g) of lettuce as influenced by organic and inorganic fertilizer combination during the second crop cycle.

Treatment	AGB(g)	BGB(g)	%AGB	%BGB	WPB(g)
Control	49.33	3.00	93.54	6.46	242
150 kg NPK 20 - 10 -10	84.92	3.42	95.14	4.86	331
150 kg NPK 15 - 15 -15	40.92	2.17	93.99	6.01	255
150 kg NPK 20 - 10 - 10 +2.5t/ha PM	170.92	7.17	95.47	4.53	895
150 kg NPK 15 - 15 - 15 + 2.5t/ha PM	153.33	6.58	95.62	4.38	846
75 kg NPK 20 - 10 - 10 + 5t/ha PM	206.50	6.17	97.03	2.97	1043
75 kg NPK 15 - 15 - 15 + 5t/ha PM	137.92	5.33	96.08	3.92	718
10t/ha PM	223.42	7.42	96.49	3.51	1308
20t/ha PM	223.67	5.92	97.56	2.44	996
F-LSD$_{(0.05)}$	88.992	2.890	2.277	2.277	542.2

WPB: Whole plant biomass yield; AGB: Above ground biomass; BGB: Below ground biomass;
PM: Poultry manure.

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EVALUATION OF PREPLANT APPLICATION OF THYMOL ON THE SUPPRESSION OF BACTERIAL WILT DISEASE IN SOME TOMATO GENOTYPES

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ABSTRACT
This work reports the evaluation of thymol in the management of bacterial wilt of tomato caused by *Ralstonia solanacearum*. Sandy-loam top soil was steam-sterilized, stored for six weeks before distribution into experimental pots and tomato transplanting. The experiment was carried out using five tomato genotypes, and was laid out in a completely randomized design in three replications. Twenty mililitre (20 ml) of the bacterial suspension (10^8 cfu/ml) was introduced into each pot by soil drenching, two hours before thymol application. Thymol at 0.2, 0.4 and 0.6 g/l concentrations were applied into each experimental pot. Pots without thymol served as untreated control. After thymol application, pots were covered with polythene sheet for three days and opened for two days before transplanting. The application of thymol revealed that, there were significant ($p \leq 0.05$) delays in number of days to the development of wilt symptom when compared with the untreated control pots. At 5 weeks after transplanting, the highest wilt incidence (86.01%) was recorded in untreated control pots while 10.00% incidence was recorded for Gem pride and Tyre-type tomato genotypes, each at 0.6 g/l application of thymol. At 5 weeks after transplanting, 0.6 g/l concentration significantly reduced bacterial wilt severity with score of 1.00 for all the tomato genotypes used. On disease incidence and severity, there were no interactions between tomato genotypes and thymol concentrations. Thus, the study revealed that thymol application at 0.6 g/l could suppress incidence and severity of bacterial wilt of tomato caused by *Ralstonia solanacearum* in endemic areas.

Keywords: *Disease incidence, disease severity, drenching, pathogenicity, Ralstonia solanacearum*.

INTRODUCTION

Control of soil-borne pathogens is complicated because very low populations are often highly damaging. Tomato producers should therefore resort to prophylactic application of pesticides prior planting/transplanting as insurance against crop damage and yield loss due to these lethal microorganisms. Sometimes, it is usually too late and impractical to apply pesticides for control of soil-borne pathogens during crop growth. The pathogens overwinter in diseased plants, plant debris or in the soil. Their inocula can be spread in soil, water or infected propagation materials (Janse *et al*., 2005; Williamson *et al*., 2002). *Ralstonia solanacearum* (Smith), formerly called *Pseudomonas solanacearum*, is a soil-borne Gram-negative bacteria pathogen and is a major limiting factor in tomato production. It colonizes the xylem, causing bacterial wilt in a very wide range of potential host plants (Denny, 2006). Bacterial wilt is among the most difficult disease to control (Kucharek, 1998). *Ralstonia solanacearum* can overwinter in plant debris or diseased plants, wild hosts, seeds or vegetative propagative organs like tubers. Infected land sometimes cannot be used again for susceptible crops for several years.

Phosphoric acid (H_3PO_3) has been found to inhibit *in-vitro* growth of *Ralstonia solanacearum* and was effective in protecting geranium plants from infection by either race 1 or 3 of the bacterium when applied as a soil drench in greenhouse experiments (Norman *et al*., 2006). The results of Huang and Lakshman (2010) demonstrated that clove oil has the potential to eliminate populations of *R. solanacearum* in infested soils. It has been demonstrated that some volatile compounds derived from plants such as thymol and palmarosa oil provide disease control potentials in plants (Aeschbach *et al*., 1994). Thymol is a naturally-derived plant chemical found in the essential oil of thyme (*Thymus* spp). In agricultural studies, this compound has broad-spectrum activities against fungi, nematodes and insects (Delespaul *et al*., 2000). Thus, this experiment examined the efficacy of thymol as pre-plant soil treatment for the control of bacterial wilt disease of some tomato genotypes in screen house conditions.

MATERIALS AND METHODS

Research location, tomato procurement, treatment and experimental design

The experiment was carried out in the laboratory and the screen house of the Department of Crop Protection, Federal University of Agriculture Abeokuta, Nigeria. Five tomato genotypes (Gem pride, F_1-Mongal, Pure-water, Santana and Tyre-type) were sourced from places as shown in Table 1. The treatment consisted of three concentrations of thymol (0.2, 0.4 and 0.6 g/l) while the untreated control pots received no thymol. The 5×4 factorial experiment was laid out in a completely randomized design with three replications.

The soil source and sterilization: Sandy-loam top soil containing 86% sand, 10.8% silt and 3.2% clay with pH 5.87 from the Teaching and Research Farm, Federal University of Agriculture, Abeokuta, Nigeria was mixed and sterilized at 102^0 C for 60 minutes using an improvised sterilizing system (Popoola *et al*., 2012). To gain its stability, the sterilized soil was stored in jute sacks for six weeks after which the soil was distributed into sixty experimental pots at 5 kg per pot.

Bacterial isolation and inoculum preparation

Ralstonia solanacearum isolate was obtained from infected tomato plant by streaming method in sterile distilled water. Suspension of the ooze was first grown on semi-selective tetrazolium chloride (TZC) medium (Kelman, 1954) for 48 hours. The medium contained 10 g peptone, 1 g casein hydrolysate, 5 g glucose, 12 g oxoid agar in 1 litre of sterile distilled water. The medium was adjusted to pH 7. It was autoclaved at 121^0 C for 20 minutes. When the medium was cooled to 55^0 C, 5 ml of 1% solution of 2, 3, 5-triphenyl tetrazolium chloride was introduced to the basal medium. Bacterial suspension was streaked on Petri plates containing TZC and incubated for 48 hrs at 28 ± 2^0C. After 48 hrs, typical mucoid, creamy white colonies with pink centre were transferred to TZC and sub-cultured on TZC medium. Inoculum concentration was prepared by suspending the bacterial cells in sterile distilled water and adjusted to 10^8cfu/ml. Twenty militre (20 ml) of the bacterial suspension was drenched into the middle of each pot containing 5 kg sterilized soil, 15 cm deep, five days before tomato transplanting.

Pathogenicity test

Pathogenicity was determined by inoculating susceptible tomato cultivar (Beske) with 20 ml bacterial suspension (10^8 cfu/ml) three weeks after transplanting by drenching. Plants were not watered 24 hrs prior inoculation. Watering recommenced 2 hrs after inoculation and every other day for the period of the experiment. Sterile water served as a negative control. Plants were kept in the screenhouse (25-28°C and relative humidity between 85 and 90%) until symptoms development based on the method of Ganiyu *et al*., (2017). The tested isolate was reisolated on TZC medium.

Preparation and application of thymol and Tomato transplanting

Thymol (Alfa Aesar®, 98%, Lancashire, United Kingdom) was prepared into 0.6 g/l concentration (0.6 g thymol, 35 ml 70% ethanol, 964 ml water, 1 ml detergent) according to Popoola *et al*. (2012) and was further diluted to obtain 0.2 and 0.4 g/l. Twenty millilitre (20 ml) each of the three thymol concentrations (0.2, 0.4 and 0.6 g/l) was applied into each pot, two hours after pathogen inoculation and covered for three days after which it was opened for two days for aeration before transplanting. The untreated control pots received 20 ml of bacterial suspension without thymol. One seedling each of three-week old tomato genotypes was transplanted into each experimental pots 5 days after thymol application.

Data collection and analysis

Data collected were plant height, number of branches/plant, number of leaves/plant, number of days to the development of visible symptom, plant survival (%), plant mortality (%). Meter rule was used to measure the plant height from the base of tomato main stem to the highest point of the plant. Number of branches and number of leaves were counted visually while number of days to the development of visible symptoms were recorded as number of days from the day of inoculation to the first day of appearance of wilt symptom. Plant survival (%) and mortality (%) were calculated as the percentage of plant in existence and the percentage of dead plants at each time of data collection, respectively. Disease incidence (%) was calculated as the percentage of plant infected. Rating scale of 0-5 according to Ganiyu *et al*. (2018) was used for the assessment of disease severity, where 0=0% plant wilted; 1=1–10% plant wilted; 2=10.01–25% plant wilted; 3=25.01–50% plant wilted;

4=50.01–75% plant wilted; 5=75.01–100% plant wilted. Data were subjected to ANOVA and means separated by LSD at ($p \leq 0.05$) using GenStat Discovery Edition 4, Hemel Hempstead, United Kingdom.

RESULTS

Effect of thymol on agronomic performance of tomato genotypes inoculated with Ralstonia solanacearum at 3 and 5 weeks after transplanting

In Table 2, the highest plant height (32.05 cm) was recorded for pure-water at 0.6 g/l thymol concentration at 3 weeks after transplanting. At 5 weeks after transplanting, plant height ranged from 40.00-54.05 cm. At 3 and 5 weeks after transplanting, number of leaves of 70.55 and 99.84, was recorded respectively, for Tyre-type at 0.6 g/l thymol concentration. Number of branches for tomato genotypes at 3 weeks after transplanting ranged from 4.50-8.50 cm while 7.10-10.70 cm was the range recorded at 5 weeks after transplanting. Plant height, number of leaves and number of branches were not affected by thymol application. Tomato genotypes and thymol interaction was significantly different ($p \leq 0.05$) in plant height and number of leaves at 5 weeks after transplanting, while number of branches was significant at both 3 and 5 weeks after transplanting.

Effect of thymol on number of days to wilt symptom appearance, plant survival and mortality of tomato genotypes.

Table 3 shows the effect of thymol on number of days to wilt symptom appearance, plant survival and mortality of tomato genotypes. Number of days to the development of wilt symptom ranged from 0-35 days. There was no symptom of wilt disease recorded on Santana and Tyre-type genotypes (0.00 days) at 0.6 g/l thymol application. There were significant delays ($p \leq 0.05$) in the number of days to the appearance of wilt symptom at 0.2, 0.4 and 0.6 g/l thymol application in the genotypes when compared with the untreated control pots. The highest significant delay number of days (35 days) for wilt symptom appearance was observed in Santana genotype when 0.4 g/l of thymol was applied, followed by 32 and 29 days in Gem pride at 0.6 and 0.4 g/l application of thymol, respectively. The highest plant survival (100%) was recorded for Santana and Tyre-type tomato genotypes at 0.6 g/l thymol application while the highest plant mortality was recorded for Pure-water at 0% application of thymol. Genotype-thymol interaction was not significantly different for number of days to symptom appearance, percentage plant survival and mortality.

Effect of thymol application on bacterial wilt incidence and severity

At 3 weeks after transplanting, bacterial wilt incidence ranged from 0.00-70.25% (Table 4). The least disease incidence (0.00%) was recorded for Gem pride when 0.6 g/l thymol was applied, which was significantly different from the highest disease incidence (70.25%) observed in Pure-water tomato at 0.6 g/l thymol application. The same pattern was followed at 5 weeks after transplanting with the highest wilt incidence (86.01%) recorded for Pure-water in untreated control pots whereas, at 0.6 g/l application of thymol, Gem pride and Tyre-type recorded 10.00% wilt incidence each. Severity at 3 and 5 weeks after transplanting ranged from 1.00-5.00. At 5 weeks after transplanting, 0.6 g/l concentration performed significantly different by reducing bacterial wilt severity of tomato with severity score of 1.00. There was no significant difference in genotype-thymol interaction on bacterial wilt disease incidence and severity.

DISCUSSION

Mainly, methyl bromide is being used in United States as chemical for pre-planting fumigation of tomato and some other horticultural crops for the management of plant pathogenic organisms including *Ralstonia solanacearum* (Rosskopf *et al.*, 2005). Nevertheless, methyl bromide has been constrained for field use (Paret *et al.*, 2010), thus, the application of thymol as one of the essential oils was evaluated as alternative biofumigant in this work. It was observed that thymol application did not have toxic effect or reversed influence on the growth and development of tomato genotypes. This was consistent with Popoola *et al*. (2012) when they observed that application of thymol did not have negative influence on the growth and development of tomato plants while Cowan (1999) reiterated that thymol is an essential oil of plant origin with antimicrobial properties. Thymol application significantly reduced the incidence and severity of bacterial wilt to minimal levels compare with untreated control plants. Pradhanang *et al*. (2003) and Ji *et al*. (2005) corroborated this fact that thymol had significant efficacy against *Ralstonia* *solanacearum* and efficiently reduced its populations in soils to an undetectable level. It was observed that plants without thymol were severely infected with bacterial wilt of tomato. This implies that in endemic areas with this deadly pathogen, tomato plants are open to serious attack which can lead farmers to have no economic returns. Ji *et al*. (2007) reiterated that application of thymol as preplant biofumigant significantly reduced incidence of bacterial wilt of tomato. Ganiyu *et al.* (2018) concluded that the use of thymol as pre-plant soil treatment for the management of *Ralstonia solanacearum* could efficiently protect tomato plants against bacterial wilt of tomato. Green house experiments and *in-vitro* studies indicated that thymol had significant efficacy against *R. solanacearum* and efficiently reduced populations of this pathogen in soils (Momol *et al*., 2000). Our results that thymol reduced bacterial wilt incidence and severity of tomato caused by *R. solanacearum* advocates that it could be used under field conditions. Thymol is produced by thyme (*Thymus* spp.) or other medicinal plants (Manou *et al.,* 1998) and as a plant derived compound, it has been recognized as safe by the United State Food and Drug Administration (FDA) and Environmental Protection Agency (Ji *et al*., 2007).

CONCLUSION

This study revealed that thymol at 0.6 g/l could curtail the incidence and severity of bacterial wilt of tomato caused by *Ralstonia solanacearum.* In endemic areas with bacterial wilt, tomato genotypes used in this experiment can thrive well with the application of thymol at 0.6 g/l as soil treatment in pot cultivation at 20 ml/5 kg soil.

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Table 1: **Names and sources of tomato accessions**

S/N	Accession	Source
1	Gem pride	IAR, Zaria, Nigeria.
2	F_1- Mongal	Ajara farm settlement, Lagos, Nigeria.
3	Pure-water	Ile-ona, Ekiti State, Nigeria.
4	Santana	Ilaro, Imeko, Ogun State, Nigeria.
5	Tyre-type	Ife-Odan, Osun State, Nigeria.

Source: Ganiyu *et al*. (2017)

Table 2: Effect of Thymol on plant height (cm), number of leaves and branches of tomato genotypes inoculated with *Ralstonia solanacearum* at 3 and 5 weeks after transplanting

Genotype	Thymol (g/l)	Plant height (cm)		Number of leaves		Number of branches	
		3 WAT	5 WAT	3 WAT	5 WAT	3 WAT	5 WAT*
Gem pride	0	7.04	10.95	16.50	32.75	6.00	8.50
	0.2	9.00	16.50	20.65	39.05	6.00	9.00
	0.4	8.95	17.55	25.77	60.45	6.00	10.50
	0.6	10.56	23.25	30.67	65.00	5.00	9.00
F_1-Mongal	0	8.57	12.00	45.34	66.95	4.50	8.90
	0.2	6.50	11.95	50.53	94.00	7.70	9.70
	0.4	7.95	18.77	53.00	96.05	7.50	9.00
	0.6	10.25	22.50	50.00	98.00	7.00	10.00
Pure-water	0	6.95	10.00	24.00	46.00	6.00	7.20
	0.2	10.05	17.00	35.56	75.35	5.50	7.50
	0.4	12.00	20.93	40.85	84.69	6.50	9.30
	0.6	12.05	24.05	42.55	93.05	7.00	10.20
Santana	0	6.55	11.60	20.00	40.45	5.00	7.10
	0.2	8.50	13.00	19.95	61.05	6.00	9.00
	0.4	10.50	18.50	25.04	70.50	5.00	8.90
	0.6	11.55	20.50	31.50	85.55	5.50	9.00
Tyre-type	0	7.50	12.00	55.00	72.00	6.50	8.00
	0.2	9.52	15.65	50.95	95.00	8.00	10.50
	0.4	10.95	20.57	60.00	99.50	7.00	9.00
	0.6	11.50	23.95	60.55	99.84	8.50	10.70
$LSD_{0.05}$							
Genotype (G)		1.48	ns	4.27	16.98	0.99	1.77
Thymol (T)		1.25	4.05	2.43	1.25	1.55	2.85
G×T		ns†	16.04	ns	43.95	1.96	8.99

*WAT: Weeks after transplanting; †ns: not significant

Table 3: Effect of thymol on number of days to wilt symptom appearance, plant survival and mortality of tomato genotypes

Genotype	Thymol (g/l)	Number of days to symptom appearance	Plant survival (%)	Plant mortality (%)
Gem pride	0	10.00	4.80	95.20
	0.2	20.00	30.00	70.00
	0.4	29.00	50.00	50.00
	0.6	32.00	59.25	40.75
F_1-Mongal	0	10.00	10.00	90.00
	0.2	16.00	15.30	84.70
	0.4	18.50	59.75	40.25
	0.6	21.00	79.50	20.50
Pure-water	0	10.00	2.50	97.50
	0.2	18.00	14.10	85.90
	0.4	21.00	29.25	70.75
	0.6	30.00	79.50	20.50
Santana	0	17.00	4.50	95.50
	0.2	26.00	39.50	60.50
	0.4	35.00	49.90	50.10
	0.6	0.00	100.00	0.00
Tyre-type	0	15.00	16.50	83.50
	0.2	26.00	34.80	65.20
	0.4	27.00	59.30	40.70
	0.6	0.00	100.00	0.00
$LSD_{0.05}$				
Genotype (G)		5.45	25.30	31.75
Thymol (T)		5.12	10.02	4.51
G×T		ns†	ns	ns

†ns: not significant

Table 4: Effect of thymol application on bacterial wilt incidence and severity of tomato genotypes at 3 and 5 weeks after transplanting

Genotype	Thymol (g/l)	Disease Incidence (%)		Disease severity	
		3 WAT	5 WAT	3 WAT	5 WAT*
Gem pride	0	35.64	44.75	2.00	2.00
	0.2	30.00	30.02	1.25	1.30
	0.4	25.50	20.71	1.00	1.09
	0.6	0.00	10.00	1.00	1.00
F_1-Mongal	0	60.29	74.15	3.55	4.00
	0.2	40.75	44.35	2.00	1.95
	0.4	20.13	13.00	1.05	1.20
	0.6	15.50	10.25	1.00	1.00
Pure-water	0	70.25	86.01	4.55	5.00
	0.2	61.03	75.34	3.30	4.37
	0.4	25.55	26.95	2.11	1.15
	0.6	20.50	20.35	1.75	1.00
Santana	0	55.75	65.45	3.04	3.90
	0.2	50.00	52.73	2.17	2.75
	0.4	24.73	24.00	2.00	2.00
	0.6	15.67	10.35	1.00	1.00
Tyre-type	0	54.75	70.66	3.65	4.00
	0.2	40.70	45.09	3.00	3.12
	0.4	10.35	11.47	1.00	1.50
	0.6	10.00	10.00	1.00	1.00
$LSD_{0.05}$					
Genotype (G)		25.75	31.45	0.63	0.55
Thymol (T)		4.02	10.11	0.54	0.78
G×T		ns†	ns	ns	ns

*WAT: Weeks after transplanting; †ns: not significant

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GROWTH AND YIELD OF CUCUMBER (*CUCUMIS SATIVUS* L.) AS AFFECTED BY PROPORTIONATE INCLUSIONS OF ORGANIC *JATROPHA CURCAS* SEED CAKE AND MINERAL-NPK FERTILIZER UNDER LOW FERTILE SAVANNA SOIL IN OGBOMOSO

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ABSTRACT

Jatropha curcas is a versatile shrub with seed of high oil content (about 60%). Although, the seed cake of *Jatropha curcas* is considered poisonous and unsuitable for feeding livestock, however, its relatively high nutrient concentrations which makes it a potential organic fertilizer material, for improving soil nutrition and crop productivity, has not been adequately studied. This study evaluated the influence of *Jatropha curcas* seed cake (JSC) either as a sole organic fertilizer material or an organic proportion combined with inorganic NPK 15-15-15 fertilizer on growth and fruit yield of cucumber (post cropping residual effects trial inclusive). Two field experiments were conducted at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria in 2019. The experiments comprised six fertilizer treatment combinations: Zero application of fertilizer material, 100% of the recommended rate of NPK fertilizer (0.8g/plant), 75% NPK fertilizer (0.31g/plant) + 25% Jatropha seed cake (12.5g/plant), 50% NPK fertilizer (0.4g/plant) + 50% Jatropha seed cake (25g/plant), 25% NPK fertilizer (0.2g/plant) + 75% Jatropha seed cake (37.5g/plant) and 100% Jatropha seed cake (50g/plant). The treatments were arranged in Randomized Complete Block Design, replicated thrice. Data collected on growth parameters (length of primary vine, numbers of secondary vine and numbers of leaves) and yield parameters (shoot weight, root weight, fruit weight, fruit diameter and fruit length) were subjected to analysis of variance. Means were separated using Duncan Multiple Range Test at 5% probability level. Application of fertilizer treatments significantly ($p < 0.05$) enhanced growth and fruit yield of cucumber, compared to the control. Higher value of fruit yield (weight = 467.0g, length = 15.9cm and diameter = 43.3cm) when compared to other treatments. In the residual experiment, the primary vine length and fruit weight were significantly higher with the applications of 100% Jatropha seed cake (135.51cm, 702.83g) and 50% Jatropha seed cake + 50% NPK (117.17cm, 513.33g). There were no significant differences between primary vine length and fruit weight values of cucumber plants which received 100% NPK (95.16cm, 464.77g) and the control (82.83cm, 333.43g). In conclusion, the integration of either application of 50% Jatropha seed cake + 50% NPK or 75% Jatropha seed cake + 25% NPK improved the growth and yield of cucumber in the study area. In the residual experiment, application of 75% Jatropha seed cake + 25% NPK and 100% Jatropha seed cake improved the growth and yield of cucumber. Therefore, application of 100% Jatropha seed cake or 75% Jatropha seed cake + 25% NPK is recommended, so as to reduce chemical inputs on soils in the study area, where organic matters are rapidly forming and varnishing.

Keywords: *Jatropha seed cake, Cucumber, Residual effects, NPK fertilizer and Proportionate inclusions*

INTRODUCTION

Tropical soils are majorly marginal and cannot supply adequate nutrients to meet tropical crops need. However, in order to boost soil fertility, local farmers opted for chemical fertilizers, which are now scarce and highly priced, apart from being reportedly harmful to plants, animals and humans alike. Meanwhile, the organic residues proposed to be dependable alternatives are also not perfectly suitable, particularly in the aspects of possible competitive uses, bulkiness, relatively low nutrient concentrations per unit volume, slow release of nutrients and the drudgery involved in their preparations. *Jatropha curcas* plant could be regarded as being versatile but relatively under-utilized oil and nutrients rich crop plant. Unlike Palm kernel cake (PKC), Jatropha seed cake (JSC) is relatively high in nutrient concentrations (particularly N), but highly poisonous and unsuitable for feeding livestock (particularly in higher dosages), hence, it is mostly found deposited and wasteful after oil extraction.

Cucumber (*Cucumis sativus*) is a cultivated plant possessing a creeping vine attribute. It belongs to the family Cucurbitaceae, which is characterized by broad leaves, thin tendrils and a typically edible and cylindrically elongated green-skinned fruit with tapered ends. It is usually eaten raw or cooked. It is a nutritious food source, which makes its cultivation to be steadily spreading over the past 3,000 years, from Asia to Europe, Middle East, Africa, and the Americas with distinctive numerous varieties. A well drained loamy soil is preferred by cucumber. Cucumber also prefers fertile soil with a pH value ranging from 5.5 to 6.8, as well as moderate moisture and organic manure contents (Berry *et al.,* 2006).

Jatropha curcas is native to Central America and has become naturalized in many tropical and subtropical areas, including India, Africa, and North America. Originating in the Caribbean, Jatropha was spread as a valuable hedge plant to Africa and Asia by Portuguese traders (Fairless, 2007). Growers of Jatropha are increasingly demanding seeds in Egypt for cultivation for the production of biofuel. In 2004 - 2005, the area planted with *Jatropha curcas* was about 100 hectares, increased seven times to about 700 ha in 2007. It is a perennial poisonous shrub which normally grows up to 5m high. It belongs to the family Euphorbiaceae, subfamily Crotonoideae and tribe Joannesieae. *Jatropha curcas* has stems and branches containing latex. It has large green to pale-green leaves. According to Begg and Gaskin (1994) and Heller (1996), the physic nut has five to seven simple, ovate, shallow lobed leaves arranged alternately with 3-5 indentations and a length and width of 6-15cm. Its petioles are about 10cm long. According to Gadekar (2006), the seed of *Jatropha curcas* contains 30% oil that can be refined into bio-diesel usable in standard diesel engine and one hectare of the crop can give 1.6 tonnes of oil under average soil conditions. The 70 % waste that is left after the oil extraction is the JSC. This cake cannot be used in animal feed because of presence of phytotoxins such as curcin. However, besides being useful for biogas production, JSC is potentially a valuable organic fertilizer, which contains about 3.2 to 3.8% nitrogen i.e. almost similar to that of the castor seed cake and chicken manure but superior to cowdung manure, depending on the source (Openshaw, 2000; Envis, 2004; Agarwal *et.al.*, 2007; Maes *et al.*, 2009). Therefore, proportionate inclusions of organic (*Jatropha curcas* seed cake) and inorganic fertilizer material could be more suitable for improving cucumber performance than sole application of any one of the two nutrients' sources, particularly in terms of rapidity of nutrients release (which could be favoured by the mineral proportions contained in the NPK fertilizer) and long lasting release of the inherent nutrients to crop plants (which could also be favoured by the organic proportions contained in the JSC). This approach could therefore be regarded as a worthwhile environment friendly strategy, which may also be favourably and relatively economical, particularly for the resource poor local farmers.

MATERIALS AND METHODS

The materials used were cucumber seed (*Tendergreen burpless*). *Jatropha curcas* seed cake obtained from University of Ilorin, NPK 15-15-15 fertilizer from Oyo State Agricultural Development Programme, Ogbomoso, Cypermethrin (insecticide), electronic weighing balance (Citizen MP500H Model) and locally made tools (Cutlass, hoes e.t.c)

Soil sampling and analysis

During land clearing and preparation, pre-cropping soil samples were collected randomly using soil auger at an arable soil depth of 0-25cm, for soil physical and chemical analyses. The samples collected were later bulked into a composite sample. The samples were air dried, crushed and sieved through 2 mm and 0.5 mm meshes for the determination of particle size, pH (H_2O), total nitrogen (N), organic carbon, available Phosphorus (P), Iron (Fe), copper (Cu), Znic (Zn), the exchangeable cations (Ca, Na, Mg and K) and exchangeable acidity. The particle size was carried out according to the Bouyoucos (1951) Hydrometer method, using sodium hexametaphosphate as the dispersant.

Total N was determined by the macro-Kjedahl method (Bremmer, 1965) and colorimetric determination by Technicon Autoanalyser (1951), while the exchangeable cations were determined using Atomic Absorption Spectrometer; (Model Buck 200A). Available P was determined by extraction with Sodium bicarbonate (Olsen *et al.,* 1984). Organic carbon was determined by chromic acid digestion (Heanes, 1984). After the termination of the first experiment, soil sampling at 0-25cm depth was carried out, for the post-cropping determination of the soil physical and chemical properties, followed by soil re-tilling and setting up of the second (residual) experiment correspondingly, without any fertilizer application.

Propagation and cultural practices

Experimental plot was made into beds of 4m x 2m size each, with a spacing of 1m x 0.5m and 1m gaps in between beds. At sowing, three seeds were sown per hole. At two weeks after sowing (WAS), thinning and supplying were concurrently done to obtain optimum evenly distributed plant population. Insect pest control was achieved by spraying Delthrin (containing 100 g/L Cypermethrin EC), at a rate of 50 ml to 20 L of water. Spraying started at 2 weeks after sowing (WAS) and was repeated every fortnight. *Jatropha curcas* seed cake was incorporated into the soil at two weeks before sowing, while the NPK 15-15-15 fertilizer materials were buried at the side of each plant, at two weeks after sowing (2 WAS). Weeding was done manually at two weeks interval. Staking was done at 4 WAS, using strong bamboo poles.

Treatments and experimental design

The field experiments comprised six fertilizer treatment combinations: T0 (Zero application of fertilizer material), T1 [100% of the recommended rate of NPK fertilizer (i.e. 20 g/plant)], T2 [75% NPK fertilizer (i.e. 15 g/plant) and 25% Jatropha seed cake (i.e. 25 g/plant)], T3 [50% NPK fertilizer (i.e. 10 g/plant) and 50% Jatropha seed cake (i.e. 50 g/plant)], T4 [25% NPK fertilizer (i.e. 5 g/plant) and 75% Jatropha seed cake (i.e. 75 g/plant)] and T5 (100% Jatropha seed cake (i.e. 100 g/plant). All treatments were applied at recommended rate according to Akanbi (2002) and Ojeniyi *et al* (2015). Two beds per treatment were used. The treatments were laid out in Randomized Complete Block Design (RCBD) and replicated three times. A total of thirty six beds were used for the experiment.

Data collection on growth and yield parameters

Data collection commenced at three weeks after sowing (3WAS). The growth parameters determined were Length of primary vine, numbers of leaves and number of secondary vines per plant. The yield parameters measured were number of fruits, fruit diameter, fruit length, fruit and shoot weights. Each of the experiments was finally terminated at 12 WAS. However, before the final termination was done, the plants were carefully monitored for fully developed green fruits (at physiological ripening stage), which commenced from 7 WAS till 12 WAS. The physiologically ripe / matured fruits were carefully and cumulatively plucked using harvesting knife and their weights were correspondingly recorded per plant. **Plant Sampling and Analysis**

Immediately after the termination of each experiment, the plant samples were collected per plant and were oven dried at 80^0C for 72 hours to a constant weight, according to the procedures described by IITA (1982), followed by the determination of nutrient concentrations and uptakes (Ombo, 1994: Gungula, 1999).

Statistical Analysis

All the data collected were subjected to analysis of variance (ANOVA), using SAS software (2019) and means were separated using Duncan multiple range test (DMRT) at 5% probability level.

RESULTS AND DISCUSSION

Pre cropping and post cropping soil characteristics

The results from the pre-cropping analyses of the soil samples used showed that the soils were generally slightly acidic with unchanging pH value of 6.10 for the pre cropping and post cropping soil analyses. The soils were found to be grossly low in the major soil nutrients particularly N, P and K (Table 1). This showed that the soil samples used were inadequate in the nutrient concentrations required for successful growth and development of an arable crop like cucumber. Hence, regular maintenance of the soil fertility either via organic matter application or artificial supply of nutrients through chemical means may be required to meet cucumber nutritional requirements, for its improved growth and yield. Moreso, although some noticeable variations were observed amongst the soil chemical properties between different treatments in relation to the post cropping soil analysis results, the textural class remained unchanged (i.e. sandyloam textural class maintained throughout the experiments). These results were in agreement with other earlier Researchers (Olabode *et al.*, 2007; Babajide *et al.,* 2008; Babajide, 2010), who reported that the soils at the study area were slightly acidic and also that they were grossly inadequate in nutrient concentrations to effectively support crop plants' growth and development.

***Jatropha curcas* seed cake analysis**

The mineral nutrient concentrations of *Jatropha curcas* seed cake were shown on Table 2. The essential nutrient concentrations (particularly N and K) were found to be relatively high. The percentages of Nitrogen, Phosphorus and Potassium contents were 3.00, 0.50 and 2.25 respectively. This makes *Jatropha curcas* seed cake a potential organic fertilizer material, which may considerably favour arable crop growth and yield. These results are in agreement with earlier Researchers; Mann *et al* (1978); Babajide (2010): Babajide *et al* (2012), who reported that organic residues are potential fertilizer materials, which on application may successfully supplement nutrients in the soil solution and release their inherent nutrients slowly over a long period of time, for effective enhancement of crop performance and soil physical and chemical properties.

Growth Parameters of Cucumber under combined application of Jatropha curcas seed cake (JSC) and NPK Fertilizer

In the first experience, application of 100% JSC significantly influenced the primary vine of cucumber (107.9), although the value observed was not significantly different from other treatments tested, but was found to be significantly higher than the control. However, in the second (residual) experiment, plants which earlier received 100% JSC had significantly higher value of primary vine (112.5), which was not significantly higher than the value obtained from application of 75% JSC + 25% NPK (i.e. 108.1), but was significantly different from others with higher dosages of NPK (i.e. at 50%, 75% and 100% levels), while the control had the least value of 18.2 (Table 3). Application of 100% JSC was observed to produce significant higher number of leaves (80.0), in the first experiment, which was statistically similar to the values obtained from T4 (75% JSC) and T3 (50% J.S.C.), but was significantly higher than T2 (75% NPK) and T1 (100% NPK) and the control (which had the least). In the second experiment, number of leaves produced was significantly enhanced by JSC application as 100% JSC produced the highest number of leaves per plant, which was not significantly different from 75% and 50% of JSC applications, but was significantly higher than all other treatments tested, while the control had the least value (Table 3). In relation to the two experiments, it was observed the higher the JSC level, the higher the number of secondary vine and vice versa, as observed that 100% JSC had significantly higher value of number of secondary vine, which was not statistically different from 75% and 50% JSC but was significantly higher than those values obtained from the plants that received lower dosages (50% and 25%) of JSC, including the control which received neither the application of JSC nor NPK fertilizer (Table 3). These results are in line with Akanbi (2002); Makinde *et al* (2007); Babajide *et al* (2008); Babajide (2010) and Babajide *et al* (2012), which indicated improved plant nutrition with increasing levels of organic-based fertilizer materials. These are also in agreement with the report of Manga *et al*. (2004), which stated that, vegetative growth can be increased with fertilizer application. Moreso, the possibility of compatible integration of different fertilizers (which may be obtained from different sources /origins), as established in the experiments could vividly corroborate the findings of Indu and Savithri (2003); Odedina *et al* (2007); Babajide (2010); Attoe *et al* (2016) and Babajide *et al* (2017a), which emphasized suitability of fertilizer integrations or combination of two or more fertilizer materials for improving arable crop performance.

Yield parameters of Cucumber under combined application of *Jatropha curcas* seed cake and NPK fertilizer

In relation to the yield parameters, almost similar trend of responses of cucumber to combined application of JSC and NPK (as in the case of growth parameters discussed earlier), were observed. Number of fruits of cucumber in the two experiments was significantly improved by application of 100% JSC, although the values were not statistically different from those of the plants which received application of 75% and 50 % JSC, including the controls which had the least values (Table 4). In the first experiment, 100% application of JSC produced significantly higher fruit length with a value which was not significantly different from all other treatments tested including the control. However, in the residual effect experiment, application of 100% JSC similarly produced significantly higher fruit length with a value (23.4cm), which was not significantly different from those plants which received 75% and 50% JSC, but the value was significantly higher than those of the other treatments, including the control (Table 4). Fruit diameter was significantly enhanced by application of 100% JSC in the two experiments conducted, as the values obtained were statistically similar to those of the plants which received 75% and 50% JSC. However, the values were significantly higher than those plants which earlier received lesser amounts of JSC, including the control which received none of the fertilizer materials. In relations to the fruits yield (i.e. fruit weight), it was observed that, although application of 100% JSC produced the highest value of 232.3g per plant, this value was not significantly different from all other treatments studied, except the control, which had the least value of 4.0 in the first experiment. In the second (residual) experiment, highest fruit weight production was observed in plants which earlier received 100% JSC application. Although the value was statistically similar to those obtained from those crop plants which received 75% and 50% of JSC application, it was significantly higher than all other treatments which received lesser dosages of JSC, including the control which had the least value (Table 4). The significant improvement in the performance of cucumber plants which received sole application of Jatropha seed cake (i.e. 100% JSC), may not be unconnected probably to the continuous supply of nitrogen for a very long period of time, which may possibly favour increased soil microbial activities and mineralization. Also, the combination of fertilizer treatments at varying proportions could be easily attributed to the availability of inorganic nitrogen for early development of leaves, improved soil structure resulting from microbial activities on the organic matter and later availability of nitrogen after mineralization of the organic matter for better growth and development of plants (Dhoble, 1998: Babajide 2010; Babajide *et al.*, 2017a). These results also corroborated the findings of Adediran *et al* (2003); Owolabi *et al* (2003) and Odedina *et al* (2007), which emphasized the suitability of agro-industrial wastes for improving the yield of tropical arable crop-plants, as they contain reasonable amounts of major and minor nutrient elements, which may be readily released when applied to the soil. Also, the results supported the earlier researches of MoyinJesu and Ojeniyi (2000); Attoe *et al* (2016); Babajide *et al* (2017a) and Babajide *et al* (2017b), which coined out the fact that; the organic wastes (agro-industrial inclusive) may successfully combine with other fertilizer materials of different origins / sources, to significantly enhance general crop performance and soil quality, particularly under depleted tropical soil conditions.

CONCLUSION AND RECOMMENDATION

Jatropha curcas seed cake is a potential organic fertilizer material, which is dependably suitable for improving arable crop production. It is found to be favourably compatible with NPK fertilizer combinations, which may supply adequate nutrients, for improving arable crop performance. Cucumber responded well to fertilizer application, irrespective of types and levels of proportionate inclusions. The residues from the *Jatropha curcas* seed cake may remain in the soil over a considerably long period of time, which may favour continuous flow of its inherent nutrients, for the benefits of crop plants. Sole application of NPK fertilizer may induce unfavourable residual effects, which may not favour continuous and adequate supply of nutrients, for the next cropping season. However, since the study area falls under tropical soil conditions, where essential nutrients are known to be characteristically depleted, application of either 100% Jatropha seed cake or 75% Jatropha seed cake + 25% NPK is therefore recommended. This is a worthwhile research in the aspects of environment friendliness and low-input technology, which may favourably improve soil organic matter content, for improving general soil health and crop performance, in addition to the consequential reduction of chemical loads on tropical soils, where the nutrients-rich topsoil is found to be incessantly missing.

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Table 1: Pre-cropping and post-cropping soil physical and chemical properties

Soil Properties and Values							
		Post-cropping (values on treatments' basis)					
	Pre-cropping	T0	T1	T2	T3	T4	T5
pH (H_2O)	6.10	6.10	6.10	6.10	6.10	6.10	6.10
Organic Carbon (g kg^{-1})	4.42	1.50	1.60	1.80	1.80	1.80	1.80
Total N (g kg^{-1})	0.28	0.10	0.14	0.16	0.17	0.18	0.18
Available P (mg kg^{-1})	5.18	2,12	2.12	2.45	2.45	2.50	2.50
Fe (mg kg^{-1})	11.72	11.68	11.61	11.58	11.70	11.70	11.70
Cu (mg kg^{-1})	2.80	2.60	2.60	2.70	2.70	2.70	2.70
Zn (mg kg^{-1})	2.90	3.0	3.1	3.0	2.80	2.80	2.80
Exchangeable K (cmol kg^{-1})	0.33	0.12	0.10	0.11	0.32	0.30	0.30
Exchangeable Na (cmol kg^{-1})	0.20	0.19	0.19	0.19	0.20	0.20	0.20
Exchangeable Ca (cmolkg^{-1})	2.04	1.26	1.64	1.82	1.98	2.00	2.00
Exchangeable Mg (cmol kg^{-1})	3.15	2.54	2.34	2.45	3.0	3.0	3.1
Sand (%)	80.12	84.30	84.60	82.70	82.40	79.28	79.30
Silt (%)	09.48	06.90	07.74	07.62	08.48	09.90	09.94
Clay (%)	10.39	08.80	07.66	09.68	09.12	10.82	10.76
Textural class	Sandy loamy	Sandy loamy	Sandy loamy	Sandy loamy	Sandy loamy	Sandy loamy	Sandy loamy

T_0 - Zero application of fertilizer material, T_1 - 100% of the recommended rate of NPK fertilizer ,T_2 - 75% NPK fertilizer and 25% Jatropha seed cake, T_3 - 50% NPK fertilizer and 50% Jatropha seed cake, T_4 - 25%NPK fertilizer, 75% Jatropha seed cake, T_5 - 100% Jatropha seed cake.

Table 2: Nutrient concentrations of Jatropha seed cake used

Nutrient Elements	Values
Nitrogen (%)	3.05
Phosphorus (%)	0.54
Potassium (%)	2.05
Calcium (%)	0.58
Magnesium (%)	0.45
Manganese (g kg^{-1})	2.19
Boron (g kg^{-1})	0.38
Copper (g kg^{-1})	0.16
Zinc (g kg^{-1})	0.13

Table 3: Effect of *Jatropha curcas* seed cake and NPK fertilizer combinations on growth parameters of *Cucumis sativus*

Treatments	Length of primary vine (cm plant^{-1})	Number of leaves (cm plant^{-1})	Number secondary vine (cm plant^{-1})
T0	33.5^{b} (18.2^{d})	13.0^{c} (16.0^{d})	4.0^{c} (4.0^{b})
T1	79.6^{a} (48.2^{bc})	41.0^{b} (28.0^{c})	9.0^{b} (7.0^{b})
T2	79.8^{a} (52.6^{bc})	41.0^{b} (31.0^{c})	10.0^{b} (9.0^{b})
T3	83.6^{a} (82.2^{b})	50.0^{b} (53.0^{ab})	15.0^{a} (15.0^{a})
T4	105.6^{a} (108.1^{a})	78.0^{a} (64.0ab)	16.0^{a} (15.0^{a})
T5	107.9^{a} (112.5^{a})	80.0^{a} (71.0^{a})	17.0^{a} (15.0^{a})

Means followed by the same alphabet within column were not significant ($p > 0.05$) different, using Duncan Multiple Range Test (DMRT). Values in parentheses are for the second (residual) experiment. T_0 - Zero application of fertilizer material, T_1 - 100% of the recommended rate of NPK fertilizer ,T_2 - 75% NPK fertilizer and 25% Jatropha seed cake, T_3 - 50% NPK fertilizer and 50% Jatropha seed cake, T_4 - 25%NPK fertilizer, 75% Jatropha seed cake, T_5 - 100% Jatropha seed cake.

Table 4: Yield Parameters of Cucumber under the combine application of *Jatropha curcas* Seed Cake and NPK Fertilizer

Treatments	Number of fruits (plant^{-1})	Fruit weight (gplant^{-1})	Fruit length (cm plant^{-1})	Fruit diameter (cm plant^{-1})
T0	7.0^{c} (4.0^{c})	68.5^{b} (38.2^{d})	12.0^{b} (6.8^{b})	9.7c (6.0^{b})
T1	13.0^{b} (8.0^{b})	230.8^{a} (72.2^{c})	27.0^{a} (8.8^{b})	10.0b (7.0^{b})
T2	16.0^{b} (8.0^{b})	229.6^{a} (102.6^{b})	24.0^{a} (11.0^{b})	12.8b (9.0^{b})
T3	30.0^{a} (22.0^{a})	227.5^{a} (210.2^{a})	27.0^{a} (22.8^{a})	20.0a (18.0^{a})
T4	29.0^{a} (22.0^{a})	229.2^{a} (208.1^{a})	26.8^{a} (23.0a)	21.8a (19.0^{a})
T5	31.0^{a} (23.0^{a})	232.3^{a} (212.2^{a})	27.1^{a} (23.4^{a})	22.3a (18.4^{a})

Means followed by the same alphabet within column were not significant ($p > 0.05$) different, using Duncan Multiple Range Test (DMRT). Values in parentheses are for the second (residual) experiment. T_0 - Zero application of fertilizer material, T_1 - 100% of the recommended rate of NPK fertilizer ,T_2 - 75% NPK fertilizer and 25% Jatropha seed cake, T_3 - 50% NPK fertilizer and 50% Jatropha seed cake, T_4 - 25%NPK fertilizer, 75% Jatropha seed cake, T_5 - 100% Jatropha seed cake.

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COMPARATIVE SOCIOECONOMIC ANALYSIS OF TEA MONOCROPPING AND INTERCROPPING SYSTEMS IN TARABA STATE, NIGERIA.

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ABSTRACT
Intercropping is the planting of two or more crops on a piece of land to maximise resources while mono-cropping is the planting of a single crop on a farm using the same resources that could have been used if more crops were planted in the same piece of land. This study compared the socioeconomic characteristics of farms and the cost and returns of farmers who practice tea mono-cropping and intercropping systems in Taraba state, Nigeria. The study was conducted in Kakara, Sabongari, Mayo kusuku and Nyiwa towns in Taraba state. The study was conducted in 2021. Two hundred and four tea farmers were purposively selected and information was collected using well structured questionnaires. Statistics and budgetary analysis were the analytical techniques used. All the farmers practising intercropping (100%) and majority who practice mono-cropping (93.1%) were males. Farmers that practise intercropping and mono-cropping systems are between age 31 and 60years. The mean age of farmers that practise intercropping was 39 years while the mean age of farmers that practise mono cropping was 47 years. Farmers that practise mono-cropping system are less educated compared to farmers that practise intercropping. There is no correlation between age of farmer, years of experience, age of farm and the cropping system the farmers practise. The total cost for tea intercropping and mono cropping systems were 2292355.26 naira and 670897.02 naira. The gross revenue for tea intercropping and mono cropping systems was 239192226 naira and 290699973 naira. The profit per farmer for tea intercropping and mono cropping systems was 2024785 naira and 3333668 naira. Tea intercropping system is more profitable than tea mono-cropping system in Taraba state Nigeria.

Keywords: *Intercropping, Mono-cropping, Profitability, Taraba state, Tea*.

INTRODUCTION

Farmers are faced with several problems and constraints as regard the resources available to them (Nyalugwe *et al*., 2022). Farmers have different options of cultivation but analyzing the costs and benefits of the different options will assist the farmers in choosing the most profitable cropping system. Farmers aim at achieving high productivity and this can be achieved when the yield obtained per unit land area is high. Intercropping is the planting of two or more crops on the same land simultaneously (Blessing *et al*., 2022; Gomez *et al*., 1983). Glaze-Corcoran *et al*., (2020) and Ekanayanke, (2003) explained that intercropping as well as crop diversification are some of the ways and means to improve and sustain productivity of lands. However, the adoption of intercropping system has numerous benefits which include good utilization of land, reduction of risk of dependence on a single crop (as the case of a monocropping system) to the provision of additional employment opportunities. Anjum *et al.* 2015 also theorized that we can have intercropping in the form of row, mixed, relay and strip intercropping. However, the annual plants can be intercropped, perennial plant can also be intercropped with annual plant and perennial plants can also be intercropped with perennial plants (Eskandrin *et al*., 2009). Also, relevant authors observed that for intercropping to be economically viable, it must have a proper selection of crops as well as good planting pattern (Rusinamhodzi *et al*., 2012). Hence there is need for the good selection of the intercrop plant. *Camella spp* also known as tea has two varieties which are China tea with the scientific name (*Camella sinensis* var. sinensis) and Indian tea (var. cassamica). Tea is an important crop and is regarded as one of the Kenya leading foreign exchange earners as compared with Nigeria. Despite its economic value, tea is a perennial crop with lifespan of over 50years and it is mostly cultivated on land which would have been be used for food crops and this calls for the need for tea plant to be intercropped with other suitable crops . Tea crop is also known to be a light humid, long and shade tolerant tree species.

Several researchers have contributed to the existing literature of the ways that intercropping has guaranteed yield stability. Blessing et al., 2022; Glaze-Corcoran *et al*., 2020 agreed that intercropping guarantees a higher crop output and improve farmers' production particularly that of the small-holders farmers, as the intercropping are not achieved by means of costly inputs. However, even though intercropping adds a great deal to the productivity of the farmers, it must also be played well in terms of the plant population, combination of crops, unless it would cause a great challenge to the farmers. Researchers like (Kanayanke 2000; Annon, 2000) have also focused on the types of crops that can be intercropped with Tea and such crops ranges from coconut, rubber, fruit trees, and beans, but with varying weather conditions as well as spacing. In the light of this, Anitha *et al*., (2001) also reported that there must be a minimum of 25 percent difference in duration of crops in order to have a yield advantages in intercropping system. Cero and Cero (2001) also theorized that intercropping is also essential for the improving and maintaining fertility of the soil, provided the intercropping is done with the proper cereal crop and tuber crop. Studies on intercropping in young tea plant (Barbra *et al*., 1982) was also carried out to determine the vegetable crops that are compatible for intercropping in young tea plants so as to yield great returns for the growers. Pypers *et al.*, 2011 then discovered that criteria for selecting the intercrops used in intercropping is that the root systems must be localized at a distant zone in order to take the advantage of more soil in different layers. However, there is lack of robust research on the intercropping of Tea, in the light of this, few research discovered that African night shade can be used as an intercrop for Camellia sinensis by adopting the Land Equivalent Ratio (LER) to derive the growth parameter as well as the physiological parameters of both the Tea plant and African night shade plant. It was discovered to be a good intercrop if proper and correct spacing could be maintained. Moreso, Peter Deegen (2005) revealed that rubber-tea intercropping has a greater land expectation value (LEV) than the monoculture of tea and the monoculture of rubber but it require more labour and more management practices. The study also evaluated the economic analysis of the tea intercropping with the use of NPV, Land Expectation Value as well as the Faustmann model. Several empirical studies of intercropping of temperate crops was majored"on the soil microclimate characterization and not on within- canopy microclimate". Even though, several studies have affirmed that intercropping helps to make good use of the available materials like space, light and nutrient (Ndakidemi, 2006). However, the global trend in agriculture is to look for highly environmental friendly cropping system and this is giving rise to more interest in cropping system research (Crew and Peoples, 2004). In a study carried out by (Gebru 2015; Wiley (1987), intercropping and mono-cropping was compared using the land equivalent ratio, concepts of unit of productivity, valuation of relative unit as well as crop requirement and it was discovered that intercropping is more better than that of the mono-cropping in those context. Wu *et al*. (2021) compared metabolic mechanism of tea mono-cropping and tea intercropped with Chinese chest nut. They found out that green tea from the Chinese- tea intercropping system founded in the 1980s was rated highest as compared with mono tea plantation in the same region. In the study based on the non-targeted metabolomics considered, 100 differential metabolites were up-regulated in the tea leaves from intercropping system relative to monoculture system. Twenty-one amino acids were up-regulated and three down regulated in response to the intercropping based on the targeted metabolomics; half of the up-regulated amino acids had positive effects on the tea taste. Levels of allantoic acid, sugars, sugar alcohols, and oleic acid were higher and less bitter flavonoids in the intercropping system than those in monoculture system. The up-regulated metabolites could promote the quality of tea and its health-beneficial health effects. Flavone and flavonol biosynthesis and phenylalanine metabolism showed the greatest difference. Numerous pathways associated with amino acid metabolism altered, suggesting that the intercropping of Chinese chestnut–tea could greatly influence amino acid metabolism in tea plants. Results from the study demonstrated that there is great potential to improve tea quality at the metabolomic level by adopting an intercropping system. Objectives: To compare the socio economic characteristics of farmers that practice tea mono-cropping and intercropping. To estimate the cost and returns of tea mono-cropping and intercropping

METHODOLOGY

Study Area is Taraba in North Eastern Nigeria.: The study was conducted in Kakara, Sabongari, Mayo kusuku and Nyiwa towns in Taraba state in 2021. Tea is mostly produced in Taraba State. Simple random technique was used to select tea farmers in the study area. Information was obtained from the respondents using well structured questionnaire. Two hundred and four copies of questionnaire were distributed, received back and used for analysis. Eighty seven farmers practised mono-cropping system while one hundred and seventeen farmers practised intercropping system.

Analytical Techniques: Descriptive Statistics, budgetary analysis and linear regression was used in this study.

1. Descriptive statistics: This involves the use of percentages, frequency and mean.
2. Budgetary analysis:

Total Cost (TC) = Total Fixed Cost (TFC) + Total Variable Cost (TVC)……....

(i) Gross Revenue (GR) = Total Output (Total number of tons of kolanut sold) X unit price………………………

(ii) Gross Margin (GM) = GR – Total Variable Cost (TVC) ………….

(iii) Net Income (NI) = GR – Total Fixed Cost (TFC) …………………………

(iv) Total Cost(TC) = TVC + TFC ....

(v) Profit(P) = GR- Total Cost (TC) ....

(vi)

RESULTS AND DISCUSSION

The socio economic characteristics of Tea intercropping and Mono-cropping farmers are as shown in table 1. Tea Farmers that practise intercropping and mono-cropping are mostly in Kakara and Nyiwa towns in Taraba state. Majority of the farmers whether practising intercropping (100%) or mono-cropping (93.1%) are males. Farmers that practise intercropping and mono-cropping systems are majorly middle aged (31-60years). The mean age of farmers that practise intercropping was 39years while the mean age of farmers that practise mono cropping was 47years. Majority of the farmers that practise mono-cropping (93.1%) and intercropping(76.9%) are married. For farmers that practise intercropping 30.8% have no formal education, 20.5% have primary education, 25.6% have secondary education while 23.1% have tertiary education. Farmers that practise mono-cropping 51.7% have no formal education, 20.7% have primary education, 10.4% have secondary education while 17.2% have tertiary education. Farmers that practise mono-cropping system are less educated compared to farmers that practise mono-cropping. Mono-cropping farmers have a higher percentage of members with no formal education. Intercropping farmers have a higher percentage of members with secondary (25.6%) and tertiary (23.1%) education. This may be one of the reasons why they adopted intercropping system instead of mono-cropping. Intercropping system helps them to maximise their farm resources. Fifty four percent of farmers that practise intercropping belong to a cooperative society while 51.7% of farmers that practise mono cropping do not belong to a cooperative society. If farmers that practise mono cropping belong to a cooperative society could have been able to engage with other tea farmers and perhaps know the importance of intercropping system. Eighty five percent of farmers that practise intercropping system plant between 1 and 3 crops. About 15% planted more than three crops. Ninety five percent of farmers that practise intercropping system cultivate ≤ 2 hectares while 72% of farmers that practise mono cropping cultivate ≤ 2 hectares. The mean age of farm used for intercropping system is 30years while that of mono cropping system is 22years. The mean years of experience of farmers that practise intercropping system is 23 years while the mean years of experience of mono cropping system is 21years.

Correlation between the socio-economic characteristics of farmers and tea cropping systems.

Table 2 presented the correlation between socio-economic characteristics and tea cropping systems

Age of farmer: The calculated chi^2 of 2.4286 is lower than the tabulated chi^2 of 3.84 at 1 degree of freedom and at 0.05 significant level. Therefore, the null hypothesis which states that there's no significant relationship between the age of farmers and the cropping systems they practice is accepted. Hence, there's no significant relationship between the age of farmers and the cropping systems they practice.

Marital status: The calculated chi^2 of 10.0799 is greater than the tabulated chi^2 of 3.84 at 1 degree of freedom and at 0.05 significant level. Therefore, the alternative hypothesis which states that there's significant relationship between the marital status of farmers and the cropping systems they practice is accepted. Hence, there's significant relationship between the marital status of the farmers and the cropping systems they practice.

Years of experience: The calculated chi^2 of 6.7451 is lower than the tabulated chi^2 of 7.82 at 3 degree of freedom and at 0.05 significant level. Therefore, the null hypothesis which states that there's no significant relationship between the years of experience of the farmers and the cropping systems they practice is accepted. Hence, there's no significant relationship between the years of experience of the farmers and the cropping systems they practice.

Educational level: The calculated chi^2 of 12.4509 is greater than the tabulated chi^2 of 5.99 at 2 degree of freedom and at 0.05 significant level. Therefore, the alternative hypothesis which states that there's significant relationship between the educational level of the farmers and the cropping systems they practice is accepted. Hence, there's significant relationship between the educational level of the farmers and the cropping systems they practice.

Age of farm: The calculated chi^2 of 13.5563 is greater than the tabulated chi^2 of 7.82 at 3 degree of freedom and at 0.05 significant level. Therefore, the alternative hypothesis which states that there's significant relationship between the age of farm and the cropping systems the farmer practices is accepted. Hence, there's significant relationship between the age of farms and the cropping systems the farmers practice in the farms. Table 3 presented the budgetary analysis of tea intercropping and mono cropping system. The Total Variable Cost for tea intercropping system is 565,555.77 naira while it is 534106.05 for tea mono cropping system. The Average Variable Cost/farmer for tea intercropping and mono cropping systems are 4833.81 naira and 6139.15 naira. The total fixed cost for tea intercropping and mono cropping systems are 1726799.49 naira and 136790.97 naira. The average fixed cost per farmer for tea intercropping and mono cropping systems are 14758.97 naira and 1572.31 naira. The total cost for tea intercropping and mono cropping systems are 2292355.26 naira and 670897.02 naira. The gross revenue for tea intercropping and mono cropping systems is 239192226 naira and 290699973 naira. The gross margin per farmer for tea intercropping and mono cropping systems are 2039544 naira and 3341379 while the profit per farmer for tea intercropping and mono cropping systems are 2024785 naira and 3333668 naira.

CONCLUSION

Intercropping system maximises the use of resources in crop production as compared to mono-cropping. Tea intercropping systems is more profitable than tea mono-cropping system. Therefore intercropping systems should be encouraged among tea farmers.

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Table 1: Socio economic characteristics of Tea intercropping and Mono-cropping system

	Tea	Intercropping	Tea	Mono-cropping
Variable	Frequency	%	Frequency	%
Town				
Kakara	75	64.1	36	41.4
Sabongari	3	2.6	3	3.5
Mayo kusuku	3	2.6	-	-
Nyiwa	36	30.8	48	55.2
Gender				
Male	117	100.0	81	93.1
Female	0	0	6	6.9
Age				
>30	21	18.0	12	13.8
31-60	84	71.8	60	69.0
>60	12	10.2	15	17.2
Mean age	38.9		47.6`	
Marital Status				
Single	24	20.5	6	6.9
Married	90	76.9	81	93.1
Divorced	3	2.6	-	
Educational Level				
No formal education	36	30.8	45	51.7
Primary	24	20.5	18	20.7
Secondary	30	25.6	9	10.4
Tertiary	27	23.1	15	17.2
Membership of Cooperative Society				
No	54	46.2	45	51.7
Yes	63	53.8	42	28.3
Number of Tea variety planted				
1-3	99	84.6	87	100.0
4-5	18	15.4	-	-
Number of crops intercropped with tea				
0	-	-	87	100.0
1	36	30.8		
2	39	33.3		
3	42	35.9		
Farm size(hectares)				
≤ 2	111	94.8	63	72.4
3-5	6	5.2	24	27.6
Age of farm				
0-10	9	7.7	-	-
11-20	42	35.9	45	51.7
21-30	48	41.1	36	41.4
31-40	15	12.8	6	6.9
>40	3	2.6	-	-
Mean	22.9		21.9	
Years of experience				
0-10	3	2.6	3	3.5
11-20	48	41.0	48	55.2
21-30	48	41.0	30	34.4
31-40	15	12.8	6	6.9
>40	3	2.6	-	-
Mean	23.1		21.3	
N	117		87	

Source: Field survey, 2021

Table 2: Relationship between the socio-economic characteristics of farmers and tea cropping systems

Variable	Mono-cropping	Intercropping
Town		
Kakara(111)	36	57
Sabongari(6)	3	3
Mayo kusuku(3)	0	3
Nyiwa(84)	48	56
Pearson chi^2 =14.3148 Pr=0.003		
Gender		
Male(198)	81	117
Female(6)	6	0
Pearson chi^2 =8.3135 Pr=0.004		
Age		
≤30years(33)	12	21
31-60years(144)	60	84
>60years(27)	15	12
Pearson chi^2 =2.4286 Pr=0.297		
Farm size		
≤ 2	63	84
3-5	25	33
Pearson chi^2 =4.8700 Pr=0.182		
Age of farm		
0-10(9)	0	9
11-20(87)	45	42
21-30(84)	36	48
31-40(21)	6	15
>40(3)	0	3
Pearson chi^2 =13.5563 Pr(0.009)		
Years of experience		
0-10	3	3
11-20	48	48
21-30	30	48
31-40	6	15
>40	0	3
Pearson chi^2 =6.7451 Pr=0.150		
Marital status		
Single (30)	6	24
Married (171)	81	90
Divorced (3)	0	3
Pearson chi^2 =10.0799 Pr=0.006		
Educational status		
No formal education	45	36
Primary	18	24
Secondary	9	30
Tertiary	15	27
Pearson chi^2 =12.4509 Pr=0.006		

Source: Field Survey, 2021

Table 3: Budgetary Analysis

		Tea Intercropping	Tea Mono-cropping
S/N	Item	Amount(Naira)	Amount(Naira)
1.	Total Variable cost	565,555.77	534106.05
2	Average Variable Cost/farmer	4833.81	6139.15
3	Total Fixed Cost	1726799.49	136790.97
4	Average Fixed Cost/farmer	14758.97	1572.31
5	Total Cost	2292355.26	670897.02
6	Average Total Cost/farmer	19592.78	7711.46
7	Gross Revenue	239192226	290699973
8.	Average Gross Revenue/farmer	2044378	3341379
9.	Gross Margin	238626648	290165880
10	Gross Margin/farmer	2039544	3335240
11.	Net Income	237465423	290563209
12.	Net Income/farmer	2029619	3339807
13	Profit	236899845	290029116
14	Profit/farmer	2024785	3333668

Source: Field survey, 2021

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GROWTH AND YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) AS AFFECTED BY DIFFERENT LEVELS OF AGROSOL FOLIAR FERTILIZER

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ABSTRACT
Agrosol fertilizer do not only improves the quantity and quality of agricultural products but also has no adverse residual effect on the soil and its products. A field experiment was conducted at Federal College of Agriculture, Moor plantation, Ibadan during the 2019 cropping season to determine the rate of agrosol fertilizer needed for optimal growth and yield of okra (*Abelmoschus esculentus* (L) moench). Okra variety NH4-45 was used for this experiment. Agrosol foliar fertilizer was applied at the rate of 0, 2.5, 7.5 and 10 in kg/ha to okra leaves at 2, 4 and 6 WAS. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. Two seeds of okra were sown at a spacing of 60x30 cm. Four plants were tagged in each plot for data collection at 3, 5 and 7 WAS. The parameter taken were plant height, number of leaves, leaf area, stem girth, number of fruit per plot and fruit weight. Data collected were subjected to analysis of variance using *SAS* package and significant means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability. The result of the study revealed that 5kg/ha of agrosol foliar fertilizer produced more fruit weight of 434.85 kg/ha significantly ($p \leq 0.05$) than those of 0, 7.5 and 10.5gk/ha levels of agrosol foliar fertilizer. The study recommends 2.5 kg/ha of agrosol foliar fertilizer which competes favourably in yield (396.01kg/ha) with the weight of yield obtained from 5kg/ha of agrosol foliar fertilizer application.

Keywords: *Agrosol fertilizer, foliar, variety, Abelmoschus esculentus*

INTRODUCTION

Crop production is exposed to new challenges: the use of bio fertilizer, conservation of resources, yield increase, quality improvement and healthy plant growth; all these features are encapsulated in Agrosol. Agrosol is a foliar applied inorganic fertilizer which not only improves the quantity and quality of agricultural products but also has no adverse residual effect on the soil and the products. Okra (*Abelmoschus esculentus* (L) *moench)* is valued for its edible green pods. The nutritional composition of okra includes calcium, protein, oil and carbohydrates, iron, magnesium and phosphorus (Omotosho and Shittu, 2007). They also reported that removal of the hulls by grinding and shifting produced a meal with 33% protein, 25% lipids and 6% ash. Okra seeds contain approximately 22% protein, 14% lipids, 30.81 carbohydrates and 27.30 crude fibre (Moyin –Jesu, 2007). Most okra is eaten in cooked or processed form and the young fruits may be eaten raw. Akinfasoye and Nwanguma (2005) noted that the oil in the seed could be as high as in poultry eggs and soybean. In Nigeria, the limiting factors in okra production and other vegetables among others include weed management, infertile soils, tillage practices, low yielding varieties and sub – optimal planting density (Adejonwo *et al.,* 1989; Burnside, 1993; Dikwahal *et al.,* 2006; Adeyemi *et al.,* 2008; Iyagba *et al.,* 2012). Fertilizer application among the various agronomic practices also influenced the growth and green pod yield in okra. Agrosol, a mixture of finely ground minerals containing a high concentration of CO_2 consist of composition of several rock types (www.agrosoil.eu, 2012). (Accessed 2019). When applied to both sides of plants leaf via a fine spray mist, agrosol enters the leaf via the stomata. As soon as it penetrates into the plant, its individual components induce a decomposition process which slowly but constantly releases CO_2 thus setting up an even CO_2 supply inside the plant. It therefore supplies the plant internal tissue with sufficient amount of CO_2. The results being that the plants ability to "breathe" is optimized with the side effect of less water being lost via transpiration. This increases the plant resistance to drought stress. The production of glucose and protein is enhanced leading to improved plant growth. In addition, and as a consequence the plant releases higher level of oxygen thus promoting the "green lung" effect. Its pH has no relevance with that of the soil because it is absorbed through the leaves and its effect takes place within the leaves. Therefore, the pH of the soil has no influence on its effectiveness. The overall benefit is better root growth (especially deeper, denser, more complex rootage), stronger more stable stalk development (cereal) and increase leaf mass (www.agrosoil.eu, 2012). The rate of application of agrosol depends on the type of crop. For most vegetables, the standard rate is 7.5 kg/ha applied at 14 day interval and each application amounting to 3.0 kg/ha (www.agrosolution.eu, 2012). Agrosol, the "pure plant energy" is already well established and renowned in countries like Germany and Australia. However, there is scarce information on the use of bio fertilizers like agrosol in Nigeria especially on crops like okra hence the objectives of this study were to:

i. determine the effect of different levels of agrosol foliar fertilizer on the growth of okra.
ii. determine the rate of agrosol foliar fertilizer needed for optimum production of okra in the study site.

MATERIALS AND METHODS

A field experiment was conducted at Federal College of Agriculture, Ibadan, South West Nigeria (Latitude 7^0 $22^{''}$N; Longitude 3^0 $58^{''}$E and 275 m above sea level). The experiment was carried out in 2018 cropping season. After land preparation by ploughing and harrowing, the plot was marked out and site laid out in a randomized completely block design with five treatments replicated three times. The experimental site was 12x11m while the plot size was 3 x 2 m with 0.5 m between plots and 1m between replicates. The treatments consist of five levels of agrosol fertilizer which are 0, 2.5, 5.0, 7.5 and 10 in kg/ha. The various levels of agrosol were applied at 2, 4 and 6 weeks after sowing. Okra variety NH4-45 was used for this experiment. Two seeds were sown per hole to give a population of 66,667 plants per hectare. The various levels of agrosol were applied at 2, 4 and 6 weeks after sowing on both sides of the okra leaves. Thinning were carried out at 2 weeks after sowing to maintain the population desired. Weeding was also carried out with hoe once weeds were seen. Five plants were randomly sampled and tagged for observation of growth and yield parameters at 3, 5 and 7 weeks after sowing i.e. a week after each application of the agrosol fertilizer. The parameters taken were: plant height, number of leaves, leaf area, stem girth, number of fruits and weight of fruits. Data collected were statistically analyzed using ANOVA to test the level of significance of treatments on the measured parameters and the significant means were compared and separated using Duncan Range Multiple Range Test (DRMRT) at 5% level of significance.

RESULTS AND DISCUSSION

The nutrient composition of agro sol is seen on table 2 while the result of the pre planting soil showed that the soil is slightly acidic pH 6.22, total nitrogen and carbon were low while available phosphorus was moderate and exchangeable bases are low (table 1). Hence the soil needs more nitrogen for the production of the test crop

Effects of agrosol fertilizer on plant height (cm), stem girth (cm) and number of leaves of okra.

The result showed that the treatments did not exert any significant effect on plant height and number of leaves of okra plant throughout the period of observation. (table3).

Effects of agro sol fertilizer on leaf area (cm^2), number of okra fruits and weight of fruits (kg)

Treatment effect was observed on leaf area of okra at 3 and 7 WAS (table4). At 3WAS, okra plant that received 2.5 kg/ha of agro sol fertilizer had leaves which were significantly wider *($p \leq 0.05$)* (138cm^2) than those treated with 7.5 kg/ha but were statistically the same with those treated with 0, 5.0 and 10kg/ha. Okra plants that received 7.5kg/ha of agrosol were statistically similar to those that received 0 and 10kg/ha of agrosol. The reason for this irregularity could be because the crops were still growing hence treatment effect was not really evident at this period. At 7WAS however, okra plants that received 5kg/ha had leaves which were significantly wider than others (380cm^2) while those of zero treatment had the lowest value. This could be because, with 5kg/ha of agrosol, sufficient CO_2 is released within the leaves of the plant for more vigorous growth and according to Harker and Hartmer, (2013) there is increased chlorophyll intensity with better root anchorage and higher level of photosynthetic activity which was able to support the leaves hence wider leaves results.

Treatment effect on number and weight of fruits : Agrosol effect on number of okra fruit harvested per plot showed that the plot that received 2.5kg/ha had fruit whose number were statistically the same with those that received 5kg/ha of agrosol but the two were significantly higher in number than others (table5.) Treatment effect was also observed on okra fruit weight. At first harvesting, crops that received 10kg/ha had significantly low fruit weight while the one that received 7.5kg/ha with 87.5 kg were significantly similar to those of 5 and 2.5 kg/ha but significantly higher in weight than those that received 0 and 10kg/ha of agrosol. At second harvesting however, okra plants that received 2.5kg/ha had fruits whose weights were significantly higher than others except that of 5kg/ha. While at third harvesting, okra plants that received 5kg/ha of agrosol had the higher weight which although was statistically similar to those of 2.5kg/ha but was significantly higher *($p \leq 0.05$)* than others. Cumulative weight at harvesting also showed that okra plants that was treated with 5 kg/ha of agrosol fertilizer was not statistically different from those that received 2.5 kg/ha of agrosol fertilizer but they were significantly higher *($p \leq 0.05$)* in weight than those treated with 0, 7.5 and 10kg/ha levels of agrosol. This agrees with Harker and Hartmer, (2013) that agrosol increases photosynthetic activity in crops and thus help to increase yield of crop. This result underscores the fact that in as much as agrosol fertilizer is good for better growth and development of okra the quantity applied should however be regulated because, much of it (>7.5kg/ha) has no significant improvement on the performance of crop plant. (www.agrosolution.eu, 2012).

CONCLUSION AND RECOMMENDATION

The result from this study revealed that, 5kg/ha of agrosol foliar fertilizer produced okra leaves which are wider and 2.5 kg/ha of agrosol produced okra plants with more number of fruits significantly than those that received 0, 7.5 and 10 kg/ha of agrosol fertilizer. Similarly, 2.5kg/ha of agrosol produced okra plants that has the same weight with those of 5kg/ha but which were significantly higher in weight than others.

Therefore, this study recommends 2.5 kg/ha of agrosol foliar fertilizer for the optimum production of okra fruits.

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Table1. Physical and Chemical Properties of Pre Cropping Soil

Parameters	Values
pH	6.22
Total carbon g/kg	2.3
Total nitrogen g/kg	1.24
Available Phosphorus mg/kg	16.87
Exchangeable Cation cmol/kg	
Sodium Na+	0.49
Potassium K+	0.31
Calcium Ca2+	1.12
Magnesium Mg2+	1.03
Exchangeable acidity H+ (cmol/kg)	1.10
CEC (cmol/kg)	4.05
Particle size distribution (g/kg)	
Sand	824
Silt	92
Clay	84
Textural class	sandy loam

Table2. Nutrient composition of Agrosol foliar fertilizer

Nutrients	**Values**
pH	8.12
Organic N (%)	2.0
Total P (%)	4.0
Total K (%)	5.0
Sulfur (%)	20
Boron (%)	0.07
Carbon (%)	7.5

Table 3. Effect of Agrosol foliar fertilizer on plant height (cm) and stem girth of okra (cm)

Agrosol fertilizer	3WAS	5WAS	7WAS
Plant height (cm)			
0.0 kg/ha	14.2	16.73	34.95
2.5 kg/ha	13.92	16.95	36.75
5.0 kg/ha	13.25	16.54	38.00
7.5 kg/ha	13.58	15.87	32.38
10.0 kg/ha	12.46	15.43	33.53
	ns	ns	ns
Stem girth (cm)			
0.0 kg/ha	1.73	2.24	4.49
2.5 kg/ha	1.94	2.16	4.42
5.0 kg/ha	2.07	2.16	4.67
7.5 kg/ha	1.84	2.17	4.39
10.0 kg/ha	1.91	2.20	4.32
	ns	ns	ns

ns = not significant

Table 4. Effects of Agrosol foliar fertilizer of okra number of leaves and leaf area (cm^2)

Agrosol fertilizer	3WAS	5WAS	7WAS
Number of leaves			
0.0 kg/ha	7.08	7.41	7.91
2.5 kg/ha	7.16	7.45	8.25
5.0 kg/ha	6.91	8.08	9.08
7.5 kg/ha	6.50	7.33	8.75
10.0 kg/ha	7.58	7.91	8.83
	ns	ns	ns
Okra leaf area (cm^2)			
0.0 kg/ha	122.17^{b}	188.00	313.50^{c}
2.5 kg/ha	138.58^{a}	174.00	321.50^{bc}
5.0 kg/ha	131.08^{a}	199.00	380.00^{a}
7.5 kg/ha	122.75^{b}	168.00	324.58^{bc}
10.0 kg/ha	123.33^{ab}	184.00	343.00^{b}
	*	ns	*

Means followed by the same letter are not significantly different from each other at 5% level of probability using DMRT; ns = not significant

Table 5. Effects of Agrosol foliar fertilizer on number of fruit and weight of okra fruits

Agrosol fetilizer	1st harvesting	2nd harvesting	3rd harvesting	Cumulative
Number of fruits				
0.0 kg/ha	7	10	9	26^{c}
2.5 kg/ha	6	14	15	35^{a}
5.0 kg/ha	6	15	13	34^{a}
7.5 kg/ha	6	11	12	29^{b}
10.0 kg/ha	4	12	13	29^{b}
	ns	ns	ns	*
Weight of okra fruits (kg/ha)				
0.0 kg/ha	77.19^{b}	84.3^{c}	84.54^{c}	246.06^{c}
2.5 kg/ha	86.2^{a}	166.2^{a}	143.64^{ab}	396.01^{a}
5.0 kg/ha	89.8^{a}	162.4^{a}	182.6^{a}	434.85^{a}
7.5 kg/ha	87.8^{a}	121.74^{b}	130.76^{b}	370.30^{b}
10.0 kg/ha	61.7^{c}	122.8^{b}	129.77^{b}	314.17^{b}
	*	*	*	*

Means followed by the same letter are not significantly different from each other at 5% level of probability using DMRT; ns = not significant.

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