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Contents

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MECHANICAL TRANSMISSIBILITY EFFECT OF TELFAIRIA MOSAIC VIRUS (TEMV) AND CUCUMBER MOSAIC VIRUS (CMV) ON GROWTH AND NUTRITIONAL COMPOSITION OF *TELFAIRIA OCCIDENTALIS*

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ABSTRACT
Screenhouse potted experiment was conducted to determine the mechanical transmissibility effect of Telfairia mosaic virus (TeMV) and Cucumber mosaic virus (CMV) on the growth and nutritional composition of two *Telfairia occidentalis* cultivars. The experiment was a complete randomized design (CRD) with 6 treatments each replicated 5 times. Virus inoculation was done mechanically through sap extracted by homogenization from infected leaf tissues. Weekly data from 4 - 8 weeks after germination was collected on plant height, number of leaves per plant and number of leaves showing viral symptoms. The nutritional composition of leaf samples was determined using Association of Official Analytical Chemists (AOAC) 1990 methods. All collected data were subjected to analysis of variance and treatment means separated using the New Duncan Multiple Range Test at 5 % level of probability. The mechanical transmissibility of the viruses was successful with inoculated plants manifesting characteristic virus symptoms. Virus severity was significantly ($P \leq 0.05$) highest in Ugu-Ala cultivar inoculated with TeMV (17.3% - 31.5%). The tallest plants were Ugu-Elu cultivar inoculated with CMV (104.4 cm - 141.3cm) while Ugu-Ala cultivar inoculated with TeMV produced the lowest number of leaves (18.0 - 26.8). Nutritional composition study revealed that TeMV and CMV caused significant reductions in dry matter, ash, crude protein, crude fat and crude fiber contents compared to healthy controls. This stresses the need for management of viruses of *T. occidentalis* by use of resistant cultivars to improve production and enhance nutritional status.

Keywords *Cultivar, mosaic, proximate analysis, Telfairia occidentalis, pathogenesis*

INTRODUCTION

Telfaira occidentalis known as fluted pumpkin is a member of the family *Curcubitaceae* (Awodim, 2007). It originated from West Africa and is a popular vegetable all over Nigeria and found in the forest zones of west and central Africa, especially in Benin, Nigeria and Cameroun (Umekwe *et al.*, 2020). The crop is commonly called Ugu by the Ibos of South Eastern Nigeria (Olomola *et al.*, 2006). *Telfaira occidentalis* has inherent immense nutritional and medicinal values with the potentials of being used industrially as a food supplement (Kayode and Kayode, 2011). The leaves of fluted pumpkin are used in soups and porridges as the vegetative parts of the crop make an excellent vegetable rich in vitamin and contains 20.5 g proteins, 45 g fat, 23 g carbohydrate, 2.2 g fibre and 4.8 g total ash (Osadebe *et al*., 2015). The leaves also have medicinal values and are used for the treatment of anemia and diabetes (Akanbi *et al*., 2007). The tender vine and foliage are eaten as potherb, while the seed is consumed as a nut (Fashina *et al*., 2002). Pumpkin seeds are rich in antioxidants known to be effective in the prevention of cancer (Uusiku *et al*., 2010). It also helps in the improvement and maintenance of other associated health conditions like ulcer (Samson and Isaac, 2019). The anti-oxidant, anti-microbial and anti-plasmodic activity of fluted pumpkin has been reported (Okokon *et al*., 2009). The average yield of fluted pumpkin in Nigeria remains low due mainly to biotic and abiotic stresses (Times and Chikezie, 2016) and the biotic diseases are mostly viral in nature (Anno-Nyako, 1988). Three viruses, inducing mosaic-type symptoms, have been reported on fluted pumpkin in Nigeria. These include Telfairia mosaic potyvirus (TeMV), a Y-Strain of Cucumber mosaic cucumovirus (CMV) and a strain of pepper veinal mottle potyvirus (Atiri, 1986). However, while TeMV was reported to be extensively widespread, accounting for about 84% of the 16 farms and private gardens surveyed in southwestern Nigeria, the discovery

of both CMV-Y and PVMV-TYVC suggested the possible existence of other viruses inducing mosaic disease in fluted pumpkin (Shoyinka *et al.,* 1987). The characteristic symptoms mostly observed on fluted pumpkin plants infected with viruses include mosaic, necrosis, mottling leaf size reduction and in most severe cases plant death (Time and Chikezie, 2016). In Nigeria, the output of fluted pumpkin has not been able to meet the demand for human consumption. It is widely acknowledged that indigenous leafy vegetables have been grossly underutilized due mainly to limited knowledge on their nutritional values (Keatinge, 2012). Literature search revealed that limited studies have been undertaken to assess the status of virus infection in relation to the nutritional composition of fluted pumpkin. The present study was thus undertaken to determine the mechanical transmissibility and effect of Telfairia mosaic virus (TeMV) and Cucumber mosaic virus (CMV) on the growth and nutritional composition of two widely grown *Telfairia occidentalis* cultivars.

MATERIALS AND METHODS

Experimental site and Agronomic Practices: The experiment was conducted in the Screenhouse of the Faculty of Agriculture, University of Ilorin. It is located in the Southern Guinea savanna agro-ecology of Nigeria on latitude 8^0 26^1 N, longitude 4^0 29^1E, and about 344.7m above sea level (Aliyu *et al.,* 2012). The two fluted pumpkin cultivars used (Ugu-Ala and Ugu-Elu) were obtained from the National Seed Council office Ilorin - Nigeria. The viral inoculum Telfairia mosaic virus (TeMV) and Cucumber mosaic virus (CMV) were sourced from the stock in the Department of Crop Protection, Faculty of Agriculture, University of Ilorin-Nigeria. The experimental design was a Complete Randomized Design (CRD) using four-litre capacity plastic pots and a total of 30 pots. The pots were filled with sandy loam soil and cured organic manure incorporated into the soil and steam sterilized at 121^0C for 120 minutes and arranged in the screenhouse. The seeds were planted at the rate of two seeds per pot at the depth of 3 to 4cm with spacing of 1m x 1m between pots and later thinned to one plant per pot at 2 weeks after germination. Watering was done twice daily for the duration of the experiment.

Experimental treatments: The following were the experimental treatments that were each replicated five times:

T1 = Ugu-Ala cultivar inoculated with Cucumber mosaic virus
T2 = Ugu-Elu cultivar inoculated with Cucumber mosaic virus
T3 = Ugu-Ala cultivar inoculated with *Telfairia* mosaic virus
T4 = Ugu-Elu cultivar inoculated with *Telfairia* mosaic virus
T5 = Ugu-Ala cultivar not inoculated (control)
T6 = Ugu-Elu cultivar not inoculated (control)

Virus extraction and inoculation procedure: The extraction of virus inoculum was by homogenization from infected leaves using mortar and pestle in 0.05M Phosphate buffer at pH 7.2 at the rate of 1g leaf sample to 5 ml of buffer. The buffer was prepared in the following way: Solution A: 1.36 g KH2PO4 in 1000 ml H20 Solution B: 1.78 g Na2 V-P04 x 2 I-0 in 1000 ml H2O. 51.0 ml of solution B mixed with 49.0 ml of solution A gives 100 ml of 0.01 M phosphate buffer solution pH 7.2 (Noordam, 1973). The inoculation procedure was done mechanically through sap to test the infectivity of virus samples using local lesion hosts to propagate the viruses. The sap was applied by gently rubbing the surface of the youngest leaves (previously sprinkled with carborundum) with a cotton wool dipped in the sap. This was done at 2 weeks after germination of plants (Balogun, 2000).

Data collection: Data were collected from 4^{th} to 8^{th} week after germination (WAG) on the following parameters: plant height (cm), number of leaves per plant and number of leaves per plant showing viral symptoms. Disease severity was derived using a modified formula-grading scheme of Merritt *et al*. (1999) and was measured by the number of leaves with viral disease symptoms relative to the total number of leaves on any given plant and expressed as a percentage.

Sample preparation for nutritional composition: Enough leaf samples were harvested from each treatment at 8 WAG. The samples were thoroughly washed with water to remove dirt and other contaminants and were later oven dried at 40^0C for nutritional determination. The dried leafy vegetable samples were ground through a 1 mm sieve using a Thomas-WILEY model 4 Laboratory Mill before analysis. The nutritional composition of the samples was determined

using Association of Official Analytical Chemists (AOAC) 1990 methods.

Dry matter content determination: The dry matter content was determined by using the oven-dry method. 2.5 g of the samples was weighed into a porcelain dish and dried at 105^0C for 5 hours in the drying oven. After drying, the samples were cooled in a desiccator and weighed to constant weight. The dry matter content was expressed as a fraction of dry weight and presented as a percentage.

Ash content determination: About 2.5 g of the ground samples was weighed in porcelain dish with a known weight. The samples in the porcelain dishes were ignited in a muffle furnace at 500^0C for 2 hours to obtain a grey ash. The samples were cooled in a desiccator and weighed to constant weight. The ash content was expressed as a fraction of the sample on dry matter basis and expressed as a percentage.

Protein content determination: Crude protein was determined by using Kjeldahl method. 2.5 g of the sample was digested in 20 ml concentrated sulphuric acid using selenium tablet as a catalyst until the mixture turned colorless. The mixture was then diluted to 250 ml in a volumetric flask and 10 ml of the mixture was mixed with 20 ml of 40 % NaOH. The mixture was distilled to liberate ammonia into weak (4%) boric acid and the distillate was titrated against standard HCl using bromocresol green as an indicator. The calculated nitrogen content from the samples in percent was converted to crude protein by multiplying by a factor of 6.25.

Crude fat determination: Crude fat was extracted from the sample by using petroleum ether in a soxhlet extractor for 16 hours. 2.5 g of finely ground sample was put into a porous thimble in a soxhlet apparatus connected to a weighed 250 ml flat bottomed quick fit flask containing 200 ml petroleum ether. The solvent was continuously boiled at 40 to 60^0C extracting the fat from the sample. After 16 hours of extraction the petroleum ether was evaporated by using a rotary evaporator. The flask containing the crude oil was then dried to constant weight at 105^0C in the laboratory oven for 2 hours. The crude oil was calculated as the fraction of original dry weight of the sample expressed in percentage.

Crude fibre determination: 2.0 g of the sample was boiled in 150 ml of 0.128 M H_2SO_4 in a beaker for 30 minutes and the residues were filtered through fluted funnel and was washed three times with hot distilled water. The residues were further boiled in 0.125 M NaOH for another 30 minutes, filtered and washed with hot distilled water, followed by washing three times with acetone. The residues were oven dried at 105 °C to constant weight and then ashed at 500^0C for 2 hours. The ash was weighed and fibre content was expressed as a fraction of the difference between the weight of the residues and ash of dry weight sample and this was expressed as a percentage.

Statistical analysis: All collected data were subjected to analysis of variance (ANOVA) using the statistical package for the social sciences SPSS version 15.0. The treatment means where significant were separated using the New Duncan Multiple Range Test at 5 % level of probability.

RESULTS AND DISCUSSION

Effect of treatment on virus severity: The effect of treatment on virus severity from 4^{th} to 8^{th} WAG is indicated in Table 1. The result showed that TeMV and CMV were mechanically transmissible to the two *T. occidentalis* cultivars but rate of infection differed. The significantly ($P \leq 0.05$) highest severity was in Ugu-Ala cultivar inoculated with TMV (17.3% - 31.5%). This was followed by Ugu-Elu cultivar inoculated with TeMV (16.5% - 26.4%) and Ugu-Ala cultivar inoculated with CMV (15.8% - 24.4%). The lowest susceptibility was in Ugu-Elu cultivar inoculated with CMV (13.5% - 23.3%). The result suggests TeMV to be the more pathogenic of the 2 viruses and all of the cultivars showed susceptibility to the viruses. The finding confirms Shoyinka et al. (1987); Oliveira et al. (2002) and Zitikaitė et al. (2011) assertions that TeMV and CMV were potent threats to *T. occidentalis* existence capable of causing reductions in growth and yield potentials of susceptible fluted pumpkin varieties.

Effect of treatment on plant height: The effect of treatment on plant height showed that there were significant differences ($P \geq 0.05$) among the treatments from 4^{th} - 8^{th} WAG (Table 2). The significantly ($P \leq 0.05$) tallest in the virus inoculated treatment was Ugu-Elu cultivar inoculated with CMV (104.4 cm - 141.3cm). However, Ugu-Ala cultivar inoculated with TeMV had the significantly ($P \geq 0.05$) shortest plants (89.5 cm -104.1cm). It has been posited that viruses become of economic importance only when they cause some deviation from

normal growth of plant such as reduction in plant height (El-Dougdough *et al.,* 2007). It is therefore assumed that the interaction between the virus pathogens and the pumpkin cultivars led to substantial diversion of metabolites which negatively affected plant growth compared to control. This conclusion is in agreement with Rahman and Akanda (2010).

Effect of treatment on number of leaves: The number of leaves per plant showed noticeable significant ($P \leq 0.05$) difference between the treatments from the 4^{th} to the 8^{th} week after germination (Table 3). The virus inoculation regime was most potent on Ugu-Ala cultivar inoculated with TeMV with the significantly ($P \leq 0.05$) lowest average number of leaves per plant (18.0 - 26.8). Conversely, the significantly ($P \leq 0.05$) highest average number of leaves per plant for virus inoculation was Ugu-Elu cultivar inoculated with CMV (22.0 – 34.0). This was followed by Ugu-Ala cultivar inoculated with CMV (21.3 – 31.5) and Ugu-Elu cultivar inoculated with TeMV (19.8 – 30.5). The reduction in number of leaves in virus inoculated plants compared to the control is disturbing because of the significance of leaves in plant physiology. The smaller the number of leaves per plant, the smaller the leaf surface area for harvesting light energy. The drop in the number of leaves produced by TeMV and CMV inoculated plants can therefore be linked directly to susceptibility to the inoculated viruses. The observed sequence is in agreement with reports of Pawar *et al.* (1990) and Mofunanya *et al,* (2020).

Nutritional composition : The nutritional composition study revealed that TeMV and CMV infection of Ugu-Elu and Ugu-Ala cultivars caused significant reductions ($P \leq 0.05$) in dry matter, ash, crude protein, crude fat and crude fiber contents when compared to the values obtained for the healthy controls (Table 4). Dry matter composition was 16.1% (Ugu-Ala cultivar inoculated with TeMV); 17.1% (Ugu-Elu cultivar inoculated with TeMV); 20.0 % (Ugu-Ala cultivar inoculated with CMV) and 21.9% (Ugu-Elu cultivar inoculated with CMV). These values were significantly ($P \leq 0.05$) lower compared with those of the controls (34.3% and 34.6%). The finding is in consonance with reports by Mariscal *et al*. (2002) which showed a negative correlation between virus severity and dry matter content. Ash profile is a measure of the nutritionally important mineral contents present in vegetables. The nutritional analysis in the study indicated that ash content was significantly ($P \leq 0.05$) low in Ugu-Ala cultivar inoculated with TeMV (7.6%) and Ugu-Elu cultivar inoculated with TeMV (7.9%) as compared to controls. This finding is a signal to the depletion of very essential minerals in virus infected treatments. This statement corresponds to previous reports of Afreen *et al*, (2011). Significant reductions in protein content have been reported in virus susceptible cultivars (Carvalho *et al*., 2006). In the present study, reduction in crude protein was also observed in virus inoculated cultivars. The lowest value of 3.8% was recorded in Ugu-Ala cultivar inoculated with TeMV. This value was significantly ($P \leq 0.05$) low compared with 8.0% in ugu-elu cultivar (control). Mofunanya *et al.* (2008) reported a decrease in the protein content to *T. occidentalis* inoculated with TeMV but Sahhafi *et al.* (2012) in another report observed that wheat varieties maintained higher protein content under mosaic virus infection. This is an indication that the amount of protein in susceptible varieties is a function of the host-pathogen relationship. The levels of crude fat significantly ($P \leq 0.05$) increased from 10.6 % in Ugu-Ala cultivar inoculated with TeMV to 14.8 % in Ugu-Elu cultivar (control). This pattern was also consistent with the values for crude fibre such that; significantly ($P \leq 0.05$) higher values were recorded in the experimental controls (3.8 % and 3.9 %) compared to virus treatments (2.8 %, 2.9 %, 3.0 % and 3.1 %). The significant reductions in fibre and fat observed in the present work correspond with findings by Mofunanya *et al*, (2008).

CONCLUSION

Telfairia mosaic virus (TeMV) and Cucumber mosaic virus (CMV) were mechanically transmissible by sap to Ugu-Elu and Ugu-Ala *T. occidentalis* cultivars. The reaction of the cultivars to the viral pathogens occasioned substantial reductions in growth and nutritional composition indicating their economic importance in vegetable production in Nigeria. This stresses the need for the use of virus-resistant *T. occidentalis* cultivars as practical means of managing viruses for improved production and enhanced nutritional status.

REFERENCES

Afreen, B., Gulfishan, M., Baghel, G., Fatma, M., Akil Khan, A. and Naqvi, Q.A. (2011). Molecular detection of a virus infecting

carrot and its effect on some cytological and physiological parameters. *African Journal of Plant Science,* 5: 407-411.

Akanbi, W.B., Adeboye, C.O., Togun A.O., Ogunride, S.O. and Adeyeye, S.A. (2007). Growth herbage, seed yield and quality of *Telfairia occidentalis* as influenced by cassava peel compost and mineral fertilizer. *World Journal of Agricultural Science,* 3(4): 508-516.

Aliyu, T.H., Balogun, O.S. and Gbadebo, F. M. (2012). Cowpea reaction to single and mixed viral infection with Blackeye cowpea mosaic virus and Cowpea yellow mosaic virus. *Agrosearch,* 12(2): 174 – 183.

Anno-Nyako, F.O. (1988). Seed transmission of Telfairia mosaic virus in fluted pumpkin (*Telfairia occidentalis* Hook F.) in Nigeria. *Journal of Phytopathology,* 121: 85-87.

AOAC. (1990). Official Methods of Analysis of the Association of Chemists. Analysis of the Association of Chemists, Washington, DC., pp: 223-225, 992-995.

Atiri, G.I. (1986). A disease of fluted pumpkin (*Telfairia occidentalis* Hook. F.) caused by a yellow vein clearing strain of pepper veinal mottle virus in Nigeria. *Journal of Plant Protection in the Tropics,* 3: 105-110.

Awodim, M.A. (2007). Effect of poultry manure on the growth, yield and nutrient content of fluted pumpkin (*Telfairia occidentalis* Hook F.). *Asian Journal of Agricultural Research,* 1(2): 167-73.

Balogun, O.S. (2000). Studies on host-pathogen interactions in tomato under mixed infections with potato X potexvirus and tobacco mosaic tobamovirus. A doctoral dissertation submitted to Tokyo University of Agriculture and Technology Japan for the award of Ph. D in Biological Production (Phythopathology) 174 Pp.

Carvalho, D.D., Ferreira, R.A., Oliveira, L.M.D., Oliveira, A.F.D. and Gemaque, R.C.R. (2006). Proteins and isozymes electroforesis in seeds of *Copaifera Langsdorffii* Desf. (*Leguminosae caesalpinioideae*) artificially aged. *Revista Árvore*, 30: 19-24.

El-Dougdoug, K.A., Mohamed, H. and Abo-Senna, A. (2007). Effect of PVY viral infection on alkaloid contents of cultivated medicinal plants. *Journal of Applied Science Research*, 3: 558-563.

Fashina, A.S., Olatunji, K.A. and Alasiri, K.O. (2002). Effect of different plant populations and poultry manure on the yield of Ugu (*Telfairia occidentalis*) in Lagos State Nigeria. Proc. of Annual conference of Horticultural Society of Nigeria.

Kayode, A.A.A. and Kayode, O.T. (2011). Some Medicinal Values of *Telfairia occidentalis*. *American Journal of Biochemistry and Molecular Biology,* 1(1): 30-38.

Keatinge, D. (2012). Vegetables: Less visible but vital for human health-why nutrient-dense indigenous vegetables must be on the plate for economic development food security and health. AVRDC News Brief, 31 May2012.

Mariscal, A.M., Bergantin, R.V. and Troyo, D.A. (2002). Cassava Breeding and varietal release in the Philippines. Asia-cassava workshop. PDPF p. 42.

Merritt, R., Nelson, T. Orum, V. and Ramon, J.G. (1999). Application of geographic information systems and geostatistics in plant disease epidemiology and management. *Plant Disease,* 83(4): 308-319.

Mofunanya, A.A.J., Omokaro, D.N., Owolabi, A.T. and Ine-Ibehe, N.E. (2008). Effect of Telfairia mosaic virus (TeMV) on the proximate, mineral and antinutritive contents of *Telfairia occidentalis* (fluted pumpkin). *Nigerian Journal of Botany,* 21: 304-315.

Mofunanya A. A. J., Ogar, V.B., Oni, J.O., Omara-Achong, T.E. and Akomaye. F.A. (2020). Growth and yield assessment of *Sphenostylis stenocarpa* affected by virus infection. *Iranian Journal of Plant Physiology,* 11(1): 3433-3441.

Noordam, D. (1973). Identification of plant viruses: Methods and experiments. Center for Agricultural Publishing and Documentation, Wageningen, Holland.

Okokon, J.E., Ekpo, A.J. and Eseyin, O.A. (2009). Evaluation of in vivo antimalarial activities of ethanolic leaf and seed extracts of *Telfairia occidentalis*. *Journal of Medicinal Food,* 12: 649-653.

Oliveira, V.B., Queiroz, M.A. and Lima, J.A.A. (2002). Fontes de resistência em melancia aos principais potyvirus isolados de cucurbitáceas no nordeste Brasileiro. *Horticultura Brasileira*, 20: 589-592.

Olomola, A., Nwadike, C. and Ogieriakhi, A.S. (2006). The effect of organic and inorganic fertilizers on the growth and yield of fluted

pumpkin. Proc. of the 35th Annual Conference of the Botanical Society of Nigeria. University of Uyo. Pp. 20-24.

Osadebe, V.O., Echezona, B.C. and Bakare, S.O. (2015). Effect of weed control treatments and cutting frequency on weed dry matter and biomass in relation to the growth and yield of fluted pumpkin (*Telfairia occidentialis* Hook F). *Agro-Science Journal of Tropical Agriculture, Food Environment and Extension,* 14: 1-8.

Pawar, P.S., Garud, T.B. Mali, V.R. and Choudhari, S.D. (1990). Effect of Sorghum Red Stripe Virus (SRSV) on leaf chlorophyll and sugar content of stalk juice in different genotypes of sorghum. *Indian Phytopathology,* 43: 345-348.

Rahman, M.S. and Akanda, A.M. (2010). Effect of PLRV infected seed tuber on disease incidence, plant growth and yield parameters of potato. *Bangladesh Journal of Agricultural Res*earch, 35: 359-366.

Sahhafi, S.R., Bagheri, F., Assad, M.T., Masumi, M, and Talebi, M. (2012). Evaluation of some biochemical responses in resistance of fifteen bread wheat (*Triticum aestivum* L.) genotypes to Wheat streak mosaic virus. *Journal of Agricultural Science,* 4: 75-82.

Samson, I.I. and Isaac, O. (2019). Haematology and comparative study of fluted pumpkin leave vegetable and seed nutrients *(Telfairia occidentalis)*. *Archive of Nutrition and Public Health*, 1(2): 1-6.

Shoyinka, S.A., Brunt, A.A., Lesemann, D., Thottappilly, G. and Lastra, R.J. (1987). The occurrence, properties and affinities of Telfairia mosaic virus, a poty-virus prevalent in *Telfairia occidentalis* (*Cucurbitaceae*) in South Western Nigeria. *Journal of Phytopathology*, 119: 13-27.

Times, I. and Chikezie, K.C (2016). Virus symptoms types associated with fluted pumpkin (*Telfairia occidentalis* Hook F.) in Benue State. *Journal of Applied Biosciences*, 106: 10279-10285.

Umekwe, P.N., Eneruvie, B.E. and Okpani, F.M. (2020). Effect of organic manure on the growth and yield of fluted pumpkin (*Telfairia Occidentalis* Hook F.) in Unwana. *World Journal of Innovative Research*, 9(5): 14-17.

Uusiku, N.P., Oelofse, A., Duodu, K.G., Bester, M.J. and Faber, M. (2010). Nutritional value of leafy vegetables of Sub-Saharan Africa and their potential contribution to human health: A Review. *Journal of Food Composition and Analysis*, 23: 499-509.

Zitikaitė, I., Staniulis, J., Urbanavičienė, L. and Žižytė, M. (2011). Cucumber mosaic virus identification in pumpkin plants. *Žemdirbystė Agriculture*, 98(4): 421-426.

Table 1: Effect of treatment on Virus severity

Treatment	Weeks After Germination				
	4	5	6	7	8
T1	15.8^{bc}	17.5^{bc}	19.0^{bc}	21.5^{bc}	24.4^{b}
T2	13.5^{b}	16.0^{b}	18.0^{b}	20.8^{b}	23.3^{b}
T3	17.3^{c}	20.8^{c}	22.5^{c}	25.3^{c}	31.5^{c}
T4	16.5^{c}	18.3^{bc}	19.8^{bc}	22.3^{bc}	26.4^{b}
T5	0.3^{a}	0.3^{e}	0.3^{a}	0.3^{a}	0.3^{a}
T6	0.3^{c}	0.3^{e}	0.3^{a}	0.2^{a}	0.2^{a}
SEM	1.359	2.676	1.986	2.269	2.668

Means within a column followed by the same letter(s) are not significantly different using the New Duncan Multiple Range Test at ($P \leq 0.05$).

Key: T1= Ugu-Ala cultivar inoculated with CMV, T2 = Ugu-Elu cultivar inoculated with CMV, T3 = Ugu-Ala cultivar inoculated with TeMV, T4 = Ugu-Elu cultivar inoculated with TeMV, T5 = Ugu-Ala cultivar not inoculated (control), T6 = Ugu-Elu cultivar not inoculated (control). SEM=Standard Error of Means

Table 2: Effect of treatment on Plant height

Treatment	Weeks After Germination				
	4	5	6	7	8
T1	103.2^{ab}	119.4^{c}	123.4^{c}	129.1^{b}	138.4^{c}
T2	104.4^{ab}	123.6^{d}	133.6^{c}	136.4^{b}	141.3^{d}
T3	89.5^{a}	91.2^{a}	96.9^{a}	99.3^{a}	104.1^{a}
T4	90.4^{a}	95.6^{b}	106.4^{b}	109.8^{a}	111.4^{b}
T5	120.0^{c}	138.8^{e}	148.1^{d}	151.2^{c}	156.9^{e}
T6	121.2^{c}	140.3^{e}	150.2^{d}	153.1^{c}	160.3^{e}
SEM	1.359	2.676	3.716	2.904	2.029

Means within a column followed by the same letter(s) are not significantly different using the New Duncan Multiple Range Test at ($P \leq 0.05$).

Table 3: Effect of treatment on number of leaves per plant

Treatment	Weeks After Germination				
	4	5	6	7	8
T1	21.3^{d}	24.4^{ab}	27.8^{abc}	30.3^{abc}	31.5^{b}
T2	22.0^{c}	26.8^{bc}	29.5^{abc}	31.0^{bcd}	34.0^{b}
T3	18.0^{a}	21.8^{a}	25.0^{a}	25.8^{a}	26.8^{a}
T4	19.8^{ab}	23.6^{ab}	26.8^{ab}	29.0^{ab}	30.5^{ab}
T5	26.3^{e}	29.0^{c}	30.0^{bc}	34.0^{cd}	38.5^{c}
T6	27.9f	30.2^{d}	32.3^{bc}	35.3^{d}	38.8^{c}
SEM	0.665	0.674	0.737	0.860	1.024

Means within a column followed by the same letter(s) are not significantly different using the New Duncan Multiple Range Test at ($P \leq 0.05$)

Table 4: Effect of treatment on nutritional composition

Treatment	NUTRITIONAL PARAMETERS				
	Dry Matter (%)	Ash (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)
T1	20.0^{b}	8.8^{b}	5.2^{c}	12.0^{b}	3.0^{a}
T2	21.9^{b}	9.0^{b}	5.7^{d}	12.1^{b}	3.1^{a}
T3	16.1^{a}	7.6^{a}	3.8^{a}	10.6^{a}	2.8^{a}
T4	17.1^{a}	7.9^{b}	4.2^{b}	10.8^{a}	2.9^{a}
T5	34.3^{c}	10.3^{c}	7.3^{e}	14.6^{c}	3.8^{b}
T6	34.6^{c}	10.7^{c}	8.0^{f}	14.8^{c}	3.9^{b}
SEM	0.495	0.248	0.241	0.224	0.437

Means within a column followed by the same letter(s) are not significantly different using the New Duncan Multiple Range Test at ($P \leq 0.05$)

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EFFECTS OF MINERAL FERTILIZERS ON THE PERFORMANCES OF SELECTED VEGETABLES GROWN IN SOILS FROM DIFFERENT LAND USE TYPES IN SOUTHWESTERN NIGERIA

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ABSTRACT
Vegetables are rich in several mineral nutrients, vitamins, anti-oxidants and dietary fibre. However, poor soil fertility may limit their production. Furthermore, their growth responses to external fertilizer input may be dependent on the type of soil on which they are grown. An experiment was, therefore, conducted between March and July, 2021, at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria, to determine the effects of nitrogen (For Amaranthus, Celosia and Corchorus) and NPK (For Okra) fertilizers on the performances of the aforementioned vegetables grown in soils from three previous land use types. The land use types, namely Arable field (S1), Cocoa plantation (S2), and Abandoned local soap production site (S3) were the main plot treatments while 0 (control), 30 and 60 kg N/ha (For Amaranthus, Celosia and Corchorus); and 0 (control), 45 and 90 kg NPK/ha (For Okra) formed the sub plot treatments arranged as 3 x 3 factorial in completely randomized design replicated three times. Data were collected on leaf production, plant height, fresh shoot and fruit weights. The data were subjected to analysis of variance and where F was significant; treatment means were separated using LSD at 5% probability level. Generally, soil from the cocoa plantation significantly influenced the best vegetative growth, fresh shoot and fruit weights of the selected vegetables compared with the other two land use types. Soil from the abandoned local soap production site had adverse effects on the performances of the selected vegetables. Irrespective of the land use types, application of mineral fertilizers enhanced the performances of the selected vegetables compared with the control. However, the optimum rate of the fertilizer required to enhance performances of the vegetables was dependent on the type of vegetable and land use type. Furthermore, for Amaranthus, 30 kg N/ha was sufficient to improve fresh shoot weight in land use types S1 (29.43 g/plant, 274.4% higher than the control) and S3 (25.37 g/plant, 130.2% higher than the control); further increase in fresh shoot weight at application of 60 kg N/ha was observed in land use type S2 (57.48 g/plant, 83.3% higher than the control). Vegetables should not be cultivated in abandoned local soap making sites while there is the need to select adaptable vegetables and appropriate external nutrient levels in either arable fields or cocoa plantations for sustainable vegetable cultivation.

Keynote: *Fresh shoot, fruit yields, land use types, mineral fertilizers*

INTRODUCTION

Indigenous African vegetables play a significant role in the food and nutrition security of the under-privileged in both urban and rural settings (Schippers, 1997). Many communities use vegetables as sources of energy, vitamins, dietary fibre and micro nutrients in their diets (Gravetti and Ogle, 2000). When picked fresh, vegetables can be used as greens in salads or blanched, steamed, boiled, and mixed with meat, fish, groundnut or palm oil. When cooked green, it can be used as a side dish in soups or as an ingredient in sauce and baby food (Grubben, 2004). Vegetables such as Amaranthus, Celosia, Corchorus and okra are of immense importance in the life of people. However, low soil fertility is one of the major problems which limit the production of vegetables (Ogbonna, 2008). The application of fertilizer is necessary for enhancing the soil nutrient status and increasing crop yield. Application of fertilizer to replace the lost nutrient in the soil is one of the strategies used by agriculturists to meet the demands of the ever-growing population (Adediran *et al.*, 2015). Vegetables have been reported to be well responsive to nutrient supply through organic manures and mineral fertilizers (Awodun, 2007). Land use is a term used to describe the specific activity that is carried out on a piece of land at any point in time. Land use therefore has a major effect on soil quality and its potential productivity (Tadele *et al.*, 2013).

Land use changes have significance in agriculture because they affect soil fertility and related properties, i.e., soil bulk density, soil organic carbon, total nitrogen, total phosphorus, and ultimately the value of ecosystem services (Wang *et al.,* 2009; Feng *et al.,* 2010). Soil nutrients play a critical role in sustaining soil quality, crop production and environmental quality in general (Ross *et al.,* 2008; Ma *et al.,* 2009). Soil nutrients are closely related to agricultural land use types and their associated management practices (Agbede, 2010; Wang *et al.*, 2010). This study was conducted to determine the effects of mineral fertilizers on the growth and yields of selected vegetables (Amaranthus, Celosia, Corchorus and okra) grown in soils collected under different land use types.

MATERIALS AND METHODS

Site Description: The experiment was carried out in a screen house in the Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria, between March and July 2021. Ogbomoso lies on latitude $8^0$10´ N and longitude $4^0$10´ E in the Southern Guinea Savanna agro-ecological zone of Nigeria.

Soil preparation and analysis: Surface soil samples (0 – 15 cm depth) were collected from arable land at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso and labelled "S1", and from Cocoa plantation in Obagun, Osun State, labelled as "S2" and on an abandoned soap production site in Inisha, Osun State, labelled as "S3". The soils were spread out to dry in the open air. The air-dried soils were passed through 0.5 and 2 mm sieves. Sub-samples were taken to the laboratory for physical and chemical analyses. The samples were analyzed for pH (1:2 soil:water ratio), particle size distribution (Gee and Bauder, 1986), total N using the micro Kjeldahl method (Bremmer and Molvaney, 1982) and exchangeable cations (K, Ca, Mg and Na). After extraction with 1N NH40AC (pH 7), K in the filtered extracts was determined with a flame photometer, whereas Ca, Mg and Na were determined with an atomic absorption spectrophotometer. Available P was determined by colorimetry using Bray 1 method (Bray and Kurtz, 1945).

Treatments and experimental design: For each vegetable, land use types, namely (S1 (soil from arable field), S2 (soil from cocoa plantation), and S3(soil from abandoned local soap production) were the main plot treatments while 0 (control), 30 and 60 kg N/ha (For Amaranthus, Celosia and Corchorus) and 0 (control), 45 and 90 kg NPK/ha (For Okra) formed the sub plot treatments arranged as 3 x 3 factorial in completely randomized design replicated three times.

Cultural practices, data collection and analysis: One hundred and eight polythene bags were filled with 7 kg soil each. The soils were from the different land use types. The soil was watered to field capacity prior to the day of sowing. The vegetable seeds were sown in each polythene bag. Thinning of plants to two per pot was done after emergence. The fertilizer treatments were applied two weeks after sowing (2WAS), about 5 cm away from the plants base in a ring form. Hand pulling of weeds and watering was done regularly. Data collection was carried out at 4 and 5 WAS on plant height, leaf count, and fresh shoot and fruit weights. Plant height was measured from the ground level to the tip of the terminal leaf with the aid of a measuring tape while leaf count was done by counting the number of fully opened leaves. The shoots of Amaranthus, Celosia and Corchorus were cut with sharp razor blade at the soil surface from each pot and weighed on electronic weighing balance. Data recorded were subjected to analysis of variance (ANOVA) using SAS statistical software (2009). Significant differences were assessed at 5% level of probability and the treatment means were separated using the Least Significant Difference procedure.

RESULTS

Soil properties: The soils from the arable field (S1) and cocoa plantation (S2) were slightly acidic (pH 6.36 and 6.66 respectively) while the soil from the abandoned local soap production site (S3) was alkaline (pH 8.01). S2 had higher organic carbon (36.11 g/kg) and nitrogen (2.92 g/kg) contents compared with S1 (14.69 and 1.48 g/kg respectively) and S3 (13.98 and 1.53 g/kg respectively). S3 soil had higher K, Ca and Mg contents than S1 and S2 soils (Table 1).

Leaf production: For *Amaranthus*, generally the number of leaves was not significantly affected by the land use types and fertilizer application. However, soil from cocoa plantation supported more leaf production (31) than soils from the other two land use types 22 and 28 for S1 and S3 respectively) and leaf number was highest

with 60 kgN/ha (31) followed by 30 kg N/ha (26) and the control (24) (Table 2). For Celosia, generally leaf production increased as N rate increased. Soil from cocoa plantation supported significantly higher leaf number (90) than soils from arable (65) and abandoned local soap production (59) sites. Similarly, application of 60 kg N/ha enhanced significantly higher leaf number (90) than the application of 30 kg N/ha (64) and the control (60) respectively (Table 2). For Corchorus, N rates did not significantly influence leaf number differently. Soils from the arable (40) and cocoa plantation (30) produced significantly more leaves than soils from abandoned local soap production site (7) (Table 2).

Plant height: Plant height of the selected vegetables varied significantly with land use types (Figures. 1-4). Generally, N fertilizer increased plant height compared with the control irrespective of the land use types. For *Amaranthus*, soil from cocoa plantation influenced significantly highest height (19.78 cm) followed by soil from the arable field (13.86 cm) which was significantly higher than the soil from the abandoned local soap production site (10.56 cm). However, the increase in plant height was more pronounced under the cocoa plantation soil than the soils from the other land use types. Application of 30 kg N/ha was optimum for plant height increment in the three land use types (Figure 1). For Celosia, plants grown in the arable soil were taller (38.11 cm) than those in the cocoa plantation soil (33.56 cm) while plants grown in soil from the abandoned local soap production site were the shortest (25.67 cm) (Figure 2). Application of 30 kg N/ha was optimum for plant height increment because at 60 kg N/ha there was decline in plant height irrespective of the land use types. For Corchorus, the influence of land use types and N fertilizer on plant height was similar to that of Celosia (Figure 3). For okra, whereas application of 45 kg NPK/ha was optimum to increase plant height in arable and abandoned local soap production land use types, application of 90 kg NPK/ha caused increase in height in cocoa plantation land use type (Figure 4).

Fresh shoot and fruit weight: Soil from cocoa plantation supported significantly highest fresh shoot weight of *Amaranthus* (45.43 g/plant) than soils from the arable (18.10 g/plant) and abandoned local soap production (19.84 g/plant) land use types which were not significantly different from each other. Nitrogen fertilizer improved fresh shoot weight compared with the control. However, except for the cocoa plantation land use type where fresh weight increase was observed even at 60 kg N/ha, fresh shoot weight decreased at that rate for the other two land use types (Table 3). For Celosia, generally shoot weight increased with increasing N rates in all the land use types. Soil from cocoa plantation supported significantly highest fresh shoot weight (93.99 g/plant) than soils from the arable (53.13 g/plant) and abandoned local soap production (45.60 g/plant) land use types which were not significantly different from each other (Table 3). Generally, the growth of Corchorus was very poor, particularly so in the abandoned local soap production land use type. Cocoa plantation land use type supported highest fresh shoot weight (16.22 g/plant) compared with arable (11.86 g/plant) and abandoned local soap production (0.62 g/plant). Application of N fertilizer had negative effect on fresh shoot weight of Corchorus except in the cocoa plantation land use type where 60 kg N/ha improved fresh shoot weight (Table 3). Fresh fruit weight of okra was significantly higher in cocoa plantation land use type (54.23 g/plant) than soils from the arable (32.37 g/plant) and abandoned local soap production (24.09 g/plant) land use types which were not significantly different from each other (Table 4). Whereas application of 45 kg NPK/ha was sufficient to increase fresh fruit weight in cocoa plantation land use type, further increase in fresh fruit weight was observed at 90 kg NPK/ha in the arable land use type. Fertilizer application had slightly negative effect on fresh fruit weight of okra in the abandoned local soap production land use type (9.8% and 20.97% reduction compared with the control for 45 and 90 kg NPK/ha respectively).

DISCUSSION

Various land use types in different locations has influenced crop production by imposing differences in soil physical and chemical characteristics by the various activities. The soils used in this study from the three land use types exhibited different physical and chemical properties. Whereas, organic carbon, nitrogen and silt contents were higher in the cocoa plantation soil compared with the arable and abandoned local soap production site soils, pH, Ca, Mg and K contents were higher in the abandoned local soap production site soil, while

the arable soil had the least value of pH and the basic cations. Variation in soil physical and chemical properties due to land use types had been reported by previous researchers (Duguma *et al*., 2010; Senjobi and Ogunkunle, 2011; Mulat *et al*., 2018). The low pH and basic cations in the arable soil may be due to continuous removal of basic cations (Ca, Mg and K) by harvested crops, which provide hydrogen ion to the soil. It may also be due to erosion and leaching of cations in cultivated soil as this process could be aggravated by intensive tillage, which in turn decreases soil pH. Other workers had reported lower soil pH values under cultivated lands as compared with uncultivated lands (Yimer, *et al*., 2007; Wasihun *et al*., 2015). Ufot *et al*. (2016) observed that soil under cultivation have low total nitrogen content as compared to uncultivated soils. The low soil organic carbon and total nitrogen observed in the cultivated arable soil , which are very crucial to soil quality in terms of productivity agrees with the report of Ogunjimi *et al*. (2017) who noted that these parameters were higher in uncultivated soil than cultivated soil. Irrespective of the land use types, application of mineral fertilizers enhanced the performances of the selected vegetables compared with the control. Inorganic fertilizers have been used to ameliorate the soil poor nutrient status (Masarirambi *et al*., 2011) owing to their rapid release of nutrients to crops and also due to their ease of handling (Adediran *et al*., 2015). Vegetables have been observed to respond well to nutrient supply through organic manures and inorganic fertilizers (Awodun, 2007; Kolawole *et al*., 2008). Eifediyi *et al*. (2013) reported significant increase in the growth parameters of *Corchorus olitorius* as the rate of mineral fertilizer increases. Makinde *et al*. (2010) observed increase in growth parameters of *Amaranthus cruentus* when both organo-mineral and inorganic fertilizers were applied. Similarly, growth parameters and dry matter of both *Corchorus olitorius* and *Celosia argentea* were improved with the application of organic manures and mineral fertilizers (Makinde *et al*., 2011). Adeyeye (2013) reported that poultry manure and urea application improved growth parameters and shoot dry matter of *Celosia argentea*. Fruit yield of okra (*Abelmuscus esculentus* L. Moench) increased with the application of NPK fertilizer (Obi *et al*., 2005; Kolawole *et al*., 2008).

The land use types affected the performances of the selected vegetables differently. Generally, soil collected from the cocoa plantation outperformed the soils from the other two land use types. The differences observed may be due to the soil properties of the land use types. Soil from the cocoa plantation had the highest organic carbon and nitrogen contents. The concentration of organic carbon influences the quality and productivity of the soil. Soil organic carbon also increases the fertility of the soil in terms of nutrient availability and biological function (Yihenew and Getachew, 2013). High organic carbon content may invariably lead to increased nitrogen mineralization. High organic matter may also maintain the soil pH. Soil pH manipulates the availability of essential nutrients which affect plant growth and soil quality as a whole (Mitiku, 2000). High organic matter in the soil may enhance the efficient use of N-fertilizer by the plant (Nyamangara *et al*., 2003). Differences in the performance of leafy vegetable in soils from land use types had been reported (Olaleye *et al*., 2008). The observation in this study that the optimum rate of the fertilizer required to enhance performances of the vegetables was dependent on land use type is in consonance with the report of Olaleye *et al*. (2008) who studied the interaction effect of land use type and N-fertilizer application on the performance of *Corchorus olitorius* and revealed that the application of 50 kgN/ha on the cocoa plantation soil gave the best performance in terms of growth parameters and fresh leaf yield.

CONCLUSION

In conclusion, the selected vegetables require application of external plant nutrient input for improved performance. However, the rates of fertilizer required vary for the selected vegetables. Generally, soil under the cocoa plantation which was more fertile supported superior performances of the selected vegetables. Soil from the abandoned local soap production site was not suitable for vegetable production.

REFERENCES

Adediran, O. A., Ibrahim, H., Tolorunse, K. D. and Gana, U. I. (2015). Growth, yield and quality of Jute Mallow (*Corchorus olitorius* L.) as affected by different nutrient sources. *International Journal of Agriculture*

Innovations and Research, 3(5): 2319 – 1473.

Adeyeye, A. S., Ogunwale, O. A. and Mofikoya, F. A. (2013). Growth, dry matter accumulation and shoot yield of *Celosia argentea* as affected by poultry manure and urea application. *International Journal of Agricultural Policy and Research*, 1(8): 210 – 215.

Agbede, T. M. (2010). Tillage and fertilizer effects on some soil properties, leaf nutrient concentrations, growth and sweet potato yield on an Alfisol in southwestern Nigeria. *Soil and Tillage Research*, 110(1): 25 – 32.

Awodun, M. A. (2007). Effect of goat manure and urea fertilizer on soil, growth and yield of okra. *International Journal of Agricultural Research*, 2(7): 632- 636.

Bray, R. H. and Kurtz, L. T. (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Science*, 33: 39 – 45.

Bremner, J. M. and Mulvaney, C. S. (1982). "Nitrogen total" in Methods of Soil Analysis Part 2

Duguma, L., Hager, H. and Sieghardt, M. (2010). Effects of land use types on soil chemical properties in smallholder farmers of central Ethiopia. Ekologia, 29(1): 1 – 14.

Eifediyi, E. K., Mohammed, K. O. and Remison, S. U. (2013). Influence of organo-mineral fertilizer (OMF) on the performance of jute mallow (Corchorus olitorius) in north central Nigeria. Nigerian *Journal of Agriculture*, Food and Environment, 9: 54 – 58.

Feng Xiaoming, Fu Bojie, Yang Xiaojun (2010). Remote sensing of ecosystem services: An opportunity for spatially explicit assessment. *Chinese Geographycal Sciences*, 20(6): 522 – 535.

Gravetti, L. E. and Ogle, M. B. (2000). Value of traditional foods in meeting macro and micro nutrient needs: The While Plant Connection. Nutrition Research Reviews, 13(1): 31 – 46.

Grubben, G. J. H. (2004). Amaranthus cruentus L. In: Grubben G, J. H. and Denton, O. A. (eds.), PROTA 2. Vegetables/L'egumes [CD-Rom]. PROTA, Wageningen, Netherlands, pp: 205 -213.

Kolawole, G.O., Olapade, A.O., Alade, C. B. and Olaniyi, J.O. (2008) Response of Okra (*Abelmoschus esculentus*) varieties to NPK fertilizer in the southern Guinea savanna of Nigeria. *Nigerian Journal of Horticultural Science*, 13: 99 – 108.

Ma, W. Q., Li, J. H., Ma, L. (2009). Nitrogen flow and use efficiency in production and utilization of wheat, rice, and maize in China. Agricultural Systems, 99(1): 53 – 63.

Makinde, E. A., Ayeni, L. S. and Ojeniyi, S. O. (2010). Effects of organic, organo-minaral and NPK fertilizer treatments on the nutrient uptake of Amaranthus cruentus (L.) on two soil types in Lagos. *Journal of Central European Agriculture*, 12: 114 – 123.

Makinde, E. A., Ayeni, S. and Makinde, S. O. (2011). Comparative effect of mineral fertilizers and organic manures on growth, nutrient content and yield of *Corchorus olitorius* and *Celosia argentea. Research Journal of Botany, 6(4): 150 – 156.*

Masarirambi, M. T., Mbokazi, B. M., Wahome, P. K. and Oseni, T. O. (2012). Effects of kraal manure application rates on growth and yield of wild okra (*Corchorus olitorius* L.) in a sub-tropical environment. Asian Journal of Agricultural Science, 4(1): 89 – 95.

McLean, E. O. (1982). "Soil pH and Lime requirement". Agronomy, 9: 199 – 223.

Mitiku, B. (2000). Study on some important physico-chemical characteristics of Gnaro plantation and natural Junipers forest soils, Borena, southern Ethiopia. M.Sc. Thesis, Alemaya University, Ethiopia.

Mulat, Y., Kibret, K., Bedadi, B. and Mohammed, M. (2018). Soil organic carbon stock under different Land use types in Kersa Sub Watershed, Eastern Ethiopia. African Journal of Agricultural Research, 13(24): 1248 – 1256.

Nyamangara, J., Berggstrom, L. F., Piha, M. I. and Giller, K. E. (2003). Fertilizer use efficiency and nitrate leaching in tropical sandy soil. Journal of Environmental Quality, 32: 599 – 606.

Obi, C. O., Nnabude, P. C. and Onucha, E. (2005). Effects of kitchen waste compost and tillage on soil chemical properties and yield of okra (*Abelmuscus esculentus* L. Moench). Soil Science, 15: 69 – 76.

Ogbonna, P. E. (2008). Effect of combined application of organic and inorganic fertilizers on fruit yield of eggplant (*Solanum melongena*). Proceedings of the 42nd Annual Conference of Agricultural Society of Nigeria (ASN) October 19 – 23 p. 236 25.

Ogunjinmi O. F., Kolawole G. O. and Oyeyiola Y. B. (2017). Soil fertility assessment and determination of potential ameliorants for an Alfisol under long-term continuous cultivation in southwestern Nigeria. Journal of Soil Science and Environmental, 8(9): 155 – 163.

Olaleye, A. O., Ndubuaku, U. M. and Dada, O. A. (2008). Comparative study of the performance of jute plant (*Corchorus olitorius* L.) on home garden soil, farmland and cocoa plantation soils as influenced by varying levels of N-fertilizer. Journal of Tropical Agriculture, Food, Environment and Extension, 7(1): 78 – 84.

Ross, S. M., Izaurralde, R. C., Janzen, H. H. (2008). The nitrogen balance of three long-term agroecosystems on a boreal soil in western Canada. Agriculture, Ecosystems and Environment, 127(3 – 4): 241 -250.

Schippers, R. (1997). Domestication of indigenous vegetables for sub-Saharan Africa: A strategy paper. African indigenous vegetables Workshop Proceedings, January 13 – 18, Limbe, Cameroon, pp: 125 – 135.

Senjobi, B. A. and Ogunkunle, A. O. (2011). Effect of different land use types and their implications on land degradation and productivity in Ogun State, Nigeria. Journal of Agricultural Biotechnology and Sustainable Development, 3(1): 7 – 18.

Tadele, A., Aemro, T., Yihenew, G. S., Birru, Y., Wolfgramm, B., and Hurni, H. (2013). Soil properties and crop yields along the terraces and toposequence of Anjeni watershed, Central Highlands of Ethiopia. Journal of Agricultural Science 5(2)

Ufot, U. O., Iren, O. B. and Chikere, N. C. U. (2016). Effects of land use on soil physical and chemical properties in Akokwa Area of Imo State, Nigeria. International Journal of Life Sciences 2(3): 273 – 278.

Wasihun, M., Muktar, M. and Teshome, Y. (2015). Evaluation of the effect of land use types on selected soil physico-chemical properties in Itang Ker Area of Gambella Regional State of Ethiopia. Journal of Biology, Agriculture and Healthcare, Evaluation 5(11):

Yihenew, G. S. and Getachew, A. (2013). Effects of different land use systems on selected physico-chemical properties of soils in northwestern Ethiopia. Journal Agricultural Science, 5: 114 – 117.

Yimer, F., Ledin, S. and Abdulakdir, A. (2007). Changes in soil organic carbon and total nitrogen contents in three adjacent land use types in the Bale Mountains, southeastern highlands of Ethiopia. Forest Ecology Management, 242(2 – 3): 337 – 342.

Table 1. Selected chemical and physical properties of surface (0 – 15 cm depth) soils collected from the different land use types

Soil properties	S1	S2	S3
pH: (H_2O)	6.36	6.66	8.01
Organic carbon (g/kg)	14.69	36.11	13.98
N(g/kg)	1.48	2.92	1.53
P (mg/g)	9.67	6.37	8.72
K (cmol+/kg)	0.205	1.453	2.072
Ca(cmol+/kg)	7.864	7.944	38.124
Mg (cmol+/kg)	1.082	1.343	6.620
Particle size distribution (g/kg)			
Sand	880	800	840
Silt	94	134	94
Clay	26	66	66
Textural class	Sandy loam	Sandy loam	Sandy loam

S1 = Arable land at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso
S2 =Cocoa plantation in Obagun, Osun State
S3 = Abandoned local soap production site in Inisha, Osun State

Table 2. Effect of nitrogen fertilizer levels on the number of leaves of selected vegetables grown in soils from different land use types at four weeks after planting in Ogbomoso, Nigeria

	Amaranthus				Celosia				Corchorus			
	Fertilizer rates (kg N/ha)				Fertilizer rates (kg N/ha)				Fertilizer rates (kg N/ha)			
Land use type	0	30	60	LUT mean	0	30	60	LUT mean	0	30	60	LUT mean
S1	17	25	25	22	48	60	87	65	47	44	28	40
S2	31	31	33	31	73	76	120	90	37	28	25	30
S3	23	24	36	28	56	58	63	59	7	7	6	7
Fertilizer mean	24	26	31		60	64	90		30	27	20	
$LSD_{(0.05)}$ LUT	ns				11.8				18.0			
$LSD_{(0.05)}$ Fertilizer mean	ns				15.6				ns			

S1 = Arable land at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso
S2 =Cocoa plantation in Obagun, Osun State
S3 = Abandoned local soap production site in Inisha, Osun State
LUT = Land use type

Table 3. Effect of nitrogen fertilizer levels on fresh shoot weight (g/plant) of selected vegetables grown in soils from different land use types in Ogbomoso, Nigeria

	Amaranthus				Celosia				Corchorus			
	Fertilizer rates (kg N/ha)				Fertilizer rates (kg N/ha)				Fertilizer rates (kg N/ha)			
Land use type	0	30	60	LUT mean	0	30	60	LUT mean	0	30	60	LUT mean
S1	7.86	29.43	17.02	18.10	44.40	56.15	58.84	53.13	13.48	12.57	9.54	11.86
S2	31.35	47.46	57.48	45.43	82.13	83.44	116.41	93.99	13.81	12.40	22.46	16.22
S3	11.02	25.37	23.13	19.84	43.25	39.98	53.58	45.60	0.78	0.60	0.50	0.62
Fertilizer mean	16.75	34.09	32.54		56.59	59.86	76.28		9.36	8.52	10.83	
$LSD_{(0.05)}$ LUT	11.7				13.5				7.6			
$LSD_{(0.05)}$ Fertilizer mean	12.7				9.8				ns			

S1 = Arable land at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso
S2 =Cocoa plantation in Obagun, Osun State
S3 = Abandoned local soap production site in Inisha, Osun State
LUT = Land use type
ns = not significant

Table 4. Effect of NPK fertilizer levels on fresh fruit weight (g/plant) of okra grown in soils from different land use types in Ogbomoso, Nigeria

Land use type	Fertilizer rate (kg NPK/ha) 0	45	90	Land use type mean
S1	19.35	33.12	44.63	32.37
S2	48.93	63.97	49.76	54.23
S3	26.85	24.22	21.22	24.09
Fertilizer mean	31.71	40.44	38.55	
$LSD_{(0.05)}$ Land use type	23.93			
$LSD_{(0.05)}$ Fertilizer mean	ns			

S1 = Arable land at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso
S2 =Cocoa plantation in Obagun, Osun State
S3 = Abandoned local soap production site in Inisha, Osun State

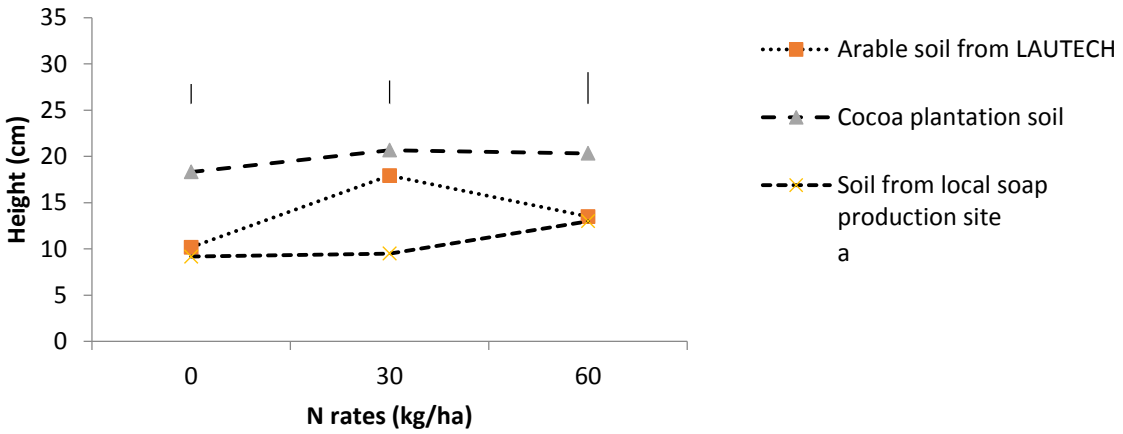

Fig. 1. Effect of land use types and urea fertilizer on the height of amaranth at 4 weeks after planting

Vertical bars represent $LSD_{0.05}$

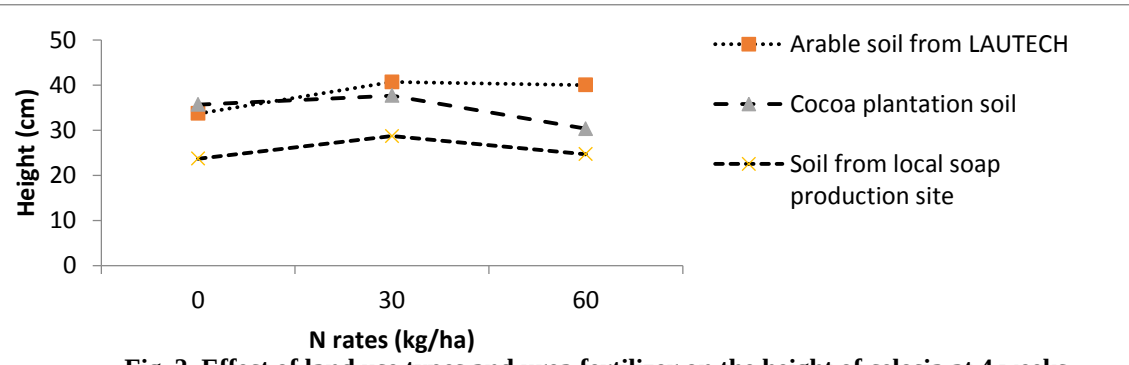

Fig. 2. Effect of land use types and urea fertilizer on the height of celosia at 4 weeks after planting

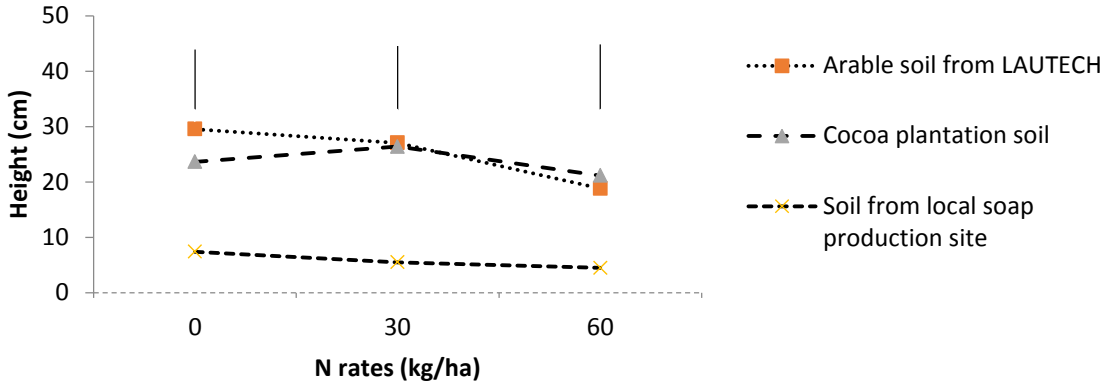

Fig. 3. Effect of land use types and and urea fertilizer on the height of cochorus at 4 weeks after planting

Vertical bars represent $LSD_{0.05}$

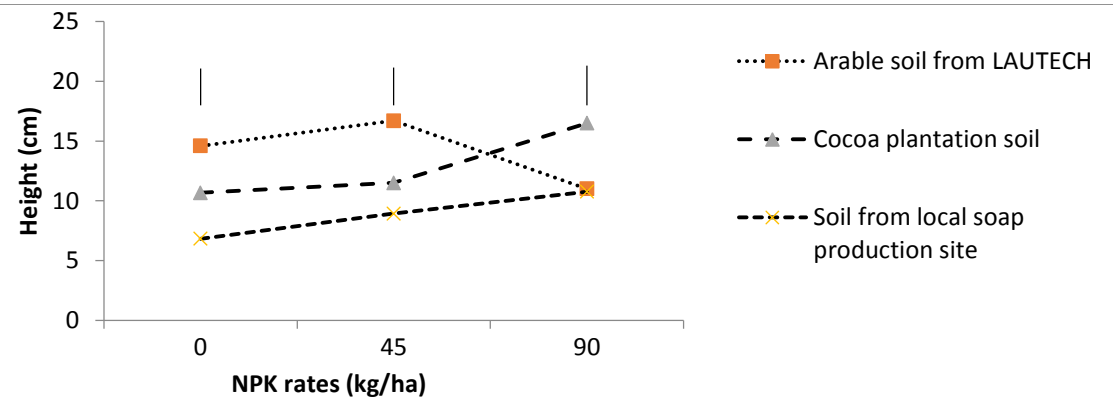

Fig. 4. Effect of NPK 15:15:15 fertilizer and land use types on the height of okra at 5 weeks after planting

Vertical bars represent $LSD_{0.05}$

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EFFECT OF ORGANIC FERTILIZER TYPES AND RATES ON EARLY GROWTH OF AFRICAN WALNUT (*PLUKENETIA CONOPHORA* MULL ARG*)*

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ABSTRACT
Plukenetia conophora is a multipurpose liana of high economic importance facing serious threat of extinction; therefore to curb this trend, producing healthy seedlings within good time frame is required. This research was therefore conducted to determine the effects of compost, poultry and cow dungs and their rates on growth and development of *P. conophora*. A total of 375 seedlings were applied three fertilizer types at 5 rates of 0ton/ha, 12.35ton/ha, 24.69ton/ha, 37.04ton/ha, 49.38ton/ha in 2kg polythene soil filled pots arranged in completely randomize design in five replicates with five seedlings per replicate. Data collected on length of liana, collar diameter, number of leaves, dry weight, leaf area, relative growth rates, absolute growth rates as well as net assimilation rate were subjected to descriptive analysis and ANOVA using SAS. Results showed that organic manure types had significant effects on plant collar diameter and leaf area. The manure rates had significant effects the on plants leaf area. The interactive effect of fertilizer types and rates showed that the highest leaf area of 127.01cm^2 was obtained with compost at 49.38ton/ha and followed by poultry waste at 49.38ton/ha while cow dung was at 37.04ton/ha. It was least for control with value of 99.45cm^2. It was concluded that types and rates of the organic manures enhanced the growth and development of *P. conophora* and were generally optimum at 49.38ton/ha.

Keywords: *Plukenetia conophora, organic fertilizer, growth rate,*

INTRODUCTION

Plukenetia conophora (Walnut), a multipurpose liana of high economic importance is valued for its seeds used as food, medicines and income generation. But as demand for its seeds is increasing, the supply of the seed from forest is threatened by increasing deforestation and unsustainable farming practices (Anegbe *et al.*, 2003). An overview of lost crops of Nigeria included *Plukenetia conophora* in the list of plants facing serious threat of extinction (Okafor 1991). Their gene pool is being eroded at an alarming rate; hence there is an urgent need for mass production of the seedlings with good vigour. The use of fertilizer for soil fertility improvement as well as increase in plant growth and yield has been in place for centuries. According to Stewart *et al.* (2005), addition of fertilizer to soil for the purpose of supplying nutrients do helps to contribute up to 40-60% yield increase. The quantity of fertilizer needed for any soil must be known because too little or too much fertilizer application has its detrimental effect(s) on plants grown (Blakesley *et al.*, 2000). According to Yisau *et al.*, (2020), seedlings of most native tree species still require the application of nitrogen, phosphorus and potassium from fertilizer for sustainable growth and production. Before the advent of chemical fertilizers, the use of organic fertilizers had been in place, the soil fertility is enhanced by animal wastes through their decomposition, thereby enriching the soil with organic matter, improves the soil's capacity to hold water and nutrients (Gaballah *et al*., 2010). Organic fertilizer is cheap, affordable and readily available to farmers. Enriching the soil with organic matter also improves soil structure and this in turn improves the soil's capacity to hold water and nutrients which are subsequently released to plant roots as needed. Organic fertilization improves soil yield, sustainability and accelerates microbial activities (Yüksek *et al*., 2019). On a general note, organic fertilizers are good soil conditioner (Aygün and Acar, 2004). Reports had indicated the usage of different organic fertilizer on the improvement of plants growth. Fagbayide and Adekunle, (2002) evaluated the influence of different levels of poultry manure on early growth of passion fruit (*Passiflora edulis Var Flavicarpa*) and observed a significant difference in growth over the

control on seedlings applied with different rates of poultry manure. Mahmound *et al.,* (2009) evaluated the effect of three compost types, plant residue, animal residue on cucumber, the result showed that composted organic wastes can be used to substitute for around 25% of chemical nitrogen fertilizer. Another studies carried out by Babalola, (2006) on fertilizer quality of composts made from various animal manures on the yield of okra and tomato showed that the growth of tomato consistently increased due to amendment with composted animal manure. The yield of okra also increased with application of swine manure (dung). The study on the effect of organic manures on the growth and dry matter yield of *Amaranthus cruentus* as investigated by Daramola *et al.,* (2006) indicated that application of the organic nitrogen sources gave taller plants, more profuse leaves, branches and shoot dry matter yield compared with the control. Since difference plant response differently to different fertilizer as well as their rates it is therefore pertinent to know the best manure and rate needed to produce good and vigorous seedlings of P. conophora in the nursery for plantation establishment. This study therefore investigates the effects of different levels of cow dung, poultry manure as well as compost on the growth and development of *P. conophora* with the view of producing vigorous seedlings for plantation establishment.

MATERIALS AND METHOD

Sources of organic manures and top soil used: The poultry droppings were collected from the poultry house at The Federal College of Forestry Ibadan, cow dung manure was collected from the abattoir at Bodija market in Ibadan. The compost manure was obtained from the Institute of Agriculture Research and Training (IAR&T), Ibadan. The collected manures were heaped and covered with polythene bags, allowed to cure for one month before usage. The topsoil was collected from Forestry Research Institute of Nigeria (FRIN) arboretum.

Experimental procedure: Three hundred and seventy five seedlings of *P. conophora* were selected from four weeks old stock-seedlings. To each 2kg capacity polythene soil filled pots, 0g, 10g, 20g, 30g, 40g (0ton/ha, 12.35ton/ha, 24.69ton/ha, 37.04ton/ha, 49.38ton/ha) of each organic fertilizer was applied to the corresponding labeled pots and each pot planted the seedlings of *P. conophora* and the pots arranged in completely randomized design with five replicates of five seedlings per replicate per treatment.

Data collection and analysis: The seedlings were allowed to adjust to the fertilizer treatment for two weeks before data collection commences. Data were collected fortnightly for 24 weeks on seedling height by the use of meter rule from the base of the plant to the tip, stem diameter with the used of digital veneer caliper and number of leaves by physical counting. Biomass assessment was carried out destructively on monthly basis for six months. The seedlings were carefully uprooted and the soils around the roots were washed, seedlings separated into roots, stem sand leaves and each placed in separate labeled sample bags weighed to determine the fresh weight and oven dried at 70^0C to a constant weight and weighed again to determine the dry weight. Data on dry weights were used to calculate the Relative Growth Rate (RGR), Absolute Growth Rate (AGR), and Net Assimilation Rate (NAR) based on the method described by Adewusi (1997) as follows:

1. Relative Growth Rate (RGR) = $\frac{lnW_2 - lnW_1}{T_2 - T_1}$ (g/*month*)
2. Net Assimilation Rate (NAR) = $\frac{W_2 - W_1}{A_2 - A_1} \times \frac{lnA_2 - lnA_1}{T_2 - T_1}$ (g/month)
3. Absolute Growth Rate (AGR) = $\frac{W_2 - W_1}{T_2 - T_1}$ (g/*month)*

A_1	=	Initial Leaf Area
A_2	=	Final leaf Area
W_1	=	Initial Dry Weight
W_2	=	Final Dry Weight
T_1	=	Initial Harvest Time
T_2	=	Final Harvest Time
In	=	Natural Logarithm (log l)

Data collected were subjected to descriptive statistics as well as analysis of variance (ANOVA) using SAS (2000).

Manure and soil analysis : The physical and chemical properties of the soil and three organic manures used were carried out (Tables 1 and 2). The collected soil and manures were thoroughly mixed and sieved using 2mm sieve in readiness for analysis. Nitrogen content was determined by the Kjeldahl procedure (Bremmer and

Mulvaney, 1982). The available P was by method described by Bray and Kurtz, (1945)

Potassium, Calcium, and Magnesium were determined according to the methods used by Houba *et al., (*1988) and Holmgren *et al., (*1977). In which 5g of air-dried soil samples was placed in 100ml volumetric flask and sample was percolated with ammonium acetate, this was homogenized for 1 hour. Sample was filtered and Ca and Mg were read by Atomic Absorption Spectrophotometry while K was measured by flame emission spectrophotometry

RESULTS

The result showed that types of organic manure used had significant effect on collar diameter as well as leaf area (Table 3), while the rate of organic fertilizer similarly had significant effect on the plant leaf area. The highest mean vine length (242.5cm) was recorded by seedlings treated with compost at 49.38ton/ha at the 24th week of application (Table 4) while the least vine length (164cm) was obtained for control treatment. The highest mean length for poultry manure was 198cm, at 49.38ton/ha. Cow dung manure treatment had 190cm at 49.38ton/ha. However there was no significant difference due to rates in length of the plant vine (Table 3). The highest collar diameter at the end of the experiment was 0.98cm which was recorded by compost manure at 37.04ton/ha (Table 5). Poultry manure recorded 0.84cm when used at 24.69ton/ha and for cow dung manure it was 0.80cm at 49.38ton/ha, while the highest collar diameter recorded in the control (0g) was 0.63cm (Table 5). However, diameter of the seedlings differed significantly due to fertilizer type at ($P< 0.05$), but their rates did not have any significant effect (Table 4).

The highest mean number of leaves (25.2) was obtained from compost at 49.38ton/ha after 24 weeks of application (Table 6). Poultry manures resulted to 22.6 leaves per plant at 49.38ton/ha while cow dung manure and the control had 21.04 at 49.38ton/ha and 17.5 respectively after 24 weeks (Table 6). Organic fertilizer types and rates did not show any significant effect on the number of leaves produced by the plant seedlings.

Leaf area of seedlings treated with compost had the highest value of 100cm^2 at 49.38ton/ha after 4th week of application. This was followed by poultry waste with 89.93cm^2 at 24.69ton/ha, cow dung manure had 81.73cm^2 using 49.38ton/ha, while the control had 81.09cm^2 (Table 7). After 24th week of application, the highest leaf area of 127.01cm^2 was obtained for compost applied at 49.38ton/ha. Poultry waste had 119.82cm^2 at 30g/2kg soil while cow dung manure had 113.04cm^2 at 49.38ton/ha, and the control had 99.45cm2, (Table 8). After 4 weeks, the highest leaf dry weight of 1.10g was obtained for compost usage at 24.69ton/ha; it was highest for cow dung at 0.99g while poultry manure was 0.89g, (Table 7). At 24 weeks, the highest LDW was 8.97g for compost at 37.04ton/ha. For poultry manure and cow dung manures the values were 8.62g and 8.04g at 30 and 49.38ton/ha respectively, while for the control, it was 8.73g (Table 8). However, types and dosage of the fertilizers did not significantly affect the seedlings leaf dry weight. At the 4th week of application, the highest stem dry weight of 0.91g was obtained with the poultry manure applied at 37.04ton/ha. This was followed by the compost with 0.90g SDW recorded at 37.04ton/ha. The cow dung manure had 0.70 at 49.38ton/ha and the control had a value of 0.69, (Table 7). At 24 weeks of application, the highest mean stem dry weight (SDW) of 18.54g was obtained with compost at 49.38ton/ha. This was followed by poultry manure with 13.87g, at 37.04ton/ha, the cow dung manure had 11.32g at 37.04ton/ha dosage and the control had 7.52g, (Table 8). Fertilizer source and dosage did not have any significant effect on the stem dry weight.

At the 4th week of application, the highest RDW of 8.72g was recorded with cow dung manure applied at 49.38ton/ha; 8.58g was obtained from poultry waste at a dosage of 49.38ton/ha while the control had 7.60g, (Table 7). At the 24th week of application, the highest RDW of 48.12g was obtained from poultry manure applied at 49.38ton/ha, followed by 48.11g with compost applied at 49.38ton/ha, while cow dung manure had 43.22g at 49.38ton/ha; the control recorded 33.41g, (Table 8). Fertilizer source and dosage did not significantly affect the root dry weight. At 4th week after application of organic fertilizer, the highest TDW, 11.30g was obtained from compost applied at 49.38ton/ha. This was followed by the cow dung manure with 10.42g recorded at 49.38ton/ha; the poultry manure had 10.37g at 49.38ton/ha soil, while the control had 9.19g/2kg (Table 7). Highest TDW at the 24th week was 75.61g, obtained from compost at 49.38ton/ha, followed by 70.43g obtained from poultry manure at 40g/2kg soil, (Table 8). There was no significant

difference between the source and dosage of fertilizer weight obtained from poultry manure at 49.38ton/ha, while cow dung manure had 62.40g at a dosage of 49.38ton/ha. The control had 45.28g (Table 8). Net assimilation rate (NAR) gm/month of *Plukenetia conophora* as affected by organic fertilizer types and rates (Table 9) showed that .Net Assimilation Rate (NAR) did not portray a discernible trend. The highest rate of 0.029gm was recorded for compost fertilizer while the least was 0.020gm/t for the control. At week 20, the highest quantity of 0.039gm/t was obtained from cow dung manure at 12.35ton/ha. The relative growth rate (RGR) as affected by fertilizer type and quantities as presented in Table 10 revealed that the highest relative growth rate (RGR) of 0.110g/t was obtained from poultry waste at week 8 under the treatment with 49.38ton/ha. However a mean RGR of 0.109g/t at week 8 was recorded in compost manure while the lowest RGR of 0.029g/t was recorded in the control at week 20. The absolute growth rate (AGR) of *P. conophora* seedlings as affected by types and rate of organic of organic manure showed that seedlings treated with compost at 49.38ton/ha gave the highest AGR of 3.898 at 8 to 12 weeks of application (Table 11). Poultry manure had 3.640, cow dung recorded 3.141, while the control had 2.176 at the same period. At weeks 20 to 24, cow dung manure had the highest AGR of 3.928 at 49.38ton/ha .Poultry manure had 3.908 at 37.04ton/ha soil while the control had 2.415g/2kg soil, (Table 11).

DISCUSSION

Production of healthy seedlings with optimal growth in the nursery requires the application of nutrients in appropriate proportion (Focho e*t al.* (2011).There is needed to augment soil fertility for growth of most tree species. If organic fertilizer is applied, it provides nutrients that are slowly released, at the same time, the soil's buffering capacity for water, cation and acidity is increased, (Bolland *et al.*, 2001). Various plant species differ in their preference for fertilizer type and rate. The study on fertilizer requirement of *P. conophora* indicated that fertilizers used had significant effects on the collar diameter as well as the plant leaf area ($P<0.05$). Leaf area is mainly the photosynthetic apparatus of plants for food production and this subsequently affects the overall growth of the plant. The highest values for growth were recorded in seedlings treated with compost which could be due to the high contents of organic carbon (38.3g/kgdw), Potassium (29.2g/kgdw) and calcium (21.5g/kgdw) in the compost compared to other treatment sources (Table 1). The fertilizer rate requirement for the growth of *P. conophora* was significant on leaf area. Increase in rates of the organic fertilizers resulted to increase in growth parameters observed, up to 49.38ton/ha. This indicated that increases in rate of the organic fertilizers applied resulted to more nutrients available for the seedlings without any detrimental effect. This is contrary with the findings of Uddin *et al.* (2012), who stated that higher doses of organic fertilizer had negative effect on seedlings of five popular leguminous Agroforestry tree components in Bangladesh. The interactive effect between fertilizer type and rate showed that the highest leaf area of 127.01cm^2 was recorded when compost was applied at 49.38ton/ha, this was followed by Poultry waste with 119.82cm^2 at 37.04ton/ha, cow dung manure with113.04cm^2 at 49.38ton/ha and least for the control with 99.45cm2 (Table 8).This trend could be attributed to the high N and P contents of the compost, poultry manure and cow dung compared to the soil (control). The nitrogen content was 16.1g/kgdw for compost and 17.3g/kgdw for poultry manure. Nitrogen is an important constituent of chlorophyll, amino acid and nitric acid (Sani *et al.*, (2000) which is needed for plant growth. Harris (1992) documented that mineral nutrient such as nitrogen and phosphorus generally stimulate growth in trees. This observation was in agreement with Fasina *et al.*, (2002) that observed that application of different levels of poultry manure on *Telfairie occidentalis* increased the vegetative growth of the plant. This is also in agreement with Fagbayide and Adekunle, (2002) on influence of poultry manure on early growth of passion fruit (*Passiflora edulis Var Flavicarpa*). They found a significant difference in growth over control on seedlings applied with different rates of poultry manure.

CONCLUSION

The study concludes that types and rates of organic manures used positively influenced growth and development of *P. conophora* most especially the leaf area. The fertilizer type and required rate for the growth of *P. conophora* by compost was optimum at 49.38ton/ha for producing the highest leaf area of 127.01cm^2. It

may be concluded that *P. conophora* required organic fertilizer most especially compost manure at a higher doze due to the high level of nitrogen, phosphorus and potassium present in them which are required for optimum growth and development. However, poultry manure and cow dung at higher dozes had proven to be beneficial for the growth and development of *P. conophora.*

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REFERENCES

Anegbeh, P. O., Usoro, C., Ukafor, V., Tchoundjeu, Z., Leakey, R. R. B. and Schreckenberg, K (2003). Domestication of *Irvingia gabonensis* 3. Phenotypic variation of fruits and kernels in a Nigerian village *Agroforestry systems* 58: 213 – 218 .

Aygün, Y., Acar, M (2004). Organic fertilizers and their importance. *Journal of Harvest* 228:68-72.

Babalola, O. A (2006). Fertilizer quality of composts made from various animal manures. Paper presented at 2nd National Conference on Organic Agriculture in Nigeria. University of Ibadan, Nigeria. 27th November – 1st December 2006. Book of Abstract Pp 29.

Bolland, M. D., Gillees, R. J. and Brennan, R. F (2001).The influence of soil properties on the effectiveness of phosphate rock fertilizers, *Australian Journal of soil Research* 39: 773 – 798.

Bray, R.H. and Kurtz, L.T (1945). Determination of total organic and available phosphorus insoil. *Soil Science* 59:39-45.

Bremmer, J.M. and Mulvaney, C.S (1982). Nitrogen-Total. In A.L. Page et al. (ed.)Methods of soil analysis part 2 2nd ed. Agronomy Monograph 9 ASA and SSSA, Madison WI. pp. 595-624.

Daramola, D. S., Adeyeye, A. A. S. and Lawal, D (2006). Effect of application of organic manures on the growth and dry matter yield of *Amaranthus cruentus*.Paper presented at 2nd National Conference, University of Ibadan, Nigeria. 27th Nov. – 1st December 2006. Book of Abstract Pp.11.

Fagbayide, J. A. and Joseph Adekunle T. T (2002). Influence of poultry manure on the early growth of passion fruit, *Passiflora edulis* var. *Flavicarp*a. Paper delivered at the 20th Annual Conference and silver jubilee. Anniv. of HORTSON. 14 May 2002 NIHORT Ibadan. Pp 138 – 140.

Fasina, A. S., Otanniyi, K. A., Alasiri, K. O (2002). Effect of different plant populations and poultry manure on the yield of Ugu. (*Telfarie occidentalis*) in Lagos State. Paper delivered at the 20th Annual Conf. and Silver Jubilee Anniv. of HORTSON 14 May 2002 NIHORT, Ibadan. Pp 127-129.

Focho, D.A., Eneke, B., Ebge, A., Fongod, A.G., Fonge, B.A. and Njoh, R.N (2011). Effects of organic and inorganic fertilizers on early growth characteristics of *Khayaivorensis* Chev (African mahogany) in nursery.*African Journal of Plant Science*Vol. 5(12):722-729.

Gaballah, M. S., Leithy, S., and Gomaa, A. M (2010). Associative impact of Bio- and Organic Fertilizers on geranium Plants grown under saline conditions. *Electronic journal of Environmental Agriculture and Food Chemistry*. ISSN 1579 – 4377, 9(3) 2010 (617 – 626).

Harris, R.W (1992). Root –Shoot Ratios. *Journal of Aboriculture*18 (1):39-42.

Homlgren, G.G.S., Juve, R.L. and Geschwender R.R (1977). A mechanically controlled variablerate leaching device. *Soil Science Society of America*41:1207-1208.

Houba, V.J.G, Novozamski , van der Lee I and Walinga, I (1988). Soil and Plant analysis. Part 5: Soil analysis procedures. Department of Soil Science and Plant nutrition, Agricultural University, Wageningen.

Mahmoud,Esawy.,Nasser, Abd El-Kader., Paul,Robin., Nouraya, Akkal-Corfini and Lamyaa, Abd El-Rahman (2009). Effect of different organic and inorganic fertilizers on cucumber yield and some soil properties. *World journal of Agricultural Sciences* 5(4): 408 – 414, 2009 ISSN 1817 – 3047.

Okafor, J. C (1991).Improving edible species of Forest Products. *Unasylva.* 165: 17 – 22 pp.

Sani, Y.A (2002). The growth yields and components of garden egg (*Solanum gilo*) as affected by intra row spacing, and nitrogen and phosphorus fertilizer. Proceedings of 18th Annual Conference of the Horticultural Society of Nigeria. pp 104 – 107.

Sharma, H. S., Fleming, C., Selby, C., Rao, J. R., Martin, T (2014). Plant biostimulants: a review on the processing of macroalgae and

use of extracts for crop management to reduce abiotic and biotic stresses. *Journal of Applied Phycology* 26(1): 465-490.

Stewart, W.M., Dibb, D.W., Johnston, A.E. and Smyth, T.J (2005). The Contribution of Commercial Fertilizers Nutrients to Food Production". *Agronomy Journal*, 97: 1–6.

Uddin, M.B., Mukul, S.A. and Hossain, M.K (2012). Effects of Organic Manure on Seedling Growth and Nodulation Capabilities of Five Popular Leguminous Agroforestry Tree Components of Bangladesh. *Journal of Forest Science* Vol. 28(4):212-219.

Yisau, J.A., Salami, K.D and Aduradola, A.M (2020). Effects of types of (organic and inorganic) fertilizer and quantities on the early growth of *Albizia zygia* seedlings. FUDMA Journal of Agriculture and Agricultural Technology. 6(1); Pp 147 – 152.

Yüksek, T., Atamov, V., Türüt, K (2019). Determination of some nutrient elements in solid vermicompost obtained from red california worm feeding with brewed tea waste and domestic food waste. *Journal of Anatolian Environmental and Animal Sciences* 4(2): 263-271.

Table 1: Some nutrient contents of organic materials used as manures

Properties	Compost manure	Poultry manure	Cow dung manure
Nitrogen	16.1	17.3	8.1
Organic carbon	38.3	26.0	16.2
Phosphorus	18.7	22.6	11.6
Potassium	29.2	20.9	2.2
Calcium	21.5	9.4	8.0
Magnesium	6.0	4.0	1.0
Iron	6.9	14.7	3.4
Zinc	155.3	181.0	142.0
Copper	29.2	37.0	23.0
Lead	0.0	0.0	0.0

Table 2: Soil physico-chemical properties

Property	Value
Sand	53%
Silt	39%
Clay	13%
PH	6.1%
N	0.012%
P	8.65%
K	0.10%
Ca	0.18%
Mg	0.31%
Organic Matter	1.42%

Table 3: Mean square analysis for the effect of types and rates of organic fertilizer on the early growth of *P. conophora*

Sources of variation	DF	Length of vine	Collar diameter	Number of leaves	Leaf dry weight	Stem dry weight	Root dry weight	Total biomass	Leaf area
Type of fertilizer	2	5344ns	0.11684**	162.4ns	17.151ns	52.36ns	187.3ns	1090.6ns	823.45**
Rate	4	79ns	0.00007ns	60.4ns	1.196ns	3.95ns	180.9ns	55.3ns	1086.54**
Type*Rate	8	129ns	0.00102ns	16.5ns	0.207ns	2.1ns	96.7ns	9.4ns	24.38ns

** = significant @p≤0.05, ns = not significant

Table 4: Mean values of vine length of *Plukenetia conophora* as affected by organic fertilizer types and rates over 24 weeks

Fertilizer types	Fertilizer Rate (ton/ha)	Age of seedlings (weeks)											
		2	4	6	8	10	12	14	16	18	20	22	24
Poultry waste	0	19.3	66.3	91.3	108.5	141.5	149.1	151.8	156	159.3	163	167	173.2
	12.35	19	68.5	100.5	103.5	129.5	139	152	160	170.5	174.2	176	183.5
	24.69	20	67.3	97.8	100	119.5	141	150.6	158.8	168.2	175.8	180.1	188
	37.04	19.8	65.4	105.2	103.6	120.5	140.8	147.5	155.9	168.5	178.7	182.2	192.7
	49.38	19.6	63	106.1	105	120.7	144	150.9	160.4	170	179	183.5	198.6
Cow-dung manure	0	18.4	54.5	110.4	111.8	132.7	140	144.7	147.2	153.9	158.2	163	168.5
	12.35	19.2	63.6	90.7	102.1	111.1	135	143.4	157	165	173.7	175.5	180.5
	24.69	20.3	68.4	93.5	107.8	125.4	133.9	150	154.2	160.7	169	171.6	179.2
	37.04	20.3	68.6	99.3	101.5	119.7	130	150.6	155.5	163.5	166.5	171	185.7
	49.38	19.6	71.3	99.6	103.4	117.9	128.8	156.1	162	177.9	183	188	190.7
Compost Manure	0	20.1	70.1	89.5	99.7	123.8	135.7	138.6	143	149.2	153.4	159.1	164
	12.35	19.6	70.2	102.1	105.7	136.2	153	158.4	161	178.5	191.1	217.9	237.3
	24.69	20.3	68	107.3	110	140.5	156.2	158.6	165	177.3	199.9	222.6	233.5
	37.04	20.3	69.5	101.4	111.1	138.2	163.5	169.8	168.3	188.6	197	224.5	239.1
	49.38	19.6	73.4	109.2	124.2	148	164.2	172.5	175	190.2	202.4	231.8	242.5

Table 5: Collar diameter of *Plukenetia Conophora* as affected by organic fertilizer types and rates over a period of 24 weeks

Fertilizer types	Rates(ton/ha)	Age of seedlings (weeks)											
		2	4	6	8	10	12	14	16	18	20	22	24
Poultry Waste	0	0.32	0.33	0.33	0.34	0.4	0.47	0.5	0.51	0.55	0.58	0.59	0.62
	12.35	0.3	0.34	0.34	0.35	0.42	0.53	0.55	0.61	0.69	0.73	0.76	0.8
	24.69	0.32	0.33	0.34	0.36	0.41	0.52	0.56	0.63	0.68	0.75	0.78	0.84
	37.04	0.31	0.35	0.36	0.36	0.44	0.51	0.57	0.63	0.69	0.74	0.78	0.8
	49.38	0.31	0.34	0.35	0.35	0.41	0.52	0.58	0.64	0.7	0.75	0.79	0.8
Cow-dung manure	0	0.32	0.32	0.33	0.33	0.39	0.48	0.51	0.51	0.53	0.57	0.6	0.62
	12.35	0.31	0.33	0.34	0.34	0.39	0.49	0.56	0.62	0.68	0.71	0.73	0.79
	24.69	0.32	0.32	0.33	0.33	0.43	0.48	0.56	0.6	0.67	0.73	0.75	0.78
	37.04	0.3	0.34	0.34	0.34	0.44	0.49	0.57	0.61	0.66	0.7	0.77	0.78
	49.38	0.32	0.32	0.33	0.33	0.42	0.51	0.54	0.6	0.65	0.7	0.76	0.84
Compost Manure	0	0.31	0.32	0.32	0.34	0.38	0.47	0.49	0.52	0.54	0.58	0.58	0.61
	12.35	0.31	0.35	0.36	0.36	0.44	0.53	0.59	0.65	0.71	0.79	0.86	0.92
	24.69	0.31	0.34	0.35	0.35	0.43	0.55	0.59	0.68	0.73	0.78	0.86	0.95
	37.04	0.32	0.36	0.37	0.37	0.44	0.55	0.57	0.69	0.77	0.79	0.88	0.98
	49.38	0.32	0.35	0.36	0.36	0.45	0.54	0.57	0.69	0.76	0.8	0.88	0.93

Table 6: Mean number of leaves of *Plukenetia conophora* as affected by organic fertilizer types and rates over 24 weeks of growth

Fertilizer types	Rates (ton/ha)	Age of seedlings (weeks)											
		2	4	6	8	10	12	14	16	18	20	22	24
Poultry waste	0	4.3	4.6	4.6	4.8	7.2	7.8	10.5	12.2	12.6	13.8	15.3	17.5
	12.35	4.5	4.6	4.7	6.8	10.2	11.7	12.9	15.5	17.6	19.4	21	22
	24.69	4.3	4.5	4.5	6.9	10	10.9	12.9	16.2	17.8	19.3	20.3	22.3
	37.04	4.5	4.5	4.6	7	11.5	11.6	13.3	16.3	17.5	18.9	20.5	21.8
	49.38	4.5	4.6	4.6	6.7	10.7	11.2	13	16.8	17.4	19.6	21.7	22.6
Cow-dung manure	0	4.4	4.5	4.6	4.8	7.4	7.7	10.8	12.1	13.0	14.0	14.8	16.8
	12.35	4.3	4.4	4.5	6.3	10.3	10.9	11.4	15.3	17.3	19.2	20.5	20.5
	24.69	4.4	4.5	4.6	6.5	9.8	10.2	11.2	15.6	16.6	19.1	19.9	21.3
	37.04	4.5	4.5	4.5	6.5	9.8	10.6	10.7	15.6	16.9	18.9	19.2	20.7
	49.38	4.5	4.6	4.7	6.6	9.7	10.7	10.9	15.7	17.8	19.3	20.6	21.4
Compost	0	4.5	4.4	4.5	4.7	7.6	7.5	10.6	12.1	12.7	14.3	14.9	17.0
	12.35	4.4	4.4	4.9	6.6	11.5	12.2	12.8	17.5	19.6	21	23.2	24.8
	24.69	4.5	4.4	4.7	6.8	10.3	11.8	13.2	18.3	19	21.5	23	23.3
	37.04	4.5	4.5	4.7	7.2	11.8	12.6	13.3	18.1	19.7	20.8	21.4	23.8
	49.38	4.5	4.5	5.2	7.3	11.7	12.6	13.4	19	20	22.2	24.7	25.2

Table 7: Effect of organic fertilizer on seedling biomass and leaf area at 4 weeks

Organic fertilizer types	Rates (ton/ha)	Root dry weight (g)	Stem dry weight (g)	Leaf dry weight (g)	Total dry weight (g)	Leaf area (cm^2)
Poultry manure	0	7.35	0.61	0.82	8.78	79.00
	12.35	7.15	0.69	0.97	8.81	89.72
	24.69	8.22	0.72	0.99	9.92	89.93
	37.04	7.87	0.91	0.96	9.74	89.84
	49.38	8.58	0.82	0.98	10.37	89.74
Cow-dung	0	7.21	0.68	0.89	8.78	79.52
	12.35	8.15	0.62	0.99	9.77	81.26
	24.69	8.2	0.69	0.97	9.86	81.25
	37.04	7.58	0.69	0.99	9.27	81.38
	49.38	8.72	0.7	0.99	10.42	81.73
Compost	0	7.13	0.69	0.89	8.72	81.09
	12.35	9.12	0.69	1	10.81	88.89
	24.69	8.92	0.79	1.1	10.82	88.63
	37.04	9.39	0.9	1	11.29	89.72
	49.38	9.41	0.9	0.99	11.3	100.00

Table 8: Effect of different organic fertilizer on seedling biomass and leaf area at 24 weeks

Organic fertilizer types	Organic fertilizer rates (ton/ha)	Root dry weight (g)	Stem dry weight (g)	Leaf dry weight (g)	Total dry weight (g)	Leaf area (cm^2)
Poultry manure	0	33.41	6.77	4.99	45.17	91.5
	12.35	41.51	12.13	8.42	62.06	108.43
	24.69	43.55	13.55	8.41	65.51	111.52
	37.04	47.88	13.59	8.62	70.09	119.82
	49.38	48.12	13.87	8.44	70.43	118.88
Cow-dung	0	31.66	6.81	5.22	43.69	89.53
	12.35	40.33	10.32	7.81	58.52	99.55
	24.69	40.12	9.44	7.57	57.13	99.05
	37.04	41.55	11.32	8.01	60.88	108.42
	49.38	43.22	11.14	8.04	62.4	113.04
Compost	0	32.42	7.52	4.89	44.83	98.02
	12.35	46.73	15.72	8.91	71.36	118.42
	24.69	46.13	16.83	8.83	71.79	122.53
	37.04	47.01	17.01	8.97	72.99	126.44
	49.38	48.11	18.54	8.96	75.61	127.01

Table 9: Net Assimilation Rate (NAR) g/month of *Plukenetia conophora* as affected by different organic fertilizers

Organic fertilizer types	Organic fertilizer rates	NAR1	NAR2	NAR3	NAR4	NAR5
Poultry manure	0	0.021	0.024	0.024	0.023	0.14
	12.35	0.027	0.032	0.028	0.025	0.024
	24.69	0.028	0.033	0.026	0.026	0.027
	37.04	0.029	0.033	0.025	0.03	0.033
	49.38	0.029	0.033	0.022	0.027	0.029
Cow-dung	0	0.021	0.024	0.021	0.018	0.14
	12.35	0.027	0.032	0.031	0.031	0.039
	24.69	0.026	0.03	0.27	0.028	0.03
	37.04	0.027	0.029	0.013	0.023	0.034
	49.38	0.027	0.028	0.014	0.023	0.036
Compost	0	0.02	0.021	0.023	0.02	0.021
	12.35	0.029	0.036	0.03	0.03	0.017
	24.69	0.029	0.035	0.028	0.028	0.03
	37.04	0.029	0.034	0.021	0.022	0.025
	49.38	0.029	0.034	0.02	0.022	0.026

NAR1 = NAR between 4th and 8th week; NAR2 = NAR between 8th and 12th week; NAR 3 = NAR between 12th and 16th week; NAR4 = NAR between 16th and 20th week; NAR5 = NAR between 20th and 24th week.

Table 10: Relative Growth Rate (RGR) g/month of Seedlings as affected by different types and rates of organic manures

Organic fertilizer types	Organic fertilizer rates	RGR1	RGR2	RGR3	RGR4	RGR5
Poultry manure	0	0.082	0.09	0.07	0.056	0.029
	12.35	0.098	0.1	0.063	0.049	0.044
	24.69	0.094	0.102	0.058	0.051	0.049
	37.04	0.099	0.105	0.052	0.057	0.063
	49.38	0.096	0.11	0.047	0.056	0.055
Cow-dung	0	0.08	0.086	0.062	0.044	0.03
	12.35	0.09	0.101	0.071	0.062	0.074
	24.69	0.088	0.099	0.067	0.058	0.056
	37.04	0.094	0.101	0.059	0.05	0.069
	49.38	0.09	0.102	0.056	0.05	0.073
Compost	0	0.082	0.085	0.068	0.053	0.041
	12.35	0.094	0.107	0.062	0.055	0.059
	24.69	0.095	0.106	0.06	0.054	0.052
	37.04	0.093	0.107	0.043	0.042	0.046
	49.38	0.095	0.109	0.039	0.042	0.047

RGR1 = RGR between 4th and 8th week; RGR 2 = RGR between 8th and 12th week; RGR 3 = RGR between 12th and 16th week; RGR 4 = NAR between 16th and 20th week; RGR 5 = RGR between 20th and 24th week.

Table 11: Absolute Growth Rate (AGR) of seedlings as affected by types and rates s of organic manures

Organic fertilizer types	Organic fertilizer rates	AGR1	AGR2	AGR3	AGR4	AGR5
Poultry manure	0	1.82	2.159	2.138	2.041	1.255
	12.35	2.663	3.098	2.74	2.521	2.498
	24.69	2.779	3.296	2.737	2.735	2.933
	37.04	3.017	3.568	2.695	3.22	3.908
	49.38	3.003	3.64	2.546	3.161	3.458
Cow-dung	0	1.745	2.045	1.917	1.631	1.268
	12.35	2.438	2.93	2.784	2.86	3.76
	24.69	2.363	2.842	3.789	2.661	2.865
	37.04	2.581	3.047	2.569	2.519	3.64
	49.38	2.599	3.141	2.556	2.577	3.928
Compost	0	1.806	2.087	2.082	1.944	1.683
	12.35	3.028	3.655	3.111	3.178	3.768
	24.69	3.049	3.666	3.059	3.145	3.338
	37.04	3.085	3.741	2.448	2.594	2.078
	49.38	3.215	3.898	2.367	2.704	3.228

AGR1 = AGR between 4th and 8th week; AGR 2 = AGR between 8th and 12th week; AGR 3 = AGR between 12th and 16th week; AGR 4 = AGR between 16th and 20th week; AGR 5 = AGR between 20th and 24th week.

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SURVEY AND BOTANICAL DESCRIPTION OF SOME COMMON ORNAMENTAL PLANTS IN FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, BOSSO CAMPUS

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ABSTRACT

A survey of ornamental plants was carried out around Federal University of Technology Minna (FUTM)Bosso campus Niger State in May 2021. The survey was intended to obtained critical information about the ornamental plants that are used within the campus. Standard procedures were followed for the identification and description of the common ornamental plants. Original coloured photographs of the ornamental plants were also taken for proper documentations. These ornamental plants were then classified based on their relative abundance, mode of propagation, habits, parts associated with aesthetic and other uses aside for beautification. Thirty-five (35) ornamental plant species were identified; from the results obtained, it was deduced that Ixoracoccinea has the highest number recorded (1366) with percentage relative abundance of 27.293 % while the lowest in number was Cycasrevoluta (1) with percentage relative abundance of 0.020 %. It was also recorded that there are different mode of propagations for the ornamental plant species which include stem cuttings, by seed, by fruits, air layering, root cuttings, grafting and offshoot. These ornamental plants that are propagated by stem cuttings had the highest number with percentage of 31.429 % and the least mode of propagation was by grafting (2.857 %). The ornamental plants encountered based on their habits include trees (51.429 %) shrubs (31.429 %) and the least was herbs (2.857 %). Therefore, it was concluded that FUTMBosso campus is endowed with numerous ornamental plants that cut-across different forms of habits.

Keywords: *Ornamental Plants, Documentations, Relative abundance, Propagation, Habits*

INTRODUCTION

Ornamentals are plants that are cultivated for decorative reasons in gardens and landscape design project as houseplants, cut flowers and specimen display Oloyede (2012). The art and science of cultivating ornamental plants is called Floriculture (Dadang *et al.*, 2020). Accordingly, Jessica (2013) mentioned that ornamental plants are cultivated for decoration, rather than by product from plants and food. The cultivation of ornamental plants comes under floriculture and tree nurseries, which is a major branch of horticulture. Olaniyan (2017) expatiated that horticulture is a branch of Agriculture, which deals with the production, processing, storage and marketing of fruits, vegetables spices and ornamental plants (Olaniyan, 2017).Osawuru and Ogwu (2021) noted that all plantsare considered necessary and can potentially serve to fulfil one or more of our basic needs, such as food, shelter, and clothing as well as environmental integrity (aesthetic values). Plant productrefers to goods and services derivable from plants and may include whole plant orplant part (used as ingredients and condiments). Ornamental plants have their ways in home gardens but their relative important vary in different gardens and places and also depending on the researchers' interests. Thus, in certain works on home gardens, the ornamentals are excluded; for example, because its presence is considered temporary and hard to count (Vlkova *et al*., 2010). Many studies about home gardens in rural area signify that food and medicinal plants are more abundance than ornamentals (Aworinde *et al*., 2013). Various methods of cultivating and keeping ornamental plants have been identified; they may be cultivated in a flower bed, shaped into a hedge or placed in a sunny apartment window. They are most often intentionally planned for aesthetic appeal, but a plant that occurs naturally and enhances the landscape could also be considered ornamental. While the most widely use of ornamental plant is their visual effect, they serve obvious reason and are used in landscapes throughout the home to beautify the surrounding (Sani *et al*., 2016). It has been further stressed that numerous

ornamental plants are chosen because they appeal to the sense of odour, in addition to their attractive appeals. Some fragrant plants (e.g. *Hyptissuaveolens*) have some beneficial effect at repelling outdoor pests such as anti-mosquitoes and flies (Sani *et al*., 2016). Ornamental plants have provided an attractive environment for human enjoyment. Few places where ornamental plants have been of benefit for environmental improvement in Nigeria are: Lucky Fibres, Cheveron in Lagos and International Institute for Tropical Agriculture (IITA) Ibadan, Muritala Muhammed Botanical Garden Epe Lagos and many more just to mention few. Thus, walking through a botanical garden can be very relaxing and healthy (Osawaru *et al*., 2012). In the Bosso Campus of Federal University of Technology, Minna, Niger State, there is presence of different ornamental plants for beautification of the environment; in fact there is a botanical garden. However, no special care was given to appropriate selection as well as identifying the plant species that form these ornamentals. Hence, there is an urgent need to document and characterise the common ornamental plants in the premises of Federal University of Technology, Minna Niger State; this thought informed this project.

MATERIALS AND METHODS

The study was carried out around the Federal University of Technology Minna, Niger State in May 2021. Geographically Minna is located in the North Central Zone of Nigeria, it covers a land area of 88 square kilometres. The geographical coordinates are $9^0$40' North and $6^0$33' East. Minna, Niger State is characterised by the presence of few scattered trees and dense grass cover. Hence, it has a vegetation type classified as Guinea Savannah. There are few rivers located within Minna and the regions near the river valley abound in plant cover. The points (red) on the map showed the sampling points within the campus (Figure1). The survey involved the collection, identification and description of various ornamental plants commonly found in the University Campus. The study area was divided into five (5) sites for accurate recording of different ornamental plants. Site A represent Boys Hostel, Site B represent Lecture theater, Site C represent Laboratories, Site D represent Masjid area and Site E represent University quarters. The ornamental plants were collected and identified using standard Floras and manuals of the region and with the help of plant taxonomist in the Department of plants Biology, Federal University of Technology Minna. In addition, the survey involved taking numerical account by counting of number of available ornamental plants seen around the Federal University of Technology Minna, Bosso campus, Niger State. Other characters, of the ornamental plants encountered, such as habit, mode of propagation as well as their uses were also considered.

Data Analysis: Data obtained were analyzed using both descriptive and quantitative statistics such as bar chart, tables, and expressed as a percentage based on their relative abundance. All data were organized on Microsoft Excel (Batrinca and Treleaven, 2015).

RESULTS

Distribution of ornamental plants within F.U.T, Minna, Bosso Campus: Federal University of Technology, Minna, Bosso Campus is endowed with different types of ornamental plants, which include both indigenous and exotic flora. A total of thirty-five (35) ornamental species were encountered in all areas selected for this study (Table 1). The highest in terms of numbers recorded (1366) and percentage relative abundance (27.293 %) was *Ixora coccinea*, while the lowest in terms of number (1) and percentage relative abundance (0.020 %) was *Cycas revoluta*. The second highest recorded was *Duranta erecta* with a total number of eight hundred and fifty-eight (858) plants and a relative abundance of 17.143 %. It is directly followed by *Berleria lupulina*, which was recorded to appear six hundred and sixty-three (663) times, with a percentage relative abundance of 13.247 %. The next in terms of numbers (381) and relative abundance (7.612 %) was *Tecoma stans*. In terms of numbers (280) and percentage relative abundance (5.594 %), the fifth ranked was *Voacanga africana.* (Table 1).In ascending order, *Cycas revoluta*, which is the least recorded in terms of numbers (1) was followed by *Euphorbia tirucalli*, with a total number of two (2) plants and percentage relative abundance of 0.040 %. The next is *Euphorbia milli*, which was recorded three (3) times and with a percentage relative abundance of 0.060 %. In an ascending order, other species whose relative abundance fall below 1 % include: *Phoenix dactylifera* (0.100 %),*Ficus religosa* (0.120 %), *Cassia fistula* (0.140 %),*Plumeria rubra* (0.160 %), *Bougainvillea glabra* (0.180 %), *Thevetia peruviana* (0.220 %), *Albizia ferruginea* (0.239 %),*Ficus elastic* (0.280 %),

Plumeria alba (0.280 %), *Hura crepitans* (0.300 %), *Syzygium guineenses* (0.400), *Caryota urens* (0.420 %), *Acacia auriculiformis* (0.460 %), *Albizia lebbeck* (0.519 %), *Thuja occidentalis* (0.759 %), and *Cassia siamea* with a percentage relative abundance of 0.779 %. In addition, *Caedium variagatum* (56) with percentage relative abundance of 1.119 %, *Delonix regia* (61) with percentage relative abundance of 1.219 %, *Jatropha integerrima* (62) with percentage relative abundance of 1.239 %, *Terminalia catappa* (66) with percentage relative abundance of 1.319 %, *Allamanda cathartica* (80) with percentage relative abundance of 1.598 %, and *Azadirachta indica* (87) with percentage relative abundance of 1.738 % were all recorded to have a percentage relative abundance greater than 1.000 % but less than 2.000 %. Similarly, *Cryptostegia madagascarensis* (250) with a percentage relative abundance of 4.995 % is the sixth highest, this was followed by *Caesalpina pulcherima* (163) with a percentage relative abundance of 3.257 %, then *Polyalthia longifolia* (152) with a percentage relative abundance of 3.037 % is the eighth. The ninth and tenth ranked plants in terms of number recorded are *Tradescantia pallid* and *Terminalia mantaly* with a total of one hundred and twenty (120) and one hundred and ten (110) plants and percentage relative abundance of 2.298 % and 2.198 % respectively.

Distribution of ornamental plants in F.U.T, Minna, Bosso Campus with respect to family, mode of propagation, habits and plant parts associated with aesthetics: In the survey carried out, thirty-five (35) ornamental plants belonging to seventeen (17) families were identified and recorded in the course of the study (Table 1). The families; Apocynaceae (with 7 plant species) and Fabaceae (with 7 Plant species) were most dominant and evenly distributed, representing 20 % each of the total plant population recorded on the campus, while the families Acanthaceae, Annonaceae, Bignoniaceae, Commeliaceae, Cupressaceae, Cycadaceae, Meliaceae, Myrtaceae, Nyctaginacea, Rubiaceae, and Verbanaceae were less dominant with one (1) plant species each and a percentage relative abundance of 2.857 % each (Table 1, Figure 2). Two Plant species were recorded for families; Arecaceae, Combretaceae, and Moraceae, each having a percentage relative abundance of 5.714 %. Family abundance of Euphorbiaceae was four (4) Plant species, indicating a percentage relative abundance of 11.429 % (Table 1). Different modes of propagation were identified in the recorded plant Species, ranging from seed to stem cutting to grafting and other modes. The plant species propagated by stem cutting were eleven (11), representing 31.429 % of the plant population recorded. Ten (10) Plant species were propagated by seed. These plants represent 28.571 % of the total plant population. Some plants were found to be propagated by more than one means, i.e. by seed or other means, such as offsets, offshoot, stem cuttings or fruits. Eight (8) plants, representing 22.857 % of the total number of ornamental plant species are propagated seed or another means. Cutting as a mode of propagation was recorded in five (5) Plant species, which is 14.286 % of the total plant species. One (1) plant species was identified to employ grafting or air laying as a mode of propagation, representing a minute 2.857 % of the ornamental plants in Bosso Campus (Table 2).

The plant species recorded were categorized into trees, shrubs, herbs, woody shrubs and those intermediate between shrubs and trees. The trees (18) which are the most dominant and most abundant, represent 51.429 % of the total ornamental plants in Bosso campus, F.U.T, Minna. The second most populated plant species with respect to habit were the shrubs, which are eleven (11) and represent a percentage relative abundance of 31.429 %. Four (4) plants are intermediate between trees and shrubs and represent 11.429 % of the total ornamental plants. One Plant was recorded to be a herb and another one, a woody shrub. The plant species with these habits represent 2.857 % each, of the total ornamental plants in BossoCampus (Table 2).

The uniqueness of ornamental plants is the aesthetics and beauty they add to the environment. As ornamental plants, all the plants (35) recorded all possess parts associated with aesthetics and beauty. For some of the plants, the floral parts serve this purpose, while it is the foliage in some of the plants. However, in some of these ornamental plants, the foliar and floral parts are both aesthetic. The plants which have their floral parts associated with aesthetics are most abundant and most dominant (23) with a relative abundance of 65.714 %. The plants where the foliar parts are associated with aesthetics are ten (10), having a percentage relative abundance of 28.571 %. 5.714 % of the total ornamental plant species in Bosso Campus have both the floral and foliar parts associated

with aesthetics. Some of the representatives of the ornamental plants are presented in Plates 1a-1e below.

DISCUSSION

In the present study, it was observed that different plant species have different aesthetic values and are used for different purposes including beautification and shades in the study area. The study identified thirty-five(35)ornamental plants belonging to 17 families within the campus of FUTM. Out of the plant families encountered, the highest species (7) encountered belonged to the family Fabaceae and Apocynaceaeis line with the study of Ogwu *et al.* (2016) in their study on the Diversity and Abundance of Tree Species in the University of Benin, Nigeria. They reported that the family Fabaceae and Arecaceae were the most abundant with three (3) species belonging to the both family. The abundance of these families especially Fabaceae could be attributed to the great distribution of the plant family in tropical rainforest and dry forest of Africa and America which is greatly used for different aesthetic purposes including medicine (Burham and Johnson, 2004). The poor distribution of some families with only one species in the study area may be attributed to environmental conditions as it is reported in many studies that environmental factors including rainfall, temperature and wind contributes to the distribution of plant (Mohamed *et al.,* 2013). The poor distribution of some families in the area could also be attributed to human activities and selective nature of human beings who prefer one ornamental plant over others; this assertion was similar to that of Wardle *et al.*(2004) that human activities affect the abundance of species. The abundance of these species in the study area could be attributed to its attraction and pleasant appearance which led to its massive planting in the area. The different modes of propagation have been identified. The propagation mode of these plants encountered ranged from seed to stem cutting to grafting and other modes. The most abundant mode of propagation is stem cutting representing 31.42% of the total plant encountered. This is line with the study of Osawuru *et al.*(2014) in their study on the Survey of Ornamental Gardens in Five Local Government Areas of Southern Edo, Nigeria. They reported that the mode of propagation shows that about 56 % are propagated vegetative, especially from stem cutting. Stem cutting as the most abundant of mode of propagation among the ornamental plants encountered could be attributed to the fact that it is the fastest mode of regenerating the plants among garden mature plants (Pal and Sarkar, 2009). Stem cutting propagation mode has an advantage as it helps reduce viability among the plants and retention of the phenotypic integrity of the plant (Osawuru *et al*., 2014).

The study further revealed that floral is the most part used as aesthetic purposes. This is consistent with the study of Dania-Ogbe (2013) who reported that floral represented more than 60 % of the total plant part used as aesthetic purposes. Similarly, it is line with the work of Adekunle *et al.,* (2013) in their study on Field survey of indigenous and useful plants, Edo, Nigeria. They also reported that floral is the most abundant plant part used for aesthetic purposes which include for medicine and food for some animal species. The study also revealed several habits among the ornamental plants encountered with tree and shrubs recorded as the most abundant habit. This is in line with the work of El-Juhany and Al-Harby (2013) in their study on Status and Diversity of Ornamental Plants in King Saud University Campus at Riyadh, Saudi Arabia. They reported that trees and shrubs were the most abundant habit representing about 45% of the total number of ornamental plant species encountered in their study. The present study also observed that the ornamental plants encountered play different roles in the area, which include food sources, medicine, shelter, shading, etc. They are also found to provide relaxation spots and are useful for erosion control and as windbreaks, this is agree with the work of Arslan and Yanmaz (2010).

CONCLUSION

It was therefore concluded that FUTM Bosso campus is endowed with numerous ornamental plants that cut-across different forms of habits; such plants have provided aesthetic as well as protection values to the community and its environment.

REFERENCES

Adekunle, V. A. J., Olagoke, A. O. and Akindele, S. O. (2013). Tree species diversity and structure of a Nigerian strict nature reserve. *Tropical Ecology*, 54(3), 275 – 289.

Arslan, M. and Yanmaz, R. (2010). Use of ornamental vegetables, medicinal and

aromatic plants in urban landscape design. acta horticulture. 881, 207-211.

Aworinde, D.O., Erinoso, S.M., Ogundairo, B.O., and Olanloye, A.O. (2013) Assessment of plants grown and maintained in home gardens in Odeda area, Southwestern Nigeria. *Journal of Horticulture Forest*, 5(2), 29–36.

Batrinca, B., and Treleaven, P. C. (2015). Social media analytics: a survey of techniques, tools and platforms. *AI and Society*, 30(1), 89-116.

Burham, R. J., and Johnson, K. R. (2004). South American Pleobotany and the Origins of neotropical rain forests. *Philosphical Transaction of the Royal Society London*, 359, 1595- 1610.

Dadang, R. J., Simborio, L. T., Casinillo, N. G., and Amoroso, V. B. (2020). The floriculture industry on the grassroots: The issues on ornamental plant growing, extraction and trading in Baganihan, Southern Philippines. *Advances in AgricultureandBotanics*, 12(1), 1-11.

Dania-Ogbe, F. M., Egharevba, R. K. A., and Bamidele, J. F. (2013). Field survey of indigenous and useful plants.Their preparation for food and home garden inEdo and Delta States, Nigeria. *The United NationsUniversity, Tokyo, Japan*, 3, 95.

El-Juhany, L. I., and Al-Harby, A. A. (2013). Status and Diversity of Ornamental Plants inKing Saud University Campus at Riyadh, Saudi Arabia. *American-Eurasian Journal of Agricultural and Environmental Science*, 13(4), 471-478.

Jessica, M. (2013). Uses of ornamental plants.*Advances in Nutrition and Food Science*,1(1), 1-5.

Mohammad, O., Yunusa, B. M., Rahman, M. A., and Herman, S. (Edits). (2013). Identification and Description of Some Common Ornamental Plant Species atAhmadu Bello University Zaria, Nigeria. *African Journal of Bioscience*, 5(87), 555-568.

Ogwu, M.C., Osawaru, M.E., and Obayuwana, O.K. (2016). Diversity and Abundance of Tree Species in the University of Benin, BeninCity, Nigeria. *Applied Tropical Agriculture*, 3(21), 46-54.

Olaniyan, A.A. (2017). Biological system: Soil and horticulture. Invited paper presented during the 35th Annual conferece of *Horticultural Society of Nigeria* (HORTSON) held at Kabba College of Agriculture, Kogi state, Nigeria from 29th32October - 3rd November, 2017.

Oloyede, F.A. (2012). Survey of ornamental ferns, their morphology and uses for environmental protection, improvement and management. *Journal of Science*, 14(2), 245–252.

Osawaru, M. E., Ogwu, M. C., and Aigbefue, D. (2014). Survey of Ornamental Gardens in Five Local Government Areas of Southern Edo State Nigeria. *The Bioscientist*, 2(1), 87- 102.

Osawuru, M.E., and Ogwu M.C. (2021). Plants and Plant Products in Local Markets Within Benin City and Environs. *Springer*: *African Handbook of Climate Change Adaptation*, pp 315–337. https://doi.org/10.1007/978-3-030-45106-6_159.

Pal, S., and Sarkar, I. (2009). Pests infesting ornamental plants in hilly region of West Bengal. *The Journal of Plant Protection Sciences*, 1(1), 98-101.

Sani Y.A, Isah A.S, Babaji B.A, Barnabas S, Yahaya R.A and Hassan M.B (2016). *Advances in Nutiritionand Food science.* 1(1), 1-5.

Vlkova, M., Polesny, Z., Verner, V., Banout, J., Dvorak, M., Havlik, J., Lojka, B., Ehl, P., and Krausova, J. (2010) Ethnobotanical knowledge and agrobiodiversity in subsistence farming: case study of homegardens in Phong My commune, central Vietnam. Genetic Resources and Crop Evolution.

Wardle, D. A., Walker, L. R., and Bardgett, R. D. (2004).Ecosystem properties and forest decline incontrasting long-term chronosequence. *Science*, 305,509 – 513.

Table 1: Distribution of ornamental plants in Bosso Campus, FUTMINNA, with respect to Family, Mode of Propagation, Habit and Plant parts associated with aesthetics

S/N	Scientific Name	Family Name	Common Name	Mode of propagation	Habit	Parts Associated with Aesthetic
1	*Acacia auriculiformis*	Fabaceae	Earleaf acacia	Stem cutting	Tree	floral
2	*Albiziaferruginea*	Fabaceae	False thorn	By seed	Tree	floral
3	*Albizialebbeck*	Fabaceae	Womans tongue or lebbeck	By seed	Tree	floral
4	*Allamandacathartica*	Apocynaceae	Allamanda or golden trumpet	Stem cutting	Shrub	floral
5	*Azadirachtaindica*	Meliaceae	Neem	Seeds and cuttings	Tree	floral
6	*Berlerialupulina*	Acanthaceae	Hophead philipino violet	Stem cutting	Shrub	floral
7	*Bougainvillea glabra*	Nyctaginaceae	Paper flower	Stem cutting	Shrub	floral
8	*Caediumvariagatum*	Euphorbiaceae	Crotons or gold dust	Stem cutting and air layering	Woody	floral
9	*Caesalpinapulcherima*	Fabaceae	Pride of Barbados	Seed	Shrub	floral
10	*Caryotaurens*	Arecaceae	Jaggary palm or fish tail palm	Seeds	Tree	foliage
11	*Cassia siamea*	Fabaceae	Golden shower	Stem cutting	Tree	floral
12	*Cassia fistula*	Fabaceae	Cassia tree	Seed or stem cutting	Shrub	Floral
13	*Cryptostegiamadagascariensis*	Apocynaceae	Purple rubber vine	By seed	Shrub	Floral
14	*Cycasrevoluta*	Cycadaceae	Cycas	Seed or by offsets	Tree	Foliage
15	*Delonixregia*	Fabaceae	Flamboyant tree or flame of forest	By seed	Tree	Floral
16	*Durantaerecta*	Verbanaceae	Golden dewdrop	Stem cutting	Shrub	Floral
17	*Euphorbia milli*	Euphorbiaceae	Crown of thorns	Fruits or seeds	Shrubs	Floral
18	*Euphorbia tirucalli*	Euphorbiaceae	Milk bush	Cuttings	Shrub or small tree	Floral
19	*Ficus elastica*	Moraceae	Rubber figure	Cutting	Tree	Foliage
20	*Ficusreligosa*	Moraceae	Pepal	Cuttings from any part	Tree	Foliage
21	*Huracrepitans*	Apocynaceae	Sand box tree	Grafting or air laying	Tree	Floral
22	*Ixoracoccinea*	Rubiaceae	Ixora	Stem cutting	Shrub	Floral
23	*Jatrophaintegerrima*	Euphorbiaceae	Spicy jatropha	Seed or by stem cutting	Shrub	floral/foliage
24	*Phoenix dactylifera*	Arecaceae	Date palm tree	Seed or off shoot	Tree	Foliage
25	*Plumeria alba*	Apocynaceae	White fragipan	Seed	Shrub or tree	Floral
26	*Plumeriarubra*	Apocynaceae	Red frangipani	Seed or rooting	Shrub or	Foliage
27	*Polyalthialongifolia*	Annonaceae	Masquerade tree	By seed	Tree	Foliage
28	*Syzygiumguineenses*	Myrtaceae	Water berry	Stem cuttings	Tree	Foliage
29	*Tecomastans*	Bignoniaceae	Yellow elder	Seed or stem cutting	Shrub	flora/foliage
30	*Terminaliacatappa*	Combretaceae	Indian almond tree	Seed	Tree	floral
31	*Terminaliamantaly*	Combretaceae	Madagascar or umbrella tree	Stem cutting	Tree	floral
32	*Thevetiaperuviana*	Apocynaceae	Yellow oleander	Root cutting	Tree or shrub	foliage
33	*Thujaoccidentalis*	Cupressaceae	Northern white cedars	Stem cutting, seed layering	Tree	floral
34	*Trasdescantiapallida*	Commelinaceae	Purple heart	Cutting from any part of the plant	Herb	foliage
35	*Voacangaafricana*	Apocynaceae	Small fruit wild frangipani	By seed	Tree	floral

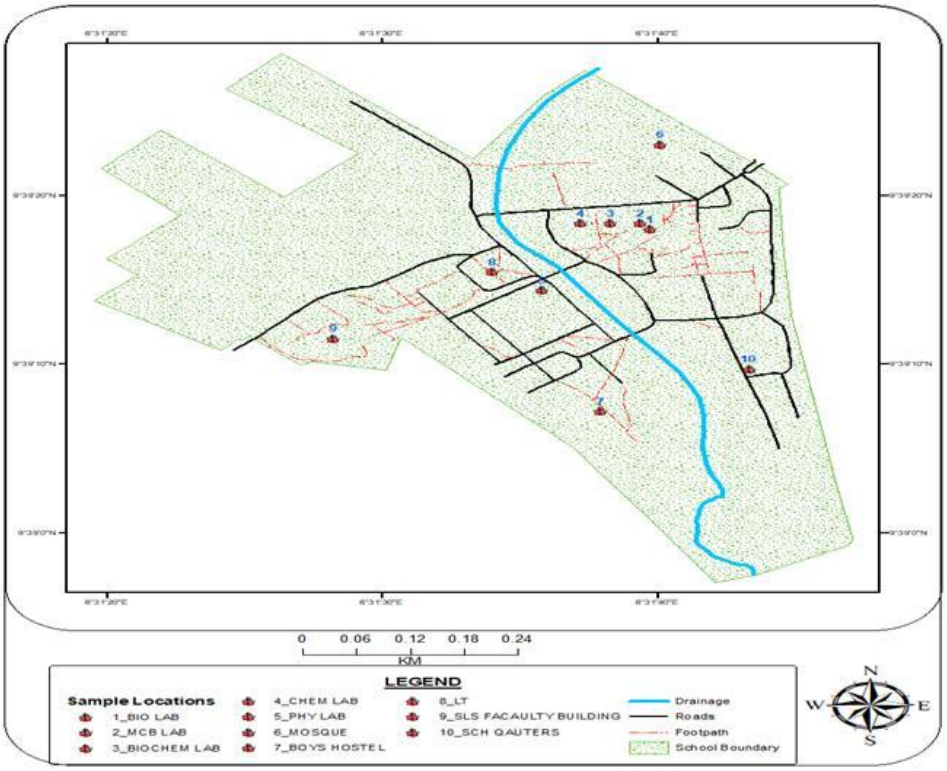

Figure 1: Map of Bosso campus showing sample area

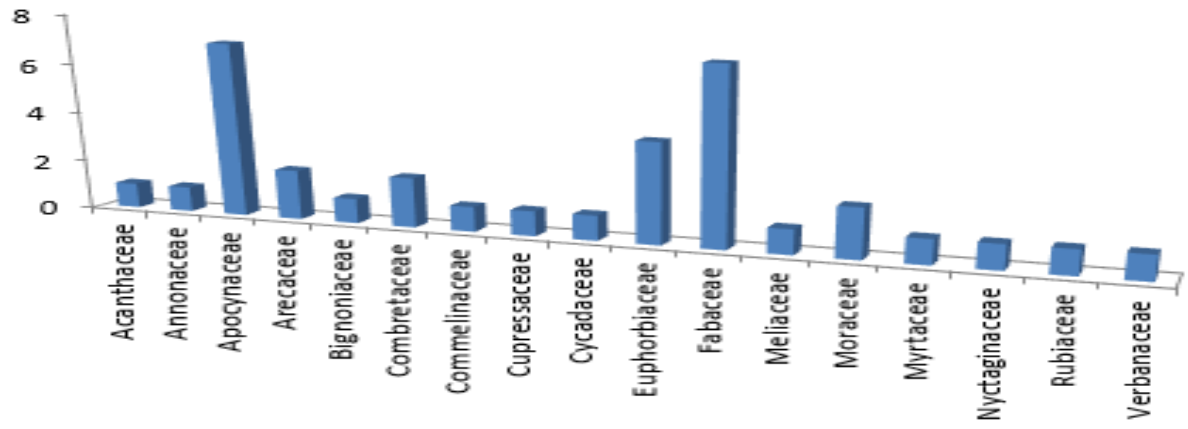

Figure 2: Family Abundance of the Ornamental Plants within F.U.T. Minna, Bosso Campus

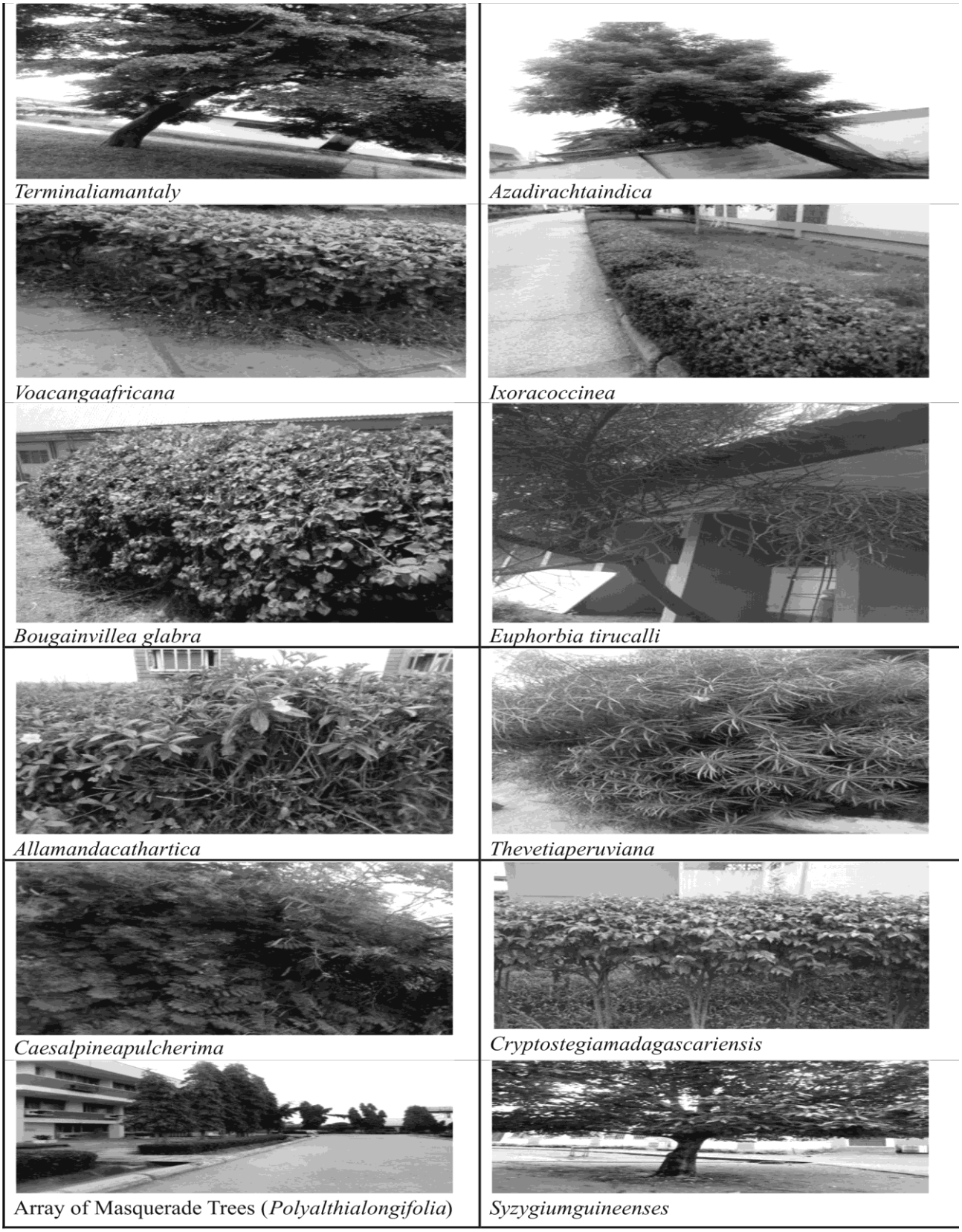

Plate 1 A: Representatives of the Common Ornamental Plants within F.U.T. Minna, Bosso Campus

White Flower FrangiPanni (*Plumeria alba*)

Red Flower FrangiPani (*Plumeria rubra*)

Cycas revoluta, a common ornamental Gymnosperm

Thuja occidentalis, an ornamental Gymnosperm

Fish-tail Palm (*Caryota urens*)

Date Palm *(Phoenix dactylifera*)

Albizia lebbeck

Terminalia catappa

Cassia fistula

Acacia auriculiformis

Plate 1B: Representatives of the Common Ornamental Plants within F.U.T. Minna, Bosso Campus

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ECONOMICS ANALYSIS OF SNAKE TOMATO PRODUCTION CROPPED IN NEWLY ESTABLISHED RUBBER PLANTATION TREATED WITH RUBBER EFFLUENT AND NPK

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ABSTRACT
The long gestation period of rubber (5 to 7 years) hinders the small holder farmers in investing in rubber plantation. During the long gestation period, rubber plant cannot be tapped for latex, hence, no revenue will accrue to the owners. 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 at Iyanomo, Edo State, Nigeria in 2018 and 2019 cropping seasons. The treatments involved sole rubber and snake tomato and their intercropped combination with NPK and rubber effluent application laid out in a randomized complete block in three replicates. 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 of snake tomato ($P<0.05$). The highest fruit yield was observed in sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15 (STNPK). The variable cost and revenue increased with soil amendment supplementation. STNPK had the highest gross margin and return per naira invested in the first year of cropping but in the second year, rubber-snake tomato with 60 kg N ha^{-1} of NPK 15:15:15 (RSNPK) and STNPK had comparable gross margin and return per naira invested. Based on this, RSNPK was suggested for small holder rubber farmers.

Keywords: *Economic analysis, fruit yield, soil amendment, variable cost*

INTRODUCTION

In Nigeria, small holder rubber farmers contribute about 75 % of total rubber production (NRAN, 2013). However, rubber production in Nigeria is presently experiencing serious setback due mainly to the long gestation period of rubber (5 to 7 years) (Michael, 2006). During this period rubber plant cannot be tapped for latex. This implies that during this period, no income accrues from the huge capital investment and maintenance of the plantation. This situation is of great concern to small-holder rubber farmers in Nigeria. To boost rubber production and make it a viable foreign exchange earner for the country, efforts must be put in to encourage the smallholder rubber farmers that contribute 70% of total rubber production. (NRAN, 2013). Hence, there is the need for appropriate plantation management systems that can assist farmers to 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. Haliru (2015) has reported that intercropping rubber with arable crops is beneficial to the growth of rubber and capable of increasing returns from rubber enterprise.

Snake tomato *(Trichosanthes cucumerina* L. Haines) crop is mainly cultivated for the red fruit pulp used as a substitute for the regular tomato sauce. The pulp is known to provide protection against harmful free radicals. Researches by Cohen *et al.* (2000), Knett *et al.* (2002) and Sahlin *et al.* (2004) have revealed that its consumption is strongly associated with reduced risk of chronic diseases such as cardiovascular diseases, cancer, diabetes, Alzheimer disease, cataracts and age related functional decline in addition to other health benefits. Intercropping rubber with this crop would generate revenue that will serve as an additional income and early returns to the rubber farmer during the waiting period of rubber phase. It also helps in control of weeds, efficient resource use in the plantation, and reduce the cost of plantation maintenance and production.

Moreover, the scarcity and untold price hike that occur annually as a result of the off season of the tomato fruit and recent invasion by tomato leaf miner *(Tuta absoluta*) that ravaged the entire tomato farm directed research efforts to looking for an alternative to the regular tomato. Snake tomato is an orphan crop and its cultivation and use as an alternative to the regular tomato is attracting global interest.

Cost of inorganic fertilizer, its availability, adulteration and its attendant effects on the world economy has been a source of concern, hence the need for an alternative. The disposal of rubber processing effluent has been a major challenge to factory owners and a source of pollution, but its use as soil nutrient amendment will go a long way to ameliorating the challenge. Hence, this study was undertaken to evaluate the profitability of snake tomato fruit production cropped in newly established rubber plantation and treated with NPK rubber processing effluent.

MATERIALS AND METHODS

Experimental Site*:* This study was conducted in 2018 and 2019 cropping seasons at the Research Farm of Rubber Research Institute of Nigeria (RRIN) within the Rain Forest zone of Edo State, Nigeria. The study site occupied a land area of 2,070 ha. The study area falls between latitude $6^0$00 and $7^0$00′ N and longitude $5^0$00′ and $6^0$00′ E. The annual rainfall ranged between 1800 – 2300 mm and relative humidity of 75 % (Orimoloye, 2011). The area is characterized by a moderately high temperatures of 30 ^{0}C minimum and 32 ^{0}C maximum. The soils of this humid forest belt are mainly ultisols and the site is classified locally as kulfo series with pH ranging between 4.0 and 5.5. The soils have been described as the acid sands derived from unconsolidated grits and sand stones containing clay peds of varying proportions (Orimoloye, 2011).

Experimental Design and Field Layout*:* The treatments involved sole rubber and snake tomato and their intercropped combination (rubber-snake tomato intercrop) with NPK (applied at 60 kg N ha^{-1}) and rubber effluent application (0, 50, 60 and 70 kg N ha^{-1}) laid out in a randomized complete block in three replicates. The treatments were:

RE1RS - Rubber effluent at the rate of 50 kg N ha^{-1} intercropped with rubber and snake tomato.

RE1ST- Rubber effluent at rate of 50 Kg N ha^{-1} cropped with sole snake tomato

RE2RS- Rubber Effluent at application rate of 60 Kg N ha^{-1} intercropped with rubber and snake tomato

RE2ST- Rubber Effluent at application rate of 60 Kg N ha^{-1} intercropped with sole snake tomato

RE3RS- Rubber Effluent at application rate of 70 Kg N ha^{-1} intercropped with rubber and snake tomato

RE3ST- Rubber Effluent at application rate of 60 Kg N ha^{-1} intercropped with sole snake tomato

RSC- Rubber and Snake Tomato intercrop without fertilizer treatment

STC- Sole Snake Tomato without fertilizer treatment

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

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

For rubber component in the intercrop, the treatments were:

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

RE1SR- Rubber Effluent at application rate of 50 Kg N ha^{-1} cropped with sole rubber

RE2RS- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with rubber and Snake tomato (Intercrop)

RE2SR- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with sole rubber

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

RE3SR- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with sole rubber

RSC- Rubber and snake tomato intercrop control

SRC- Sole Rubber Control without fertilizer treatment

Cultural practices*:* The plot measuring 26 x 60 m was cleared of the existing vegetation manually with the aid of cutlasses and hoes, the debris was packed out of the plot and, thereafter, the field was marked out into plots measuring 3 x 7 m with one metre pathway. The rubber effluent was applied two weeks before the transplanting of the budded rubber stump to the designated plots as per treatment. The Rubber saplings (budded rubber stump) were transplanted to the field two weeks after application of effluent. The pulled budded

stump (young rubber) was placed in the hole in such a way that the budded patch is just above the ground level at a spacing of 3 x 7 m which gave rise to 476 stands per hectare, each plot had four rubber stand. Two-week old snake tomato seedlings were transplanted to the field one week after rubber saplings were transplanted at a spacing of 0.5 x 0.5 m which gave rise to a total of 40,000 plants ha^{-1}. The NPK fertilizer was applied to the designated plots as per treatment at two weeks after transplanting of snake tomato seedlings. The plots were irrigated immediately after planting. Missing stands were supplied eight days after transplanting. Weeds were controlled manually as and when due. The plants were sprayed with a mixture of neem leaf extract and garlic against lepidopterous larvae and fungus diseases (Law-Ogbomo *et al*., 2018).

Data Collection*:* Estimate of fruit yield was obtained from the fruit weight. Fruit weight per plant was obtained through the summation of all the harvested fruits from the sampled plants divided by the number of plant to obtain the average calibrated in kg. From fruit weight, fruit yield was estimated thus:

Fruit yield = $\frac{Fruit\ weight}{Ground\ area} \times 10\ t\ ha^{-1}$

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 estimator for gross margin was expressed as:

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

Returns per naira invested = $\frac{TR}{TVC}$

The total variable cost includes cost of labour on land preparation, sowing, transplanting, fertilizer application/manuring, vine caring, harvesting and processing; cost of planting materials, cost of NPK/rubber effluent, transportation, stakes and twine.

The data collected were subjected to analysis of variance using GENSTAT statistical package twelfth edition 2012 version. Means were separated using least significant difference (LSD) at 5 % level of probability

RESULTS AND DISCUSSION

Soil property and rubber affluent composition:

The soils were strongly acidic and low in organic C, total N, available P and exchangeable Ca (Table 1). This implied that the soil has low fertility status. This finding is in agreement with Law-Ogbomo and Osaigbovo (2018) who reported that most Nigerian soils are of low native fertility owing to the highly weathered soils coupled with leaching and continuous cropping. 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 chemical analysis of the rubber effluent used for the study showed that it is moderately acidic with total dissolved solids, chemical oxygen demand and biochemical oxygen demand (Table 2). It contained N, available P, organic C, K, Mg, Na and Ca in appreciable amount. This observation 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. This is an indication that rubber effluent, which ought to be a waste and pollutant to the environment can be made to be an avenue for wealth creation through its conversion to organic fertilizer.

Fruit yield*:* The highest fruit yield (169.20 t ha^{-1}) was observed in STNPK in the first year experiment and in the combined analysis. In the second year experiment, RSNPK (66.10 t ha^{-1}) and STNPK (63.60 t ha^{-1}) had the highest fruit yield (Table 3). This observation is in line with Esekhade *et al*. (1996) who reported that both food and horticultural crops can be intercropped with rubber during the immature period as they had no adverse effect on rubber. In both experiments and in the combined analysis, fruit yield increased with increase in rubber effluent application rate up to 70 kg N ha^{-1}. The reduction in fruit yield of snake tomato observed in plants without soil amendment 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 levels for some essential plant nutrients (total N, available P and exchangeable Ca). Apart from the nutrient being low, there could also be the problem of availability of phosphorus, calcium and magnesium to the plant since pH was less than 5.50 indicating strong acidity. The higher yield obtained from plants treated with NPK and higher rate of rubber effluent is a reflection of the application

of fertilizer to the soil through improved supply of nutrients to plants leading to better utilization of carbon and consequent synthesis of assimilates. Higher fruit yield was recorded in the first year experiment than in the second year experiment.

Economic return: Economic of snake tomato cropping in a newly established rubber plantation on fruit production is presented in Table 4. The total variable cost varied from ₦ 193,880.00 to ₦ 453,130.00 for RSC and STNPK, respectively. Generally, there was increase in total variable cost as the rubber effluent application rate increased up to 70 kg N ha^{-1}. The highest and lowest revenue, gross margin and return per naira invested were recorded with STNPK and RSC, respectively. Revenue, gross margin and return per naira invested increased with increase in rubber effluent application rate. Revenue, gross margin and returns per naira invested were higher in RE1RS, RE2RS and RE3RS than in RE1ST, RE2ST and RE3ST. RSC had negative gross margin and less than one in return per naira invested. This is an indication that fertilization is important for achieving 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 plants could be due to higher fruit yield. The unfertilized snake tomato plants both sole and intercropped were not viable due to poor yield production. The success of this system is an indication that rubber farmers can begin to draw revenue from their investment from the first year of cropping. This will result in economic development leading to improvement of their standard of living for sustainable rural development and poverty alleviation.

The results of the economic analysis of snake tomato intercrop in a two-year old rubber plantation treated with rubber effluent and NPK is presented in Table 5. Total variable cost increased with increase in rubber effluent application rate. The total variable cost ranged from ₦ 199,005.00 with RSC to ₦ 324,225.00 with RSNPK. Revenue, gross margin and return per naira invested followed the trend as the total variable cost. RE1RS, RSC and STC had negative gross margin and less than one in return per naira invested. RSNPK had the highest gross margin and return per naira invested. The revenue accrued from snake tomato from this initial stage is an indication that under-utilized land resources in the spaces between rubber plants at the early stage of its growth and development is efficiently utilized by snake tomato to ensure income flow to the farmers. This observation was in agreement with findings by Giroh *et al* (2011) who reported intercropping rubber with other crops was profitable and provided an additional source of revenue to farmers.

CONCLUSION AND RECOMMENDATION

The study shows that intercropping rubber plant with snake tomato and amending the soil with NPK and rubber effluent was economically viable. Apart from the first year of cropping, the fruit yields of both sole and intercropped snake tomato is comparable. Intercropping rubber with snake tomato enhanced income flow to farmers from the first year of the investment. Soils of the experimental site had low nutrient status. Fertilizer application increased the fruit yield of snake tomato and the profitability of the enterprise as the unfertilized plants were not economically viable. Based on the findings from this study, snake tomato intercropping with rubber should be supplemented with fertilizer application to improve the fertility of the soil for higher growth of rubber and fruit yield of snake tomato. The optimum returns were observed on fruit yield obtained from STNPK and RSNPK (sole and intercropped snake tomato treated with NPK applied at 60 Kg N ha^{-1} (400 Kg NPK ha^{-1})). Rubber-snake tomato intercrop treated with NPK applied at 60 kg N ha^{-1} (400 kg NPK ha^{-1}) is thereby suggested for small holder rubber farmers.

REFERENCES

Cohen, J.H., Kristal, A. R., and Stanford J.L. (2000). Fruit and vegetable intakes and prostate cancer risk. Journal National Cancer Institute. 92: 61-68

Esekhade, T.U., Ugwa, I.K. and Aigbekaen E.O., (1996). Suitability and Economic viability of intercropping in rubber in an acid sandy soil of Southern Nigeria. *Indian Journal Natural Rubber Research*, 9: 36–39

Giroh, D. Y., Francis, Y. S. and Jen, E.I. (2011). Economic analysis of intercropping rubber (*Hevea brasiliensis*) in the rubber growing areas of Edo and Delta States, Nigeria. *Global Journal of Pure and Applied Sciences*, 18(1&2): 15-18

Hailu, G. (2015). A Review on the Comparative Advantages of Intercropping to Mono-Cropping System. *Journal of Biology, Agriculture and Healthcare*. 5(9):1-14

Howstuffworks, (2013). Properties and uses of rubber. Retrieved from http://science.howstuffworks.com/life/botany/rubberinfo1.htm?&lang=en_us. Accessed June 1, 2013.

Knett, P.; Kumpulainen, J.; Jarvinen, R.; Rissanen, H.; Heliovaara, M.; Reunanen, A.; Halulinen, T. and Aromaa A. (2002). Flavonoids intake and risk of chronic diseases. *American Journal of clinical Nutrition* 76: 560-568

Law-Ogbomo, K. E. and Osaigbovo, A. U. (2018). Productivity of cucumber (*Cucumis sativus* L) and postharvest soil chemical properties in response to organic fertilizer types and rates in an ultisols. *Tropical and Subtropical Agroecosystems*, 21:513 – 520

Law-Ogbomo, K. E.; Ahmadu, R. and Ogedegbe, S. A. (2020). Comparative effects of some soil amendments on the agronomic performance of maize varieties in a low fertile soil. *Notulae Scientia Biologicae*, 12(1), 189-195.

Law-Ogbomo, K. E.; Osaigbovo, A. U.; Akaeze, O. O.; Osagie, J. O.; Nwaoguala, C. N. C.; Edegbe, I. C.; Edosa, V. I. O. and Adekunle, . T. (2018). Agronomic response of watermelon (*Citrulus lunatus* (Thumb) Matsum and Nakai) to plant population and fertilizer types in low fertile soil environment. *Journal of Forestry, Environment and Sustainable Development*, 3 (1): 30 – 35

Michael U (2006). Keynote address on the Presidential Initiative on Rubber Production and utilization. Rubber Research Institute of Nigeria, 17th January 2006.

Nigerian Rubber Association of Nigeria (2013): The Need for the revitalization of the rubber industry in Nigeria. *NRAN Press Statement* June 2013.

Orhue, E. R., Uzu, F., and Osaigbovo, A. (2007). Effect of Combining Rubber Effluent with Single Super Phosphate (ssp) on Some Soil Chemical Properties and Early Growth of Maize (Zea mays. L). *Journal of Agronomy*. 2.10.3923/ja.2007.250.261.

Orimoloye, J. R. (2011). Characterization and evaluation of some soils of southern Nigeria for rubber cultivation. Ph.D. Thesis, University of Ibadan, Ibadan, Nigeria 231 pp.

Sahlin, E.; Savage, G. P. and Lister, C. E. (2004). Investigation of the anti-oxidant properties of tomato after processing. *Journal of Food Composition Analysis*, 17:635-647.

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

Parameter	Soil
pH(H_2O) 1:1	5.40
Organic carbon (g kg^{-1})	17.20
Total nitrogen (g kg^{-1})	0.84
C:N	20.48
Available phosphorus (mg kg^{-1})	10.50
Exchangeable cation (cmol kg^{-1})	
Calcium	0.80
Magnesium	0.20
Ca/Mg	4.00
Potassium	0.16
Sodium	0.06
Exchangeable acidity (cmol kg^{-1})	
hydrogen	0.20
Aluminum	0.10
Particle size (gk g^{-1})	
Sand	886.00
Silt	61.00
Clay	55.00
Textural class	Sandy loam

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 soil amendment on fruit yield of snake tomato cropped in newly established rubber plantation

Treatment	Fruit yield (t ha^{-1})		
	1st	2nd year	Combined
RE1RS	28.60	23.10	25.90
RE1ST	28.30	27.90	28.10
RE2RS	52.20	36.70	44.50
RE2S2	50.20	37.90	44.00
RE3RS	86.40	40.80	63.60
RE3ST	71.40	45.50	58.40
RSC	17.00	21.10	19.10
RSNPK	135.20	66.10	100.70
STC	27.50	20.30	23.90
STNPK	169.20	63.60	116.40
Mean	66.60	38.30	52.40
$LSD_{(0.05)}$	20.230	9.820	10.550
$LSD_{(0.05)}$ year		4.720	

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

Table 4: Economic analysis of snake tomato cropped in a newly established rubber plantation treated with rubber effluent and NPK

Item cost and return (₦ 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	1995.200
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	67,500.00	65,400.00	85,250.00	82,500.00	138,000.00	119,250.00	51,250.00	199,000.00	64,400.00	241,500.00	871.100
Total variable cost	219130.00	217030.00	238880.00	236130.00	293630.00	274880.00	193880.00	410630.00	207030.00	453130.00	950.300
Revenue	250,250.00	247,800.00	456,750.00	437,500.00	750,000.00	624,750.00	148,750.00	1,183,500.00	240,800.00	1,480,500.00	315.000
Gross margin	31,120.00	30,770.00	217,870.00	201,370.00	456,370.00	349,870.00	45,130.00	772,870.00	33,770.00	1,027,370.00	63.000
Return per naira invested	1.14	1.14	1.91	1.85	2.55	2.27	0.77	2.88	1.16	3.27	0.055

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 a two year rubber plantation treated with rubber effluent and NPK

Item cost and return (N ha^{-1})	RE1RS	RE1ST	RE2RS	RE2ST	RE3RS	RE3ST	RSC	RSNPK	STC	STNPK	$LSD_{(0.05)}$
Land preparation	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	ns
Planting material	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	ns
Sowing	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	ns
Pre-emergent herbicide and its application	34,630	34,630	34,630	34,630	34,630	34,630	34,630	34,630	34,630	34,630	ns
Fertilizer and its application	9,000	9,000	11,000	11,000	13,000	13,000	0	69,000	0	69,000	1391.2
Stake collection and staking	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	ns
Harvesting, processing and packaging	58,875	64,875	75,875	75,375	81,000	86,875	56,375	112,625	55,375	109,500	552.8
Total variable cost	210,505	216,505	229,505	229,005	236,630	242,505	199,005	324,255	198,005	321,130	19.1
Revenue	202,125	244,125	321,125	331,625	367,000	398,125	184,625	578,275	177,625	556,500	58.3
Gross margin	-8,380	27,620	92,120	102,620	130,370	155,620	-14,380	254,020	-20,380	235,370	37.6
Return per naira invested	0.96	1.13	1.40	1.45	1.55	1.64	0.93	1.78	0.90	1.73	0.046

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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SIMPLE LINEAR REGRESSION ANALYSIS OF CLIMATIC VARIABLES ON THE YIELD OF PEARL MILLET (*PENNISETUM GLAUCUM* L.R. BR.) IN JIGAWA, NIGERIA

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ABSTRACT
A study was carried out to assess the effects of some selected climatic variables (rainfall, maximum and minimum air temperature, relative air humidity as well as sunshine duration) on the yield of pearl millet in three local government areas of Jigawa State. The experiments were conducted over 2016 and 2017 planting seasons at the experimental farm of Federal University, Dutste located at 11^0 42' N, 9^0 34' E [FUD], Bilyaminu Usman Polytechnic, Hadejia located at 12^0 48' N, 10^0 01' E (BUPH) and College of Education, Gumel located at 12^0 62' 9^0 38' E (COEG]) Jigawa State. The Experiment was laid on a randomized complete block design (RCBD) and replicated thrice, in each of the three locations, the total of 25m by 18m experimental area were splits into plots size of $5m^2$ with 1mtr distance between and within replicate to the study the effects of five climatic variables viz; rainfall, maximum and minimum temperatures, relative humidity and sunshine hour on the yield of pearl millet. Data collected were subjected to simple linear regression analysis at 5% probability level. The results revealed that contributes 40% to the development of tillers, relative humidity contributes 45% to spike length and sunshine hours 47% to the yield per hectare. At Gumel it was revealed that maximum temperature contributes about 51% to the number of tillers, relative humidity 58% to yield per plot and the sunshine hour contributes about 68% to the yield per hectare. At Hadejiya the results shows that relative air humidity contributes 51% while maximum air temperature 41% and 46% respectively.

Keywords: *Linear regression, climatic variables, yield, Pearl Millet*

INTRODUCTION

Between January and March 2021, the agriculture contributed to 22% of the total Gross Domestic Product. Over 70% of Nigerians engage in the agriculture sector mainly at a subsistence level (FAO, 2021). Despite the contribution to the economy, Nigeria's agricultural sector faces many challenges which impact on its productivity climate change inclusive (FAO, 2021). Agricultural produce in Nigeria is mostly rain fed. Unpredictable rainfall variation makes it difficult for farmers to plan their operations (Anabaraonye *et al.*, 2019; BNRCC, 2011., Huma Heidar, 2019)). Higher temperatures, lower rainfall, droughts, and desertification reduces farmlands, lowers agricultural productivity and affects crop yields (Huma Heidar, 2019). Crop growth and development is mainly a function of temperature if water is available to the optimum satisfaction. Although weather and climate have never been constant and they have always experienced changes either positive or negative. Increased temperature will affect the physiological processes necessary for crop growth and development of crops and ultimately crop yields are most likely to drop over the present level. A climatic anomaly plays an important role in increasing the uncertainties in crop production. (Rasul, *et al*, undated). Agriculture has been the mainstay of livelihood for over 90% of the population of Jigawa State. Agriculture is heavily reliant upon rainfall and the use of traditional implements. Out of the 2.24 million hectares total land area of the State, about 1.6 million hectares are estimated to be cultivated during the raining season while about 308,000 hectares of the land mass is potential for irrigated cultivation. The major crops in state are the rainy and dry season crops. Rain fed crops include millet, sorghum, cowpea, groundnuts, sesame, rice, maize, sweet potatoes, Bambara nuts, water melon, cassava, cotton, okra, Roselle and water melon. And the dry season farming production include tomatoes, pepper, onions, wheat, sugarcane, carrots, cabbage, lettuce, maize and a host of other leafy vegetables. About 11 years assessment of crop farming shows that the State largest crop production is millet and sorghum with an average of 491M/Tons and 460M/Tons per year respectively (Jigawa state ministry of agriculture, 2013). However, production levels fluctuate each year. Perhaps due to changes in climate experienced in recent times. Although climatic variables are natural and beyond human manipulations, there are other factors of

productions that may compound the problem of crops production, millet in particular.

Linear regression analysis is one of the most important and commonly used statistical methods that serve three major purposes: (I) description, (2) control, and (3) prediction (Neter, Kutner, Nachtsheim, and Wasserman, 1996, Alejandro,2008). According to Larsen, regression models are statistical models which describe the variation in one (or more) variable(s) when one or more other variable(s) vary. Inference based on such models is known as regression analysis (Larsen, 2003, Alejandro,2008). Regression takes us one large step further. A regression is a test to see if we can predict one variable's value if we know the value of another variable (or variables). Here, we will limit ourselves to Simple linear regressions, which fit the data to a straight line. Regressions are really Cartesian geometry, the classical formula y = mx+b and the X and Y axis chart; where, the X axis is our independent variable, and the Y axis is our dependent variable. Linear regression analyzes the relationship between two variables, X and Y. For each subject or experimental unit, you know both X and Y and you want to find the best straight line through the data. In some situations, the slope and/or intercept have a scientific meaning. In other cases, you use the linear regression line as a standard curve to find new values of X from Y, or Y from X (Neter, *et. al*, 1996, Alejandro, 2008). Linear regression is discussed as a technique that is used to analyze a response variable Y which changes with the value of the intervention variable X Sellam and Poovammal (2016)

MATERIALS AND METHODS

Field experiments were conducted over 2016 and 2017 planting seasons at the experimental farm of Federal University, Dutste situated at 11^0 42' N, 9^0 34' E [FUD], Bilyaminu Usman Polytechnic, Hadejia situated at 12^0 48' N, 10^0 01' E (BUPH) and College of Education, Gumel situated at 12^0 62' 9^0 38' E (COEG]) all in Jigawa State. Soil samples were collected at 0 - 20cm and 20-50cm depth. Four treatments (SOSAT C-88 [LCIC – MV1] and LCICMV4 Jirani [improved varieties], Zango (V_3) and Matsangari [local varieties] obtained from Jigawa State Agricultural and Rural Development Agency (JARDA) were laid (RCBD) replicated thrice. A total of 25*18m experimental area were splits into plots size of $5m^2$ with 1mtr distance between and within replicate to the study the contribution of rainfall, maximum and minimum air temperature, relative air humidity as well as sunshine duration on pearl millet in three local government area of Jigawa State viz; Dutse, Gumel and Hadejia. Almost the same farm management practices were employed and applied to the three selected site throughout the two growing seasons under studying. The land was first cleared prior to the commencement of onset of the rain for both the seasons. At the onset of rain, the field was then ploughed, harrowed and ridged. Data collected were analyzed using the descriptive statistics and regression analysis procedures of stata (2011), minitab version (16) and SAS (2003), tested at 5% significant level.

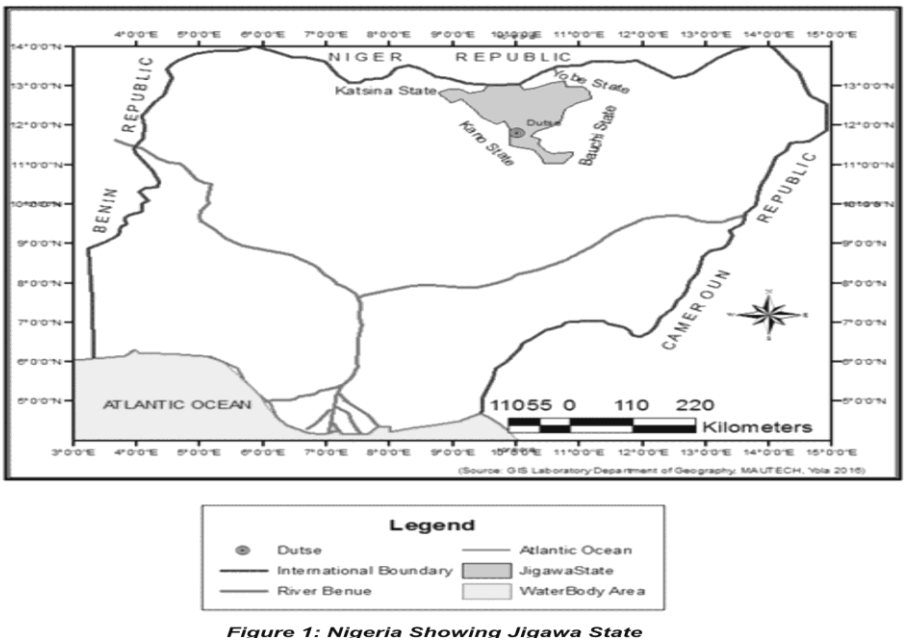

Figure 1: Nigeria Showing Jigawa State

RESULT AND DISCUSSION

The coefficient of Maximum Temperature (MXT) is significant and the result suggested that increase in MXT reduces the growth of tillers as indicated by the equation in Dutse. A unit increase in maximum temperature leads to decrease in the number of tillers by 15 units on average. maximum temperature contributed up to 20% to the growth of tillers as shown in Table 1. The same trend was observed with RH and SS, but their percentages contribution differs. The former contributed about 40% while 22% by the later. The result revealed that increase in maximum temperature increases the growth of spike length as indicated by the equation on Table 1. Here, a unit increase in maximum temperature led to an increase in spike length by 15 units on the average. It can also be seen from the table above that the maximum temperature contributed up to 26% to the growth of the spike length. The trend, however, differs between Minimum temperature (MNT) and Relative Humidity (RH) as the former indicates a decrease in the number of the spike length by 9 units which contributed about 39% while the later portrays increase in spike length by 2 units by which contributed about 45%. With regards to the Panicle Diameter (PDM), the Table shows decreased panicle diameter with increased RF. In this case, a unit increase in RF leads to a decrease in panicle diameter by 0.5 units on the average. The contribution of relative humidity reaches around 43% in the growth of panicle diameter. Here the trend shows a significant difference between the RF and SS, the former indicates a decrease in the number of panicle diameter by 0.5 units and contributed about 43%, while SS indicates significant increase in panicle diameter by 3cm and contributed to the growth of panicle diameter by 44%. On the weight of grain per panicle, the decrease in relative humidity decreases Weight of Grain Per Panicle (WGHT) as contained in the equation. The relative humidity decrease leads to a decrease in weight of grain per panicle's by about 1unit on the average. The contribution of SS is only around 12% to the growth of weight of grain per panicle but with a decreased unit of averagely 0.4kg. The relative humidity in respect to Yield Per Meter Square (YMSQ) appears also to be significant with the percentage contribution of 31% as observed from the R – value (0.31). The result however reveals that a unit decrease in RF leads to a decrease in yield per meter square by 0.01kg and the trend however shows that as SS increases the yield per meter square by 0.7kg. The contribution of SS reaches around 41% on the yield per meter square. On the yield per plot, the decrease in RF also decreases yield per plot. It shows that Yield per Plot (YPPL) increases, with the increasing SS, a signification of a difference in the trend. The RF's contribution is around 31% while that of SS is around 41% as indicated by the R – value of each. A unit increase in SS leads to an increase in yield per plot by 3kg on the average. Yield per hectare increase with the increase in RH by 107kg on the average. Same trend was observed with SS, yield per hectare increases with increased SS. The contribution of RH and SS is 0.27 (27%) and 0.47 (47%) respectively. Unlike the case of RH and SS, the yield per hectare here decreases with the decreased in RF as contained in the equation in Table 1. As rainfall decreases by 24mm, yield per hectare will decrease by about 24kg per hectare on the average and contributed around 29% on the yield per hectare as indicated by the R^2 value. The result on the contribution of climatic variables on Table 2 suggested that increase in maximum temperature reduces the growth of tillers as indicated by the equation in Gumel. A unit increase in maximum temperature leads to decrease in the number of tillers by 5 units on average. Maximum temperature contributed up to 51% to the growth of tillers as shown in table 2. The same trend was observed with minimum temperature and it contributed about 49% to the growth of tillers. But the result shows that SS contributed positively to the development and growth of tillers with the percentage contribution of about 35%. Here as SS increases the number of tillers is expected to increase by about 6 on the average. It can be clearly understood that increase in maximum temperature reduces the growth of the Spike length (SPL) as indicated by the equation. The result however, reveals that a unit increase in maximum temperature leads to a decrease in SPL by 3cm on the average. In this case, the trend shows a variation between minimum temperature and SS as the former indicates decrease in the SPL with increase minimum temperature by 2units while the later (SS) leads to increase in the SPL by 4units on the average. The contribution of minimum temperature is around 34% while SS reaches around 32% as shown from the R – value on the Table 2.

The panicle diameter (PDM) decreases with the increased minimum temperature. A unit increase in minimum temperature leads to the decrease in panicle diameter by 0.4cm on the average which is quite insignificant. The RF

on the other hand, increases the growth of Yield per Plot (YPPL) by 0.04 and contributing about 44% on the average in the same location (Gumel). The trend here is in the same line as the increase in RH too increases the growth of YPPL by closely 5units. While its (RH) contribution to the increase yield per plot reaches around 58% which is quite significant. The table also shows that; maximum temperature's increase leads to the decrease in the Yield per Hectare (YPHEC). Thus, a unit increase in maximum temperature leads to a decrease in yield per hectare by 7kg on the average as indicated by Table 2. The contribution of maximum temperature here is around 45%. Increase in minimum temperature causes decrease in yield per hectare by 54.2kg and contributed around 68% as shown by the R – value. The trend reveals similarity between RH and SS as their increase leads to increase in yield per hectare. The RH increase leads to the growth of YPHEC by 176kg on the average while an increase in SS stimulates the growth increase in yield per hectare by 622kg and their contributions fall around 21 and 22% respectively. This trend is particular to Gumel location. This is similar to the report of Jin *et al*., (2018) that an average annual increment of 30 kg ha^{-1} to 121 kg ha^{-1} in the yields of millet as the temperature rose in three different cities in China (Xifeng, Anding, and Ganzhou). The result of simple linear regression of Maximum Temperature (MXT) and number of tillers (NT) reveals that increase in the maximum temperature reduces the increase in the number of tillers by approximately 2 units on the average. Maximum temperature contributes up to 27% to the growth of number of tillers as observed from Table 3. The trend differs between relative humidity and sunshine hour as the former indicates that its increase leads to a decrease in the tillers by around 3units while sunshine hour increase leads to the increase in the tillers by 7units on the average. Here, relative humidity and sunshine hour contributed around 51, and 18% to the growth of tillers respectively. With regards to spike length, the increase in maximum temperature leads to an increase in spike length by 5 units on the average. The contribution of maximum temperature is around 41% as indicated by the R- value. From the same Table 3, the simple linear equation on the contribution of relative humidity to the growth of spike length is 57% but it further increases lead to the decrease of the spike length by 1cm. Similar to maximum temperature, sunshine hour had positively contributed up to 17% to growth of spike length which shows a unit increase in sunshine hour will increase spike length by about 14cm. On yield per meter square, the contribution of maximum and minimum temperatures and relative humidity reaches around 19, 21 and 30% respectively. While increase in maximum temperature leads to an increase of yield per meter square by 0.06kg, but increase in minimum temperature and relative humidity decrease yield per meter square by 0.7 and 0.1 kg respectively. The simple regression results on the yield per plot and yield per hectare in Table 3 shows a similar trend in both maximum and minimum temperatures as well as relative humidity. The contribution of maximum and minimum temperatures, and relative humidity to the yield per plot is 18, 18 and 24% while that of yield per hectare is 46, 19, and 23% as contained in Table 3. However, the result shows that a unit increase in maximum temperature leads to an increase in the yield per plot and that of yield per hectare by 0.33kg and 189kg while an increase in minimum temperature and relative humidity leads to a decrease in both yield per plot and per hectare by 0.74, 0.11kg and 272, 39kg respectively. Similar to this findings Kenneth, (2014) reported that the R value of 0.688 and R square of 0.474 meaning temperature explains 47.4% of yield variation in rice. Y = 12.621 + -0.336 * Temperature.

CONCLUSION

In the present study, maximum temperature and relative humidity are the two climatic variables that each influenced growth of tillers in Dutse. At Gumel minimum temperature and sunshine hours contributed much to the development and growth of tillers in the area. The simple linear regression result obtained at Hadejia revealed that maximum temperature contributed 27%, relative humidity 51% and sunshine hours 18% to tiller development. The growth of spike length in Dutse indicated an increase with the increase in maximum temperature and a decreased with the increase in relative humidity and sunshine hours in the same location. The contribution of maximum temperature to the growth of spike length in Gumel is different from that of Dutse, here the spike length decreases with increasing maximum temperature. On the other hand, the growth of spike length increases with the increase in

relative humidity and sunshine hours in the same location. The same climatic variables influenced the growth of spike length at Hadejia. For the panicle diameter, rain fall and sunshine hour are the two climatic elements that each influenced the increase in the size of panicle diameter in Dutse, while minimum temperature that was the only climatic variable that contributed to the growth of panicle diameter in Gumel and Hadejia respectively. On the weight of grain per panicle, it was found that only in Dutse location where rainfall and sunshine hour exercised their individual influence to the attainment of the weight of grain per panicle. The rainfall and sunshine hour in respect to yield per meter square appears to be significant also only in Dutse location with the percentage contributions of 31% and 41%. At Hadejia the yield per meter square is influenced by maximum and minimum temperatures and relative humidity which their individual contribution reaches around 19, 21 and 30% respectively. The contribution of each climatic variable on the yield per plot at Dutse revealed that only rainfall 31% and sunshine hour 41% have influence over yield per meter square. At Gumel, it is influenced by climatic variables rainfall 44% and relative humidity 58%. At Hadejia the contribution of maximum and minimum temperatures, and relative humidity to the yield per plot is 18, 18 and 24%. The contribution of individual climatic variable on the yield per hectare used in this study, revealed that at Dutse both rainfall, sunshine hour and relative humidity contributed positively to the increase in the yield per hectare. At Gumel maximum and minimum temperatures contributes 45% and 68% but their further increase brings about decrease in the yield per hectare 7kg and 52kg respectively. While rainfall 21% and sunshine hour 22% increase leads to the increase yield per hectare by 176kg and 622kg on the average. Similar result was reported at Hadejia on yield per hectare where maximum as well as minimum temperatures, and relative humidity contributed 46, 19, and 23% respectively.

REFERENCES

Abdulkadir, N.A and Mohammad, A.A. (2016): Assessment of Some Macro Nutrients Status in the Surface Soil of Kano University of Science and Technology, Wudil, Research Farm Gaya, Kano State. Nigeria. Journal of Environmental, Technology and Sustainable Agriculture Vol. 2(1), December, 2013 Special series, Pp. 65 – 68.

Bello, M. S., Roel M., Jibrin, M.J., Alpha, Y.K and Jairos, R (2018): Quantifying Variability in Maiza Yield Response to Nutrient Application in the Northern Nigerian Savanna. Agronomy 2018, 8(2), 18; Available at https://doi.org/10. 3390/ agronomy8020018.

Brady, N.C. and Weil. R.R. (2013). The Nature and Properties of Soils. 14th Ed. Prentice Hall Upper Saddle River Pp960.

Coskun, G., Imanverdi, E., Feride, C., and Zeynep, D. (2016): Spatial Variability of Soil Physical properties in a cultivated field. Eurasian Journal of Soil Science 2016, 5 (3) 192 – 200.

Dos Santos, R. D., Neves A. L. A., Pereira L. G. R, Sollenberger L. E., Rodrigues J. A. S., Tabosa J.N., Verneque R. S., Oliveira G. F., Jayme D.G. and Gonçalves L. C. (2016): Agronomic traits, ensilability and nutritive value of five pearl millet cultivars grown in a Brazilian semi-arid region. *Journal of Agricultural Science* (2016), 154, 165–173. © Cambridge University Press 2015.

Ekinya, E.E. (2013): Preliminary Evaluation of Different Sources of Organic Manuar on the Production of Okro (Abelmoschus Esculentus L. Moench) in Bauchi State. Journal of Environmental, Technology and Sustainable Agriculture Vol. 2(1), December, 2013 Special series, Pp. 54 – 60.

Food and Agriculture Organization (FAO, 2021). Nigeria at a Glance. Available at https://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/

Gangaiah, B. (2012). Agronomy Kharif Crops Millets Soeghum (Jowar) Pearl Millet (Bajra) Finger Millet. Indian Agricultural Research Instituted, New Delhi. Pp. 1 – 27.

Huma Heidar (2019). Climate change in Nigeria: impacts and responses. Helpdesk Report UK Department for International Development and other Government departments, but the views and opinions expressed do not necessarily reflect those of DFID, the UK Government, K4D or any other contributing organisation.

Jacques, R.T (2014): Relationship Between Soil Physical Properties and Crop Yields in Different Cropping System in Southern Cameroon. PhD. Dissertation. Institute of plant Production and Agroecology in the Tropics and Subtropics, University of Hohenhein, Germany.

Jukanti A. K., Laxmipathi, C. L., Gowda, Rai K. N., Manga, V. K. and Bhatt R. K. (2016) : Crops that feed the world 11. Pearl Millet

(Pennisetum glaucum L.): an important source of food security, nutrition and health in the arid and semi-arid tropics. Food Security. Doi.10.1007/s/1257-016-0557-y accessed 13/09/2017

Khairwal *et al* (2007). Pearl Millet Crop Management and Seed Production Manual. Patancheru 502 324, Andhra Pradesh, India: International Crop Research for Semi-Arid Tropics. Pp. 104.

Kwari, J.D., G.I.C Nwaka and R.I. Mordi (1999): Syudies on Selected Soil Fertility Parameters in Soils of North eastern Nigeria. Phosphate Sorption. Journal of Arid Agriculture (1999). 9.61 – 70.

Mohammad, N. A., Mehrdad, G. D., Mohaddeseh, S. P., Javad, J., Javad, S. K., and Roghayeh, J. (2017): Relationship of Soil Physical and Chemical Properties with Ecological Species Groups in *Pinus Taeda* Plantation in Northern Iran. BIODIVERSITAS ISSN: 1412-033X Volume 18, Number 1, January 2017 E-ISSN: 2085-4722. Pp. 422-426.

Mohammed, S., and Ahmed, M.M (2016): Soil Suitability Assessment for Pearl Millet Cropping in Musawa Area, Katsina State, Nigeria. Pyrex Journal of Plant and Agricultural Research Vol 2(1) pp. 37-43 April, 2016 available at http://www.pyrexjournals.org/pjpar.

Maman, G. (2014): On-Farm Assessment of Physico-Chemical Properties of an Arenosol under Application of Mineral Fertilizers and their Impact on the Yield of Millet in the Sahelian Zone of Niger. Unpublished PhD. Thesis Department of Crop and Soil Sciences, Faculty of Agriculture, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, September, 2014 Pp. 1 – 189.

Maman Garba, Vincent Logah, Jasmien Wildemeersch, Sabiou Mahaman, Guéro Yadji, Charles Quansah, Mensah Bonsu, Wim Cornelis & Robert C Abaidoo (2015): Improvement in physical quality of a Sahelian Arenosol and implications on millet yield, Archives of Agronomy and Soil Science, DOI: 10.1080/ 03650340. 2015. 1104414.

Olaitan, S.O. and Lambin, G. (1998): Introduction to Tropical Soil Science. Macmillan Publishers Ltd London.

Olojugba M. R. and Fatubarin A. R (2015): Effect of seasonal dynamics on the chemical properties of the soil of a Northern Guinea savanna ecosystem in Nigeria. *Journal of Soil Science and Environmental Management.* Article Number - CA91D5552493 Vol.6 (5), pp. 100-107, May 2015. https://doi.org/DOI 10.5897/ JSSE M13 . 0414

Oyewole, C.I. (Undated): Millet Growing Areas in the World. Department of Crop Production, Faculty of Agriculture, Kogi State University, P.M.B. 1008, Anyigba, Kogi State, Nigeria

Ramawatar M., Maurya, S.K. and Raj Kumar M. (2017): Productivity, Soil Properties and Economics of Rainfed Pearl Millet as Influenced by Mulching and Organic Sources of Nutrients. International *Journal of Current Microbiology and Applied Sciences*. ISSN: 2319-7706 Volume 6 Number 2 (2017) pp. 566-574. Available at http://dx.doi.org/ 10.20546/ijcmas.2017.602.064

Salem, A., Askira, M.S., and Umar, S. (2016): Status and Distribution of Exchangeable CA and K in Soils of Dadin Kowa Gombe State, Nigeria. *Dutse Journal of Agriculture and Food Security* (JUJAFS) Vol. 3 No. 2, December, 2016. Pp. 7 – 12.

Alejandro, R.V. (2008): Linear Regression Analysis to Study Transportation Cost Variances within Divisions at Company XYZ. A Research Paper Submitted in Partial Fulfillment of the Requirements for the Master of Science Degree in Technology Management. The Graduate School University of Wisconsin-Stout December, 2008. Pp. 1 – 52

Jin, W., Sai Karanthi, V., Rachit, S., Valerie, O. and Vijaya, R (2018): Effect of Climate Change on the Yield of Cereal Crops: A Review. *Climate* 2018, *6*(2), 41; doi: 10.3390/cli6020041

Kenneth, P. (2014): Rainfall and Temperature Correlation with Crop Yield: The Case of Asunafo Forest, Ghana. *International Journal of Science and Research*. Volume 3 Issue 5, May 2014

Table 1: Result of Simple linear regression on the contribution of each climatic variable on the yield Parameters and component in Dutse location

Parameters and component	Equation	R^2 (%)
Number of tillers	Y = 497.46 -14.69MXT	0.20
	Y = 137.94 – 1.46RH	0.40
	Y = 116.71-13.18SS	0.22
Spike length	Y = 456.30+15.17 MXT	0.26
	Y = 228.70 -9.04 MNT	0.39
	Y = -78.03+1.42RH	0.45
panicle diameter	Y = 9.27-0.055RF	0.43
	Y = -14.08 + 3.11SS	0.44
Weight of grain per panicle	Y = 1.050 - 0.008 RF	0.18
	Y = -2.49+0.477 SS	0.21
Yield per meter square	Y = 1.342 - 0.011RF	0.31
	Y = -3.979 + 0.719SS	0.41
Yield Per Plot	Y = 6.709 - 0.056 RF	0.31
	Y = -19.893 + 3.597SS	0.41
Yield Per Hectare	Y = -6511.45 +107.30RH	0.27
	Y = -9709.92 + 1686.27SS	0.47
	Y = 2644.59 - 23.98RF	0.29

Table 2: Result of Simple linear regression on the contribution of each climatic variable on the yield Parameters and component in Gumel location

Parameters and component	Equation	R^2 (%)
Number of tillers	Y = 200.18 - 5.16MXT	0.51
	Y = 110.318 – 3.321 MNT	0.49
	Y = -1.93 + 5.552SS	0.35
Spike length	Y = 134.91 – 3.356 MXT	0.28
	Y = 81.93 – 2.404MNT	0.34
	Y = -2.85 + 4.554 SS	0.32
Panicle diameter	Y =17.44- 0.439 MNT	0.22
Yield per plot	Y = 2.085 + 0.044RF	0.44
	Y =-32.83 +0.478RH	0.58
Yield Per Hectare	Y = 24221 - 710.88MXT	0.45
	Y = 13770 - 542.217MNT	0.68
	Y = -12285 + 176.83RH	0.21
	Y = -2694.73 + 622.76 SS	0.22

Table 3: Result of Simple linear regression on the contribution of each climatic variable on the yield Parameters and component in Hadejia location

Parameters and component	Equation	R^2 (%)
Number of tillers	Y = -16.60960 + 1.66628MXT	0.27
	Y = 90.98376 - 0.69938RH	0.51
	Y = -14.99340 + 7.69597SS	0.18
Spike length	Y = -95.48771 + 3.93414MXT	0.41
	Y = 38.808919 – 1.40285RH	0.57
	Y = -66.18142 + 14.27946SS	0.17
Yield per Meter square	Y = -1.37133 + 0.06814MXT	0.19
	Y = 4.27619 - 0.15749MNT	0.21
	Y = 2.80902 - 0.02584RH	0.30
Yield per plot	Y = -6.68692 + 0.33652MXT	0.18
	Y = 20.38263 - 0.74101MNT	0.18
	Y = 13.10745 - 0.11689RH	0.24
Yield Per Hectare	Y = -4370.31301 + 189.25251MXT	0.46
	Y = 7630.68401 - 272.11408MNT	0.19
	Y = 4710.24187 - 39.75914RH	0.23

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BIOCHEMICAL AND PHYTOCHEMICAL ANALYSES OF AVOCADO, CASHEW AND SOURSOP LEAVES

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ABSTRACT
Ethno-medicine has widespread in all field of medicine and gradually taking over the orthodox medicine with different range of products The chemical composition of young and matured leaves of Avocado *(Persea americanna),* Cashew *(Anacardium occidentale),* and Soursop *(Annona muricata)* was evaluated in the Central Research Laboratory unit of the Faculty of Agriculture, University of Benin, Benin City, Nigeria. The proximate composition was investigated using the weende system, while the phytochemicals were determined by gravimetric and spectrophotometric methods. Matured leaves of avocado had the highest amount of crude protein (25.76 %) which was not significantly ($P<0.05$) different from that in matured leaves of soursop (23.92 %). The matured avocado leaf also contained the highest amount of ash (15.85 %) and crude fiber (21.20 %) but with the lowest amount of oil (5.17 %). Matured soursop leaf had the highest amount of oil (19.70 %. The NFE (nitrogen free extract) values ranged from 17.25 % in matured soursop leaf to 48.8 % in young cashew leaf. The matured leaves of soursop recorded the highest levels of calcium, magnesium, sodium, and phosphorus, while young soursop contained the highest amount of potassium. The phytochemicals present in the leaves were alkaloid, tannin, flavonoid, phenol and saponins of which matured soursop leaf recorded the highest concentrations (1.10, 7.57 and 3.15 respectively). Tannin levels ranged from 0.18 in matured cashew leaf to 0.42 in young cashew leaf, with significant differences ($p<0.05$) between the leaf samples. The phytochemicals content of these plants' leaves make them medicinal potentials in therapeutic usage while the mineral and nutrition contents enhance their usage as leafy vegetable for human and animal consumption.

Keywords: *Laboratory, leaf sample, phytochemicals, proximate composition.*

INTRODUCTION

The practice of ethno-medicine is based on the fact that in addition to the biochemical or nutrient groups, plants contain phytochemical substances that can improve the quality of health. Phytochemicals are non-nutrient, secondary metabolic compounds which occur in the different parts (leaves, bark, roots, fruits, pods and seeds) of plants. They have continued to attract scientific interest because when ingested at tolerable levels, they may function as nutraceuticals, promoting nutritional physiology and health of organisms (Thomas, 2000). There is ample evidence supporting the health benefits of food (fruits, vegetables, legumes, whole grains and nuts) and non-food plant parts (Ajebesin, 2011). It has being an ancient practice to use extracts of leaves as drugs, and this has been proven to be effective, most often based on ancestral experience. The leaves are usually extracted in boiling water or in liquor, and administered orally to treat disorders like malaria, diabetes, cardiac related diseases, ulcers, and toothache (Edeoga *et al*, 2005). For the leaves there are three stages of growth (young, medium and matured stages) occurring in flowering plants. This suggests that the occurrence and concentration of chemical components in the leaves may vary according to stage of growth. The need for a scientific approach in exploring plants for health purpose is the premise of this study. It was conducted with the objectives to determine by chemical analyses, the proximate, mineral and phytochemical components of the leaves of three common fruit trees (avocado, cashew, and soursop) exploited as herbs in Nigeria; and to determine the variability in type and concentrations of their phytochemicals at the young and matured stages of growth.

MATERIALS AND METHODS

Sample collection, experimental design and preparation

The leaves of avocado, cashew, and soursop trees were harvested from different orchards found within the University campus in Ugbowo, Benin-City, lying between latitude $5^0.45'$ and

$7^0.00'$ N and longitude $5^0.60'$ and $6^0.56'$ E. Average weather conditions are Temperature 27 – 32 ^{0}C, Relative humidity 79-90 % and annual rainfall of about 2000 mm. The treatments involved two growth stages of the leaves (young and matured) from avocagro (*Persea americanna*), cashew (*Anacardium occidentale*) and soursop (*Annona muricata*) making six treatments laid in a complete randomized design and replicated time times. Three trees from each of the three different plants species - avocado, Cashew, and Soursop were sampled. Thus a total of eighteen (18) samples were collected and transferred to the Central Research laboratory of the Faculty of Agriculture, University of Benin, where analytical work was performed. The fresh leaves were spread on cardboard, placed on clean table slab, to dry gradually under ceiling fan set at medium speed and at room temperature, for four days, to avoid loss of active compounds. Dried leaf samples were then milled into powder using a Tecator sample mill. The milled samples were then dispensed separately into air-tight, water-proof sample pouches, zipped, labelled and kept on shelve in air-conditioned room (14 ˚C) prior to analysis.

Chemical analysis Proximate analysis: Proximate analysis was performed for moisture content, crude protein, crude fiber, ash content (mineral) and the nitrogen free extract (soluble carbohydrates). Standard analytical techniques recommended by the Association of Official Analytical Chemists were used (AOAC, 2010).

Crude Protein: Two (2) grams of each sample was transferred to a Kjedhal flask. Then an amount (20ml) of conc. sulfuric acid (H_2S0_4) and 1g of selenium catalyst were added. The solution was then heated until it became colorless. The process converts protein nitrogen to ammonia in the form of ammonium sulfate. Sodium hydroxide (NaOH) was added to the digest to liberate the ammonia; which was distilled off, collected into about 5 ml of boric acid and determined by titration. Based on the assumption that the nitrogen content of protein is 16 %, the crude protein (CP) content of sample was computed by multiplying nitrogen content determined by the classical factor (6.25), according to the following equations and calculations:-

Stage 1: $(NH_2) + H_2S0_4$ —— $(NH_4)_2S0_4 + CO_2 + O_2$

Stage 2: $(NH_4)_2S0_4 + NaOH$ —— $NaS0_4 + 2NH_3 + H_2O$

% N= VA x V_F x MW_N /100 Ws x aliquot. $\%\ CP = \%\ Nr\ x6.25$

Where: VA - volume of acid used in titration, V_F - volume of volumetric flask used for digestion. MW_N - molecular weight of nitrogen (0.00014), Ws - weight of sample.

Ash Content: Two (2 g) of sample was measured into a previously weighed and ignited crucible, then placed in muffle furnace and heated at 560 °C for 6 hours to ash indicating combustion of the organic matter in the original sample. Following, the residue (ash) was removed from the furnace, cooled in a desiccator and weighed. The ash content is expressed thus: Weight of ash/Weight of sample x 100/1.

Ether Extract: Fats and fatty substances are characterized by their solubility in the series of organic solvents and this phenomenon was utilized in determining the lipid content of the various samples, crude lipid was determined following extraction with petroleum ether as solvent in soxhlet extractor. Then the solvent was distilled off and the residue was dried for over an hour in a vacuum oven set at 72 °C. Following, residue was cooled, desiccated and weighed. The drying and weighing process was repeated severally until a constant weight was attained. Thus ether extract (EE) content of sample was calculated using this equation: %Ether extract = Weight of oil / Weight of sample x 100 /1

Nitrogen Free Extract: This represents the soluble carbohydrate component of organic matter in samples; and was determined by arithmetic: the summation of the values of ash, crude protein, ether extract and crude fiber components of the samples; and subtraction of that sum from the total dry matter content of sample - % NFE= % DM - % (CP + Ash + EE).

Mineral analysis: The triple acid digestion method of Sahrawat *et al.* (2002) was employed for mineral analysis. Each leaf sample (1g) was weighed into a micro-Kjeldahl digestion flask to which 20 cm^3 of mixture of concentrated HNO_3, H_2SO_4, and 60 % $HClO_4$ (9:2:1v/v) were added. The flask was put on a heating block and digested to a clear solution, cooled and then content was transferred into a 100 cm^3 volumetric flask and made-up to mark with distilled water. The solution was used for determination of mineral elements

Phytochemical analysis: Aqueous and ethanol extracts of the leaves were analyzed for the presence of saponins, alkaloids, tannins and oxalate using prescribed qualitative and quantitative methods

Determination of saponins: The method used for determination of saponins was that described by Obadoni and Ochuko (2001). Portions (5 g) of each leaf samples were measured in replicates and transferred into a conical flask. Then 25 ml of 5 % aqueous ethanol was added to each. The samples were heated over a hot water bath for 4 hours with continuous stirring at 55 ^{0}C. The mixtures were filtered and the residues re-extracted with another 50 ml of 20 % ethanol. The combined extracts were reduced to 40 ml over water bath at about 90 ^{0}C. The concentrate was transferred into a 250 ml separating funnel and 10 ml of petroleum ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated by using 10 ml of propan-2-ol. The extracts were recovered and each washed twice with 20 ml of 5 % aqueous sodium chloride. The remaining solution was heated over water bath to evaporate. Thereafter the samples were dried in the oven until a constant weight was obtained. The saponin was thus calculated as a percentage of initial sample weight.

Determination of Alkaloid: Alkaloid was determined using Harborne and Baxter (1999) method. Three replicate portions (2.5 g) of each leaf sample were weighed and each transferred into 250ml beaker. Then 100ml of 10% acetic acid in ethanol was added; then covered and allowed to stand for 4 hours. Thereafter solution was filtered and then extract was concentrated over a water bath to one-quarter of the original volume. Concentrated ammonium hydroxide (NH_2OH) was added to the extract drop wise until precipitation was completed. The whole solution was allowed to settle and then precipitate was collected and washed with dilute ammonium hydroxide and then filtered. The residue obtained was the alkaloid, which was dried and weighed.

Determination of tannin: Tannin concentration in leaf extract was determined using Van-Burden and Hobinson (1981) method. 500mg of each sample was weighed into a 50ml plastic bottle. 50ml of distilled water was added and shaken for one hour in a mechanical shaker. This solution was filtered into a 50 ml volumetric flask and made up to the mark. Then 5 ml of the filtrate was transferred with pipette into a test tube and mixed with 2 ml of 0.1M $FeCl_3$ in 0.1N HCl and 0.008 M potassium ferricyanide. The absorbance was measured in an SPC- 260 spectrophotometer set at 120 nm for 10 min.

Determination of oxalate: Total oxalate content was measured using the enzyme method as described by Lui *et al* (2009). Each sample (2g) was homogenized with 1.6ml 0.5 mol/L HCl first, and then diluted with 1ml distilled water. The homogenate was transferred into 10mL graduated tubes and heated in a boiling water bath for 20min. After cooling, distilled water was added to each tube to bring the volume of the homogenate up to 10ml, gently shaken and then left to stand overnight. The next day, about 1ml of the homogenate was clarified by centrifugation (12,000rpm for 10min) at 4^{0}C. Thereafter 0.016ml NaOH (2mol/L) was added accurately to 0.5 ml supernatant. Oxalate content in the extract was determined using 20mg oxalate oxidase in the form of dry powder. This was prepared from dried leaf samples. The samples were placed in 2 mL test tube, and about 0.1mL distilled water, 0.8 mL color reagent, and then 0.04 ml horseradish peroxidise (50U/mL) followed by 0.05-0.1mL oxalate extract were added in succession to initiate the reaction;, while the samples were kept in incubator for 90min. [The color reagent (pH4.0) was prepared by combing substances: 10mg of 4-aminoantipyrine, 25μL N, N-dimethylaniline per 100mL of 125mmol/L succinate-NaOH buffer with 75% alcohol (v/v)]. Following incubation, the absorbance of the reaction mixtures were read at 555nm in a SPC-260 spectrophotometer. Oxalate content was thus determined with reference to the standard curve which was prepared by adding 0,2,4,6,8,10 μg oxalic acid into 1mL reaction system respectively. The data was presented as mean mg oxalate/100g.

Statistical analysis: Analysis of variance was performed for the data generated from measurements and tests of significance were determined by Duncan multiple range tests.

RESULTS

Proximate composition of leaves: Crude protein (CP) content of matured soursop leaf and matured avocado leaf were not significantly different ($p>0.05$). Similarly, CP content of young soursop leaf, matured cashew leaf, and young cashew leaf were not significantly different ($p>0.05$). The crude fiber (CF) values between matured soursop leaf (21.51%) and matured avocado leaf (21.20%) were not significantly ($p>0.05$) different, just as CF of young soursop, young avocado and matured cashew also showed non-significant differences, while young cashew leaf was significant low

($p<0.05$) in CF content (Table 1). Whereas matured and young soursop leaves, and matured and young avocado leaves, differed significantly ($p<0.05$) in their Ash, crude protein, fiber, oil

Mineral components of leaves: Chemical analysis showed that the matured avocado and young avocado leaves, and the matured cashew and young cashew leaves were not significantly different ($p>0.05$) in their calcium (Ca) levels, but they differ significantly ($p<0.05$) from Ca content of matured soursop leaf (11941mg/kg) and young soursop leaf (8363mg/kg). The matured soursop leaf had the highest concentration of the element (Table 2). The potassium levels in the leaves of the three plant species were significantly different ($p<0.05$); whereas matured avocado, young avocado, matured cashew and young cashew leaves showed no significant differences ($p>0.05$) in their magnesium (Mg) levels while the concentrations in matured and young leaves of soursop were significantly different from the young and matured avocado and cashew leaves (Table 2).

Phytochemical components in leaves*:* The concentrations of alkaloid, tannin, flavonoids, phenol and saponin in matured and young soursop leaves were significantly different ($p<0.05$) (Table 3). Matured soursop had the highest contents of alkaloid, flavonoid and saponin while the young cashew leaves had the highest tannin and phenol contents. There were significant differences ($p<0.05$) between young and matured leaves of avocado in their concentrations of each of the phytochemicals measured except in alkaloid where the matured leaves had higher content than the young leaves. Also, matured and young cashew leaves showed no significant difference ($p>0.05$) in their alkaloid, flavonoid and saponin contents but differed significantly ($p<0.05$) in their tannins and phenol components.

DISCUSSION

The use of plant products in health care has gained a global popularity in recent years, many plant components have been extracted and used for various health conditions. The components are usually extracted from plant parts depending on their concentration and distribution within the plant; and are processed and packaged as nature care products and nutritional supplements (Gurib-Fakin, 2006). This study has proven that the young and matured leaves of soursop, avocado and cashew contained phytochemicals, nutrients and minerals in varying quantities and (EE) and soluble carbohydrates (NFE) values, their percentage dry matter (DM) and moisture content (MC) were not significantly different ($p>0.05$).

degrees. This observation is in agreement with the finding of Usunobun and Okolie (2016) who reported there is abundant evidence that like their fruits, the leaves of some tropical fruit trees, including avocado (*Persea americana*), cashew (*Anacardium occidentalis*), soursop (*Annona muricata*), papaya (*Carica papaya*), guava *(Psidium guajava*), almond (*Terminalia catapa*), contain phytonutrients and important minerals in varying quantities and degrees.

Water (moisture) is a universal solvent; it is present in living and non-living things alike. Its physiological and metabolic roles as medium for transport and substrate interaction, and in temperature regulation and homeostasis are evident in the functioning of living organisms (Olomu, 2011; Egedege, 2014). Moisture content (MC) is variable within and between plant species. In this study, water content was higher in cashew leaves *Anacardium occidentale* than the other two plants examined. The ether extract (oil) content of soursop leaves, *Annona muricata,* was significantly higher than amount of oil in avocado leaves, *Persea americanna,* and the oil content of cashew leaves, *Anacardium occidentale.*

The protein contents (CP) of the leaves ranged from 17.29% in young cashew to 23.92% in matured soursop leaves. Proteins are components of structural and globular materials that promote growth, repair and replace worn out tissues, maintain functional processes, including formation of blood proteins, and boosting the immune system (Gurib-Fakin, 2006; Egedege, 2014). The soluble carbohydrates (NFE) value in chemical analysis of biological materials is usually an approximation because it includes the cumulative errors of the other determinations; and thus it is also expressed as a proportion of total dry matter (DM). However, the NFE is worth estimating because carbohydrates primarily produce energy to power the cells and tissues of the body on consumption. Dietary fibers alter the colonic environment in such a way as to protect against colo-rectal diseases. It provides protection by increasing faecal bulk, which dilutes the increased colonic bile acid concentrations that occur with a high fat diet (Nasaringa, 2003; Edeoga *et al*, 2005). Evidence from epidemiological studies suggest that increased fiber content in the body of organisms

tend to reduce incidence of degenerative health conditions like diabetes, high blood pressure, piles, digestive disorders (SACN, 2008). This implies that dietary fiber tends to exerts neutraceutical properties, which means it is having both nutritional and therapeutic value. Hence leafy vegetables are highly recommended in nutrition and dietetics (Olomu, 2011). Ash content refers to the minerals which are present in a biological material, usually in the form of chemical compounds. Mineral elements serve as structural components of tissues and as constituents of the body fluid and vital enzymes in major metabolic pathways; and thus are essentials for the function of all cells. They play many roles as co-factors and essential components of cellular systems maintaining functional processes in plants and animals (Olomu, 2011). Most minerals occur as soluble chemical compounds hence they are able to diffuse through tissues to different parts of the plants. The leaf samples examined in this study contained appreciable levels of calcium (Ca), potassium (K), magnesium (Mg), sodium (Na) and phosphorus (P). Young and matured leaves of *Annona muricata* contained the higher concentrations of all the minerals compared to the leaves of *Anacardium occidentalis* and *Persea americanna* corroborating the previous report of Usunobun and Okolie (2016). In converse matured leaves of *Anacardium occidentalis* and *Persea americanna*, contained higher levels of minerals (Na, K, Mg, Ca and P) than their young leaves.

Phytochemicals are found virtually in all plants. They are present in different parts and at different concentration in the plant (Edeoga *et al*, 2005). In this study, the presence of alkaloid, tannins, flavonoids, phenols and saponins have been confirmed in all avocado, cashew, and soursop leaves, corroborating the work of Foong and Hamid (2012) and Falodun *et al*, (2011). Depending on their properties and concentrations, the phytochemicals may have tonic effects, promoting nutrition and health, or toxic effects, hampering nutrition and health. It has been reported that flavonoids are potent water-soluble super anti-oxidants and free radical scavengers. They prevent oxidative cell damage, have strong anticancer activity and protect against all stages of carcinogenesis (Narasinga, 2003; Dar and Munger, 2010). Flavonoids in the intestinal tract lower the risk of heart disease, inflammation and represent the most common and widely distributed groups of plants phenolic compounds. The flavonoid content in the leaves of matured avocado and soursop (young and matured) in this experiment revealed a significant amount, and this could be the reason for the anti-inflammatory, anticancer and anti-hypertensive property of these plants as earlier reported (Anaka *et al*, 2009; Imafidon and Amaechina, 2010).

Alkaloids are important plants secondary metabolites which have a wide range of properties and activities when ingested or infused in animals. Isolated pure forms of alkaloids and their synthetic derivatives are used as basic medicinal agents for their analgesic and bactericidal effects (Gurib-Fakin, 2016). Plants that have tannins as their components are astringent in nature and can be exploited in the management of intestinal disorders such as diarrhea and dysentery (Serrano *et al*, 2009). In this study, the leaf samples contained appreciable amounts of phenols. Plant phenols have been indicated to act as anti-inflammatory, anti-clotting, antioxidants, and immune enhancing agents (Adeyemi *et al*, 2002). This explains why these leaves are used in trado-medicine / herbal care in Nigeria. For example, young cashew leaves which contained the highest amount of tannins in this study, is used in the treatment of fevers and microbial infections (Muhammad and Muhammad, 2021). Cashew leaves and bark are indicated for hepatitis, sickle cell anaemia, diabetes, dysentery and malaria (Muhammad and Muhammad, 2021); the extract of avocado leaves are reportedly useful as adjuvant in the treatment of fevers and peptic ulcer (Muhammad and Muhammad, 2021); and soursop leaves are exploited for cancer prevention and management (Adeyemi *et al*, 2002; Edeoga *et al*, 2005). The leaves of these tree crops are borne luxuriantly and abundantly during their season, and are readily available. Thus, while the fruits of fruit trees as well as many forest trees are naturally produced for eating, their leaves are abundantly produced for healing. Customarily, the leaves are harvested, washed and extracted in boiling water or in liquor, and administered orally. The need for a scientific approach is hereby suggested; first by chemical evaluation, and then characterization and utilization of the plant products. This behooves on researchers to determine the ingredients in the leaves in order for man to benefit maximally from the provisions of nature.

CONCLUSION AND RECOMMENDATIONS

The young and matured leaves of three species of fruit trees (avocado, cashew and soursop) were examined for their biochemical and phychemical compositions. Matured avocado leaves (MAL) had the highest contents of crude protein (CP) and ash, however CP content of MAL was at par with that of matured soursop leaves (MSL). MSL had the highest crude fibre and ether extract. Nitrogen free extract was highest in young cashew leaves. Ca, Mg, Na and P were highest in MSL while K content was highest in YSL. MSL also had the highest contents of alkaloid, flavonoid and saponin while the highest tannin and phenol contents were in YCL. Since the quantities of saponin, phenols, flavonoids, tannins and alkaloids present in the leaves were at non - critical levels, suggesting that leaves may not be deleterious to the user. The alkaloids and flavonoids present suggest antioxidant potentials of the leaves and justify their therapeutic use in herbal medicine, and in drug formulation. Thus, with the upsurge in the use of herbal remedies there is the need for adequate research on the degree of variability of the phytochemicals and minerals, including micro-minerals, in the leaves of these plant species at their different stages of growth. Adequate research work is recommended in this regard, particularly on the characteristics and interactions of the phyto-compounds and their nutraceutical properties in plants to ensure the development of new food and health products.

REFERENCES

Adeyemi, O.O., Okpo, S.O. and Ogunti, O.O. (2002). Analgesic and anti-inflammatory effects of the aqueous extract of leaves of avocado. *Fitoterapia*, 73: 375-380.

Ajebesin, K. K. (2011). Dacryodes edulis (G. Don) H.J. Lam: A review on its medicinal, phytochemical and economical properties. *Research Journal of Medicinal Plant, 5 (1), 32-41.*

Anaka, O.N., Ozolua, R.I., and Okpo S.O. 2009. Effect of the aqueous seed extract of Persea americana mill (Lauraceae) on the blood pressure of Sprague Dawley rats, *African Journal of pharmaceutical and* Pharmacology, 3(10):485-490.

AOAC. 2010. Official Methods of Analysis. 18th edition, Association of Official Analytical Chemists, *AOAC, Washington DC.*

Dar, J. and Munger, R. (2010). Plant phenolics: extraction, analysis and their antioxidant and anticancer properties. *Molecules,* 15: 7313-7352.

Edeoga, H.O., Okwu, D.E. and Mbaebie, B.O. (2005). Phytochemical constituents of some Nigeria medicial plants. *African Journal of Biotechnology*, 4(7):685 - 688.

Egedege G.I.O. (2014). Chemical, Nutritional and Toxicological evaluation of the Styzolobium, *Mucuna sloanei* (ITMU) *Doctoral Thesis, Department of Biochemistry, University of Benin, Benin-City, Nigeria.*

Falodun A., Osakue J., Uzoekwe A. S. and Sheng-Xiang Q. (2011). Phytochemical and anticancer studies on ten medicinal plants used in Nigeria. *Bayero Journal of Pure and Applied Sciences 4(1):36–39.*

Foong C. P. and Hamid R. A. (2012). Evaluation of anti-inflammatory activities of ethanolic extract of *Annona muricata* leaves. *Rev. Bras. Farmacogn, 22:6.*

Gurib-Fakim A. (2006). *Medicinal plants: traditions of yesterday and drugs tomorrow. Mol. Asp. Medicine*, 27:1–93.

Harborne, J. B. and Baxter H. (1999). *The handbook of natural flavonoids*. Volume 1 and 2. Chichester, UK: John Wiley and Sons.

Imafidon, K.E. and Amaechina F.C. (2010). Effect of aqueous seed extract of *Persea americanna* Mill (Avocado) on blood pressure and lipid profile in hypertensive rats. *Advanced Biological Research*, 4(2):116-121.

Lui, E., Luo, W. and Zhou, H. (2009). Determination of oxalate in plant tissues with oxidase prepared from wheat. *Biology of Plant*, 53: 129 – 132.

Muhammad, A. and Muhammad, T. (2021). Medicinal uses of cashew (*Anacardium occidentale*). *Journal of Science, Technology and Research*, 2(1): 1 – 10.

Narasinga R. (2003). Bioactive phytochemicals in Indian foods and their potential in health promotion and disease prevention. *Asia Pacific Journal of Clinical Nutrition*, 12 (1): 9-2

Obadonic, B. O. and Ochuko, P. O. (2001). Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria. *Global Journal of Pure and Applied Science*, 8: 203 – 208.

Olomu, J.M (2011). Monogastric Animal Nutrition; Principles and Practice. Second Edition. *St Jackson publishing. Benin City, Nigeria.* p. *206-222.*

SACN, (2008). Draft SCAN position statement in dietary fiber and health and the dietary fiber definition.

Sahrawat, K. L., Kumar, G. R. and Murthy, K. V. S. (2002). Sulfuric acid-selenium digestion for multi-element analysis in a single digest. *Communication in Soil Science and Plant Analysis*, 33(19&20): 3757 – 3765.

Serrano J., Puupponen-Pimia R., Dauer A., Aura A. and Saura-Calixto F. (2009). Tannins: current knowledge of food sources, intake, bioavailability and biological effects. *Molecular Nutrition Food Research,* 53: S310–29

Thomas, S.C.L., (2000). *Culture, Utilization and Phytopharmacology, Medicinal Plants, CRC Press, USA. P5.*

Usunobun U. and Okolie N. P. (2016). Phytochemical analysis and mineral composition of *Annona muricata leaves. International Journal of Research and Current Development*, 1:7-10.

Van-burden, W. and Wink, J. (2000). *Phytochemicals Medicinal Plants of the World* .Timber Press, New York, p. 16 – 18.

Table1: Proximate composition of Soursop, Avocado and Cashew leaves (g/100g)

Sample	CP	CF	EE	NFE	ASH	DM	MC
MSL	23.920^{ab}	21.510^{a}	19.700^{a}	12.513^{b}	12.513^{b}	94.750^{a}	5.110^{d}
YSL	19.910^{cd}	17.060^{b}	15.400^{b}	33.680^{c}	8.753^{c}	94.640^{a}	5.203^{d}
MAL	25.760^{a}	21.200^{c}	5.170^{e}	25.960^{d}	15.847^{a}	90.770^{a}	6.077^{cd}
YAL	21.420^{bc}	18.290^{b}	6.800^{d}	33.990^{c}	12.200^{b}	92.560^{a}	7.290^{bc}
MCL	19.220^{cd}	17.250^{b}	8.110^{c}	40.980^{b}	5.380^{d}	90.730^{a}	7.290^{ab}
YCL	17.290^{d}	15.150^{c}	6.270^{d}	48.800^{a}	4.220^{d}	91.580^{a}	8.267^{a}

*Each value in the table is the average of the triplicate measurement. Values with the same superscripts along each column are not significantly different from each other at P > 0.05.

KEY: MSL=Matured soursop leaf; YSL=Young soursop leaf; YAL=Young avocado leaf; MAL=Matured avocado leaf; MCL=Matured cashew leaf; YCL=Young cashew leaf.

Table 2: Mineral composition of some Soursop, Avocado and Cashew leaves (mg/kg DM)

Sample	Ca	K	Mg	Na	P
MSL	11941^{a}	372.1^{b}	9357^{a}	609.2^{a}	411.6^{a}
YSL	8363^{b}	384.5^{a}	5431^{b}	314.0^{b}	352.2^{b}
MAL	57^{c}	150.9^{c}	71^{c}	82.9^{c}	47.6^{e}
YAL	45^{c}	130.6^{d}	62^{c}	51.6^{d}	39.6^{f}
MSL	74^{c}	101.4^{e}	61^{c}	53.8^{d}	73.7^{c}
YCL	63^{c}	81.6^{f}	52^{c}	43.9^{d}	52.3^{d}

*Each value in the table is the average of the triplicate measurement. Values with the same superscripts along each column are not significantly different from each other at P > 0.05.

KEY: MSL=Matured soursop leaf; YSL=Young soursop leaf; YAL=Young avocado leaf; MAL= Matured avocado leaf; MCL=Matured cashew leaf; YCL=Young cashew leaf.

Table 3: Phytochemical composition in soursop, avogado and cashew leaves (g/100 g DM)

Sample	Alkaloid	Tannin	Flavonoid	Phenol	Saponin
MSL	1.103^{a}	0.217^{de}	7.573^{a}	0.273^{d}	3.150^{a}
YSL	0.763^{b}	0.233^{cd}	5.597^{b}	0.217^{d}	2.943^{b}
MAL	0.710^{b}	0.330^{b}	4.310^{c}	1.277^{a}	1.427^{c}
YAL	0.490^{b}	0.273^{c}	2.880^{d}	0.770^{c}	1.253^{d}
MSL	0.483^{c}	0.180^{e}	2.390^{d}	1.053^{d}	1.253^{d}
YCL	0.403^{c}	0.420^{a}	2.370^{d}	1.230^{a}	1.273^{cd}

*Each value in the table is the average of the triplicate experiments. Values with the same superscripts along each column are not significantly different from each other at $P > 0.05$

KEY: MSL=Matured soursop leaf; YSL=Young soursop leaf; YAL=Young avocado leaf; MAL= Matured avocado leaf; MCL=Matured cashew leaf; YCL=Young cashew leaf.

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INFLUENCE OF MYCORRHIZA-FORTIFIED QUAIL MANURE ON SOYBEAN (GLYCINE MAX) VARIETIES GROWN IN TWO AGRO-ECOLOGICAL ZONES OF NIGERIA

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ABSTRACT

Amongst the nitrogen fixing grain legumes, soybean (*Glycine max*) is ranked first and second in terms of protein and oil content respectively. Meanwhile, despite the versatility and other great potentials (soil fertility improvement inclusive) of soybean, its production suffers various limitations, particularly N and P deficiencies, which induced low yield per unit area. Therefore, researching into exploitation of organic / biological means of improving soil nutrition is worthwhile, for improving the performance of versatile arable crops like soybean. Two screen house experiments were concurrently conducted in the year 2018 cropping season, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso (southern guinea savanna) and the Arable Research site of the Oyo State College of Agriculture and Technology, Igboora (derived guinea savanna), to assess the response of indigenous and hybrid varieties of soybean to selected mycorrhizal inocula, while quail droppings were used as the organic basal manure. The experiments were 3 x 3 x 2 factorial comprising three levels of mycorrhiza inoculation (M0 = No inoculation with any mycorrhizal strain, M1 = inoculation with *Glomus clarum* and M2 = inoculation with *Glomus mossae*), three soybean varieties (V1= Ogbomoso Local or Igboora Local, V2 = TGX2004-10F and V3 = TGX2010-15F) and two levels of soil sterilization (S- = unsterilized and S+ = Sterilized). The trials were arranged in a Completely Randomized Design, replicated thrice. Data were collected on growth and yield parameters, and were subjected to analysis of variance. Means were separated using Duncan's Multiple Range Test at $p \leq 0.05$. Soil inoculation with any of the arbuscular mycorrhizal strains significantly improved soybean growth and yield parameters, in the two locations, compared to the control. As similarly observed in most of the growth and yield parameters measured, the highest seed yield of 5.1 tons/ha were observed in the medium maturing soybean hybrid varietyTGX2004-10F (i.e. V2), which received *G. clarum* under unsterilized soil conditions, but the value was not significantly from those obtained from the other hybrid variety investigated, but significantly higher than the local hybrids in the two locations, while the control had the least values. Also, in the two ecoregions or locations, the local varieties inoculated with *Glomus clarum* had significantly higher growth and yield, comparable to *Glomus mossaea* and the control, whereas, whereas the hybrids were non-selective in being infected or inoculated by the two mycorrhizal inocula tested, as significant soybean performance was observed in the two strains investigated, compared to the control. Thus, the performance of soybean in low fertile soil is more mycorrhizal strains dependent than the locations. Therefore, *G. clarum* and *G. mossaea* were recommended for the soybean hybrids while *Glomus clarum* was specifically recommended for the local varieties in both of the agroecological zones.

Keywords: *Soil fertility, Arbuscular mycorrhizal fungus, Basal Quail manure, Soybean varieties, Ecoregions*

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is an annual grain legume of the pea family Leguminoseae or Fabaceae. Soybean (*Glycine max* L. Merrill) is the world's leading source of oil and protein (FAO, 1996). It has the highest protein content of all arable crops and ranks second (after groundnut), in terms of oil content amongst

grain legumes (Dugje *et al.*, 2009). The spread of soybean from its native centre of origin has been mainly due to its adaptability and predominant use as a food crop for human nutrition, source of protein for animals, medicinal plant and lately as an industrial crop (Dugje *et al.*, 2009). In Nigeria, soybean is originally and widely grown in both the middle belt and the savanna zone of Nigeria (IITA, 1995) but, its production has presently expanded beyond the aforementioned traditional production areas, to also cover other Northern and Southern parts of the country that were otherwise considered unsuitable or marginal for soybean production (Dugje *et al.*, 2009). Soybean is a versatile food crop, and due to its additional supply of nitrogen to the soil, particularly under crop rotation system, it becomes an important crop plant in soil nutrients management, as it plays vital roles in enhancing crop diversification as well as in benefitting other crops (Lianne and Edward, 1999, Nwoko and Sanginga, 1999). The major challenge of agriculture over the decades is the difficulty in achieving a sustainable crop production to meet up with the world's rapidly increasing demand for food. The accelerated decline in tropical soil fertility and mismanagement of soil moisture and nutrients make the achievement ever remote (Fagbola *et al.*, 2001: Peter *et al.*, 2000). Moreso, despite the versatility and great potentials of soybean as an arable crop, its production in Nigeria which remains grossly on small scale, as well as its associated low yield per unit area, could be easily traced down to various limitations (soil fertility inclusive). Soybean production had been earlier reported to be majorly limiting by deficiencies of N and P, particularly under tropical soil conditions (Nwoko and Sanginga, 1999). These primary macro nutrients are well known for volatilization and immobility respectively, which make them insufficient to meet crop demands to induce improved crop performance (Dare, 2008). Therefore, there is need to improve soybean production in order to bridge the gap between production and domestic / industrial demands. Meanwhile, as a result of the fact that the required P for N-fixation, growth and development by grain legumes like soybean, cannot compensate for the nutrients absorbed by the growing crops under marginal tropical soil conditions, and that the chemical fertilizers are highly priced and well known for their harmful residual effects, agricultural researches in the last decade had suggested organic and (or) biological processes to circumvent or reduce the edaphic and environmental constraints associated with the tropical arable crop production (Ames *et al.*, 1991; Fagbola *et al.*, 2001; Babajide, 2014). Therefore, there is an urgent need for environment friendly strategies that can help replace the incessant application of synthetic fertilizers (Babajide, 2010). Amongst such good strategies is artificial inoculation of beneficial soil-inhabiting microsymbionts like mycorrhiza. Mycorrhiza had been reported to enhance soil nutrition (Babajide, 2014). The significant contributions of mycorrhizae to the nutrition and growth of plants are well established (Fagbola *et al.*, 2001; Dare, 2008). The uptake of highly mobile nutrients such as NO_3- can also be enhanced by mycorrhizal association even under drought conditions (Osonubi *et al.*, 1991). Several studies have demonstrated the transport of inorganic N by arbuscular mycorrhizal fungi (Hawkins *et al.*, 2000). Also, the uptake of other macro and micronutrients like K, P, Ca, Mg, S, Cu, Fe, Zn, and B had been reported to be enhanced by mycorhizal inoculation (Babajide, 2010). There is considerable evidence to suggest that arbuscular mycorrhizal are able to increase the host plant's tolerance to water stress (Fagbola and Dare, 2003). Moreover, it is likely that the contribution of the arbuscular mycorrhizal symbiosis to plant drought tolerance results from a combination of physical, nutritional, physiological and cellular effects (Ruiz-Lozano, 2003). Usually, both water and nutrient uptake are higher in drought stressed mycorrhizal plants than in non-mycorrhizal plants (Srivastava *et al.*, 2002). However, arbuscular mycorrhizal fungi can only alleviate moderate drought stress, and in more severe drought conditions, they become ineffective (Bryla and Duniway, 1997). This research was therefore aimed at assessing the response of local and hybrid soybean varieties to different mycorrhizal strains under sterilized and unsterilized soil conditions, in two distinctive ecoregions of Nigeria.

MATERIALS AND METHODS

Description of the two experimental sites: Two screen house experiments were concurrently conducted in the year 2018 cropping season, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso and the Arable Research screen house of Oyo State College of Agriculture and Technology, Igboora, to assess the response of indigenous and hybrid soybean varieties to selected mycorrhizal strains, while quail droppings were

used as the organic basal manure. Ogbomoso and Igboora are located in Oyo state, Nigeria. Ogbomoso is located on latitude 8^0 10' N and longitude 4^0 10' E. It falls under the southern guinea savanna ecoregion of the south-western Nigeria. Igboora is located on latitude 7° 28'N and 4° 33'E in the derived savannah zone of south western Nigeria. Both Ogbomoso and Igboora are naturally characterized by bimodal rainfall distribution. The rainfall distribution involves early rains which start in late March / early April and end in late July / early August, followed by a short dry spell in August. The late rainy season spans between August and November (Babajide *et al.*, 2017a). The soil sample used in Igboora belongs to Oxisols of the Iwo soil series, while the soil sample used in Ogbomoso belongs to Alfisols of the Egbeda soil series (Smyth and Montgomery, 1962). The experimental site in Igboora had been under cultivation of intercropped arable crops (okra, maize and cassava), for more than eight years, while that of Ogbomoso had been subjected to continuous cultivation of yam and guinea corn, for six years, before the experiments were set up in the two locations.

Land clearing, soil sampling and analysis and pot filling: After manual land clearing with simple farm tools like hoe, cutlass, mattock, rake, e.t.c., soil samples were collected by placing the soil auger at a depth of 0-15 cm, which were made into composite samples at the two locations, for laboratory analyses of the soil physical and chemical properties. The samples were prepared for routine analyses, following the procedures contained in I.I.T.A., (1982). From the collected soil samples, unwanted materials such as debris, steel, stone and other foreign particles were carefully removed. The composite auger samples were then 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, and available phosphorous (P), Iron (Fe), copper (Cu), zinc (Zn), the exchangeable cations (Ca, Na, Mg and K). The particle size analysis was carried out according to the Bouyoucos (1951) hydrometer method, using sodium hexametaphosphate as the dispersant. Soil pH was determined in a 1:1 soil: water ratio and 2:1 soil: KCl ratio (IITA, 1982). Available phosphorus was determined using Bray and Kurtz P-1 method (Page *et al*., 1982). Total nitrogen was determined by the micro Kjeldal method (Bremner and Mulvaney, 1989). The exchangeable K and Na were determined using the EEL flame photometer while Ca and Mg were estimated using Versenate titration method, and the organic carbon was determined using the Walkley and Black method (Nelson and Summers, 1982). The soil textural class was determined from the soil textural triangle.

Soil sterilization and inoculation of microsymbionts: Soil sterilization was done by autoclaving for two consecutive day at 120 ^{0}C (Babajide, 2014). Separate chopped root fragments of maize plants containing mycorrhizal propagules of either *Glomus clarum* or *Glomus mossaea* obtained from the Soil Microbiology Laboratory of the Department of Agronomy, University of Ibadan, Nigeria, were used for inoculation. Only 20g of each of the inocula of the root-soil-fungal spore mixture, was placed at about 3 cm depth of the soil (Carling *et al.,* 1978; Babajide, 2014).

Treatments, experimental design and filling of pots with soil: The experiments were 3 x 3 x 2 factorial comprising three levels of mycorrhiza inoculation (M0 = No inoculation with any mycorrhizal strain, M1 = inoculation with *Glomus clarum* and M2 = inoculation with *Glomus mossae*), three soybean varieties (V1= either Ogbomoso Local or Igboora Local variety i.e. late maturing varieties with 120-130 days maturation, V2 = TGX2004-10F (medium maturing hybrid with 101-110 days maturation) and V3 = TGX2010-15F (early maturing hybrid with 90-100 days maturation) and two levels of soil sterilization (S0 = unsterilized and S1 = Sterilized). The trials were arranged in a Completely Randomized Design, replicated thrice. Two pots per treatment were used. Each pot was filled with 10 kg soil. About 5cm to the brim of each pot was left unfilled, to prevent undesirable washing away of the soil particles and fertilizer materials which may occur during watering. Also, six perforations were carefully made at the bottom of each pot, using hot-red 4 inches nail, prior to the pot filling. The perforations were then plugged with cotton wool to regulate drainage and encourage proper soil aeration.

Quail manure sampling and incorporation: Quail manure was collected from the Poultry unit of Teaching and Research Farms of Ladoke Akintola University of Technology, Ogbomoso. Samples were randomly collected from the cured well-cured quail manure for laboratory chemical analyses, using standard methods (IITA, 1982). The manure was evenly and equally incorporated into the potted soil samples at both locations, at two weeks before seed sowing, at the rate of 0.5 ton ha^{-1}.

Seed propagation and cultural practices: After pre-planting treatments of the clean soybean seeds of different varieties, four seeds were sown per pot accordingly. The local soybean varieties were sourced from the local farmers in respective location, while the hybrids were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan. The emerged seedlings were later thinned to one per stand at two weeks after sowing. Manual weeding was regularly done by carefully uprooting the emerging weeds from the pots. Regular watering was also maintained at the two locations.

Determination of mycorrhizal root colonization and weight of nodules: At 60 days after sowing, destructive samplings were carried out on each of the two plants per treatments, in each location, by allowing the plants to be well-watered before carefully uprooting and detachment of the nodules followed by scouting for the remaining nodules in the soil samples. Root nodules were then carefully detached and weighed to determine the weight of root nodules per plant. At the final termination of the experiments, final harvestings were done. The root samples were carefully cut into 1cm length and stored in 50% ethanol. The root samples were then carefully rinsed with slow running tap water (before the commencement of the root staining procedure). Mycorrhizal staining commenced by heating the roots in 10% KOH for 40 minutes at 80^0C (Phillip and Hayman, 1970). Roots were bleached in alkaline H_2O_2 for 10 minutes, after which they were rinsed in water and soaked in 1% HCl for 10 minutes. The staining solution chlorazol black E (Brundrett, *et al.,* 1984) was used on the roots containing 0.03% chlorazol black E, lactic acid (400 ml), and water (200 ml). Stained roots were later de-stained with 50% glycerol. The degree of mycorrhizal colonization was assessed by spreading the root samples evenly on a grid plate and observing them under the dissecting microscope at low magnification. The total number of roots and the infected roots intersecting the grids were counted using the gridline intersect method (Giovanetti and Mosse, 1980). The percentage mycorrhizal root colonization was calculated by the ratio between the number of intersects with infection and the total number of intersects multiplied by 100 (Fagbola *et al.,* 2001).

***Data collection, plant sampling and analysis*:** Data were collected on growth and yield parameters. The growth parameters determination commenced at 100 days after sowing. The growth parameters measured were plant height using measuring tape placed at the base of the main stem of the plant to the tip, stem girth by using venier calipers, the value obtained was later converted to stem girth using a fomular πD (where π = 3.142 and D = diameter), number of branches was determined by direct counting of all the well developed branches per plant and the number of leaves was also determined by direct counting of all the fully opened leaves per plant. Each of the experiments was finally terminated at about 20 days after the recommended day of full maturation of each its varieties. However, before the final termination was done, the plants were carefully monitored for fully ripe pods which were carefully and cumulatively plucked (to avoid shattering) and recorded correspondingly per plant. The pods were later dried and threshed, to separate the seeds from the pods and weighed, to determine the total soybean seed yield. Immediately after the termination of each experiment, the plant samples collected were oven dried at 80°C 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 data collected were subjected to analysis of variance (SAS, 2018). Means were separated using Duncan Multiple Range Test (DMRT) at $p<0.05$.

RESULTS AND DISCUSSION

As indicated on Table 1, the soil samples used at both experimental locations were acidic with pH (H_20) values of 6.0 and 5.8, for Ogbomoso and Igboora respectively. Also, they were texturally sandy-loam and grossly low in the major essential nutrient concentrations, particularly N and P (Table 1). These results agreed with Babajide *et al*, (2017a) and Babajide *et al,* (2017b) which emphasized that the soils in the study areas are grossly low in essential nutrient concentration, and could be supported by adequate supply of fertilizer materials to ensure improved arable crop performance. The well cured quail manure droppings applied as basal organic manure was slightly acidic (Table 2) and relatively high in nutrient concentrations, particularly N and P (Table 2). The results were in support of the research findings of Akanbi, (2002); Makinde and Ayoola, (2010) and Salami and Babajide, (2015), who reported farmyard manures as being relatively high in nutrient concentration and suitable for improving soil nutrition and performance of tropical arable

crops. Soil inoculation with different arbuscular mycorrhizal strains significantly improved soybean growth and yield parameters, irrespective of the locations, compared to the control (Table 3). Soil sterilization did not significantly influenced soybean root infectivity or colonization by the mycorrhizal strains. Mycorrhizal root colonization level was found to be related to nodules weight and improved crop performance in the two locations (Table 4). As similarly observed in most of the growth and yield parameters measured, the highest seed yield of 5.1 tons/ha were observed in the medium maturing soybean hybrid varietyTGX2004-10F (i.e. V2), which received *G. clarum* under unsterilized soil conditions, but the value was not significantly from those obtained from the other hybrid variety investigated, but significantly higher than the local hybrids in the two locations, while the control had the least values. Also, in the two ecoregions or locations, the local varieties inoculated with *Glomus clarum* had significantly higher growth and yield, comparable to *Glomus mossaea* and the control, whereas, whereas the hybrids were non-selective in being infected or inoculated by the two mycorrhizal inocula tested, as significant soybean performance was observed in the two strains investigated, compared to the control. These results corroborated the findings of Fagbola *et al.*, (2001); Dare, (2008) and Babajide, (2014), who reported improved crop performance via improved soil nutrition as established crop plants inoculated by mycorrhizal propagules or inocula. However, findings from this research established that the performances of soybean varieties tested were more mycorrhizal strains dependent than the locations. These contradicted the findings of Dare, (2008) and Babajide, (2010), who reported the effectiveness of mycorrhizal inoculation and improved performance of yam and sesame (respectively), as being location dependent.

CONCLUSION

Mycorrhizal inoculation may favour improved soybean performance irrespective of varieties, under low fertile soil conditions. All soybean varieties investigated responded positively well to mycorrhizal inoculations, although special preference for *Glomus clarum* root colonization was observed in the local varieties as significantly higher levels of root colonization and better performance were observed in them, comparable to G. mossaea inoculation in the two experimental locations, unlike the two hybrid varieties which responded similarly and indiscriminately to the two mycorrhizal types tested. Hence, the performance of different soybean varieties inoculated with mycorrhizal strains, under low fertile soil condition is more of mycorrhizal strains dependent than the locations. Hybrid varieties yields were significantly higher than the local varieties at the two locations, irrespective of the soil conditions investigated, Also, soil sterilization did not have significant effects on soybean root colonization by the mycorrhizal strains. Therefore, *G. clarum* and *G. mossaea* were recommended for the soybean hybrids while *Glomus clarum* was specifically recommended for the local varieties in both study areas.

REFERENCES

Akanbi, W. B. (2002). Growth, Nutrient uptake and yield of maize and okra as influenced by compost and nitrogen fertilizer under different cropping systems. Ph. D. Thesis, Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria pp. 232.

Ames, R.N., Thiagaranja, H.M. Ahmad and W.A. McLaughin, (1991). Co-selection of compactible rhizobia and vesciculararbuscularmycorrhizal fungi for cowpea in sterilized and non-sterilized soils. *Boilogy and Fertility of Soils*, 12: 102-116.

Babajide, P. A. (2010). Response of Sesame (*Sesamum indicum* Linn.) to Integrated Nutrient Management Approach in an Alfisol, in Oyo State, Nigeria (Ph.D. Thesis), University of Ibadan, Ibadan, Nigeria. 173 pp.

Babajide, P.A. (2014). Contributions of bio-organo-chemical nutrient management approach to growth, yield and phytochemical composition of sesame (*Sesamum indicum* Linn.), under low fertile alfisol conditions. *International Journal of Current Microbiology and Applied Sciences.* ISSN:2319-7706. Vol.3 .No.3 (8): 957- 976.

Babajide, P.A., Modupeola, T.0., Yusuf, R.O., Oyatokun, O.S. and Gbadamosi, T.S. (2017a). Evaluation of proportionate combinations of indigenous rice bran and mineral fertilizer for improved performance of tomato (Lycopersicon lycopersicum) under low fertile soil conditions. *Asian Journal of Soil Science and Plant Nutrition.* Vol. 1 (1):1-8.

Babajide, P. A., Popoola, O.J., Gbadamosi, J., Oyedele, T.A. and Liasu, M.O. (2017b).

Evaluation of phyto-extraction potentials and performance of false sesame (*Ceratotheca sesamoides*) under induced soil pollution by automobile lubricant in savanna ecoregion. *International Journal of Research Granthaalayah.* Vol. 5 (11): 355-365.

Bouyoucos, G. J. (1951). A recalibration of the hydrometer method for making mechanical analysis of soils. *Agronomy Journal* 43: 434-438.

Bremner, J.M. and Mulvaney C.S. (1989). Total Nitrogen in methods of soil Analysis Part 2. In: Page *et al.,. American Society of Agronomy,* Madison W.Pp. 595-624.

Brundrett, M. C., Piche, Y. and Peterson, R. L. (1984). A new method for observing the morphology of vesicular arbuscular mycorrhiza. *Canadian Journal of Botany.* 62: 2118 – 2134.

Bryla, D. R. and Duniway, J. M. (1997). Effects of mycorrhizal infection on drought tolerance and recovery in safflower and wheat. Plant and soil 197: 95-108

Carling, D. E., Riehle, W. G., Brown, M. F and Johnson, D.R. (1978). Effect of a vesicular arbuscular mycorrhiza fungus on nitrogen reductase and nitrogenase activities in nodulating and non-nodulating soybeans. Phytopathology 68: 1590 – 1596.

Dugje, I.Y, Omoigui, L.O. Ekeleme, F. Bandyopadhyay, R. Lava Kumar, P. and Kamara, A.Y. (2009). Farmers' Guide to Soybean Production in Northern Nigeria. IITA publications.

Fagbola, O., Osonubi, K. Mulongoy, S. A. and Odunfa (2001). Effects of drought stress and arbuscular mycorrhiza on growth of *Gliricidia Sepium* (jacg.), walp. and *Leucaena leucocephala* (Lam) de wit. In simulated eroded soil conditions. Mycorrhiza 11: 215-223.

Fagbola, O. and Dare, M. O. (2003). Performance of pepper (*Capsicum frutescens L.*) on simulated degraded and non-degraded soils as affected of mycorrhiza inoculation and organomineral fertilizer. *Nigerian Journal of Horticultural Sciences.* Vol. 8: 11 – 14.

Food and Agricultural Organization of the United Nations (FAO).(1996). Production yearbook of the food and agricultural organization of the United Nations, Rome, Italy. 38:56-62.

Giovanetti, M., and Mosse, B. (1980). An Evaluation of Techniques for Measuring Vesicular Arbuscular Mycorrhizal Infection in The Roots New phyto. 84; 489-500.

Gungula, D. T. (1999). Growth and nitrogen use efficiency in maize (*Zea mays L.*) in the Southern Guinea Savannah of Nigeria. Ph D. Thesis, University of Ibadan. Pp 181.

Hawkins, H. J., Johansen, A. and George, E. (2000). Uptake and transport of organic and inorganic nitrogen by abuscular mycorrhizal fungi. Plant and Soil 226: 275-285

International Institute of Tropical Agriculture, (1982). Selected Methods for Soil and Plant Analysis. International Institute of Tropical Agriculture, Ibadan Nigeria. IITA Manual Series, No. 7.

International Institute of Tropical Agriculture. (1995). Soybean for good health: how to grow and how to use soybean in Nigeria**.** IITA, Ibadan, Nigeria. 23 pp

Lianne, M.D and Edward, G.G, (1999). Soil Nitrogen amendment effects on Nitrogen uptake and grain yield of maize. Vol. 91, Issue: 4, pp:650-656.

Makinde E.A. and Ayoola, O.T. (2010). Growth, yield and NPK uptake by maize with complementary organic and inorganic fertilizers. *African Journal of Food, Nutrition and Development* Volume 10, No..3; Rural outreach programme.

Nelson, D.W. and Summer, L.E. (1982). Total carbon, organic carbon and organic matter. In: A.L.Page (ed). method of soil analysis part 2. Agronomy monograph, No.9 AMm soil Agron. Madison,W.I.. Pp 539-579.

Nwoko, H. and Sanginga, (1999). Dependence of promiscuous soybean and herbaceous legumes on arbuscular mycorrhizal fungi and their response to bardyrhizobial inoculation in low phosphorus soils. *Applied Ecology* 13: 251-258.

Ombo, F. I. (1994). Self sufficiency in local fertilizer production for Nigeria. In Proceeding fo the 3rd African Soil Science Conference, (August 20 – 23, 1994) at University of Ibadan, Ibadan. Nigeria. P. 112 114.

Osonubi, O. Mulongoy, K, Awotoye O. O, Atayese M. O, Okali D. U. (1991). Effects of ectomyrrohizal and vesicular-arbuscular mycorrizal fungi on drought tolerance of four leguminous woody seedlings. Plant Soil 136:131-143

Page, A.L., Miler, R.H. and Keenery D.R. (1982). Method of Soil Analysis Part 2, Chemical and Microbial Properties. ASA Madison.

Peter G., Francesco G. and Montague Y. (2000). Integrated Nutrient Management, Soil Fertility, and Sustainable Agriculture:

Current Issues and Future Challenges. "A 2020 Vision for Dare, M. O. 2008. Variability of yam (*Dioscorea spp.*) genotypes to Arbuscular mycorrhizal colonization and fertilizer application in yam growing regions of Nigeria. Ph D. Thesis, Department of Agronomy, University of Ibadan, Nigeria. 132p.

Phillips, J. M. Hayman, D. S. (1970). Improved Procedures for Clearing of Roots and Staining Parasitic and VAM Fungi for Rapid Assessment of Infection. Trans. Of British and Mycol. Society 55; p. 158-160.

Ruiz-Lozano, J. M. (2003). Arbuscular mycorrhizal symbiosis and alleviation of osmotic stress. New perspectives for molecular studies. Mycorrhiza 13: 309-317

Salami, T.B. and Babajide, P.A. (2015). Growth and shoot yield of *Basella alba L.* as influenced by harvesting frequency and varying application rates of poultry manure under guinea savanna zone of Nigeria. *Journal of Sustainable Development.* Vol. 12(1):95-100.

SAS (2018). Sas Institute Inc., Cary Nc., U.S.A. (Software Statistical Programme 2018.

Smyth, A. J. and Montgometry, R. F. (1962): Soils and land use in Central Western Nigeria. Govt. of Western Nig. Press, Ibadan pp. 265.

Srivastava, A. K., Singh, S., Marathe, R. A. (2002). Organic citrus, soil fertility and plant nutrition. *Journal of sustainable Agriculture* 19:5-29

Table 1: Results of the physico-chemical properties of the Soil Samples used in Ogbomoso and Igboora

Soil Properties	Values	
	Ogbomoso	Igboora
pH (H_2O)	6.00	5.80
Total N (gkg^{-1})	0.10	0.04
Organic carbon (gkg^{-1})	1.28	1.06
Available P ($mgkg^{-1}$)	0.41	0.20
Exchangeable K ($cmolkg^{-1}$)	0.20	0.18
Fe (mg kg-1)	2.10	2.20
Cu (mg kg-1)	1.86	1.92
Zn (mg kg-1)	2.00	2.12
Exchangeable Na (cmol kg^{-1})	0.22	0.16
Exchangeable Ca (Cmol kg^{-1})	0.12	0.10
Exchangeable Mg (Cmol kg^{-1})	0.29	0.19
Sand (%)	82.40	86.24
Silt (%)	10.64	8.64
Clay (%)	06.96	05.12
Textural class	Sandy loam	Sandy loam

Table 2: Chemical properties of the quail droppings used for as basal manure application

Properties	**Gc**
pH (H_20)	6.7
N (%)	3.60
P (%)	0.52
K (%)	2.28
Ca (g/kg)	2.68
Mg (g/kg)	2.52
Fe (g/kg)	13.32
Zn (mg/kg)	90.20
Cu (mg/kg)	22.80
Organic C (g kg^{-1})	48.10

Table 3: Growth parameters of soybean varieties as affected by selected mycorrhizal strains under sterilized and unsterilized soil conditions in Ogbomoso and Igboora

Treatments	Plant height (cm)	No. of Leaves	Stem girth (cm)	No. of Branches
S+M0V1	46.2^{c} (42.6^{bc})	176.8^{b} (160.0^{b})	3.0bc (2.6^{bc})	11.0^{b} (10.0^{b})
S+M0V2	58.8^{b} (51.7^{b})	172.5^{b} (158.4^{b})	3.0bc (2.5^{bc})	12.2^{b} (11.6^{b})
S+M0V3	56.4^{b} (50.1^{b})	176.6^{bc} (168.2^{b})	3.2b (2.7^{bc})	13.1^{b} (11.4^{b})
S+M1V1	76.2^{a} (78.4^{a})	216.2^{a} (191.0^{a})	4.5ab (4.1^{a})	21.2^{a} (19.9^{a})
S+M1V2	78.8^{a} (76.6^{a})	222.0^{a} (189.4^{a})	4.6ab (4.0^{a})	23.0^{a} (20.4^{a})
S+M1V3	75.4^{a} (77.0^{a})	198.8^{ab} (191.0^{a})	5.0a (4.3^{a})	22.1^{a} (22.2^{a})
S+M2V1	50.2^{b} (49.0^{bc})	158.6^{c} (145.0^{c})	3.4b (2.9^{bc})	14.0^{b} (12.5^{b})
S+M2V2	70.6^{a} (71.2^{a})	210.0^{a} (191.2^{a})	5.0a (4.6^{a})	21.2^{a} (19.5^{a})
S+M2V3	70.1^{a} (73.2^{a})	215.4^{a} (188.0a)	4.9ab (4.5^{ab})	20.0^{a} (19.0^{a})
S-M0V1	44.5^{c} (42.2^{bc})	188.6^{b} (174.8^{ab})	2.8bc (2.9^{bc})	12.0^{b} (10.0^{b})
S-M0V2	52.6^{b} (54.4^{b})	178.0^{b} (175.0^{ab})	3.2b (3.3^{b})	13.2^{b} (11.1^{b})
S-M0V3	55.8^{b} (57.0^{b})	180.2^{b} (180.6^{ab})	3.1b (3.3^{b})	13.4^{b} (12.0^{b})
S-M1V1	75.0^{a} (76.0^{a})	220.4^{a} (192.2^{a})	4.8ab (4.9^{a})	20.0^{a} (17.0^{a})
S-M1V2	77.6^{a} (79.0^{a})	196.4^{ab} (188.6^{a})	5.6a (5.3^{a})	22.6^{a} (23.0^{a})
S-M1V3	79.5^{a} (74.9^{a})	224.5^{a} (192.2^{a})	5.4a (5.4^{a})	22.0^{a} (22.0^{a})
S-M2V1	54.2^{b} (55.8^{b})	148.5^{c} (130.5^{c})	3.0bc (3.1^{b})	13.4^{b} (14.1^{ab})
S-M2V2	75.4^{a} (77.2^{a})	206.6^{a} (190.5^{a})	5.2a (5.0^{a})	23.2^{a} (21.0^{a})
S+M2V3	72.1^{a} (71.8^{a})	208.1^{a} (192.0^{a})	5.3a (5.2^{a})	23.0^{a} (20.5^{a})

Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT. M1 = inoculation with *Glomus clarum* and M2 = inoculation with *Glomus mossae*a,V1= Ogbomoso Local or Igboora Local, V2 = TGX2004-10F and V3 = TGX2010-15F, S- = unsterilized soil and S+ = Sterilized soil.
Values without parentheses = Ogbomoso. Values in parentheses = Igboora.

Table 4: Mycorrhizal root colonization and yield parameters of soybean varieties as influenced by selected mycorrhizal strains under sterilized and unsterilized soil conditions in Ogbomoso and Igboora

Treatments	Mycorrhizal root colonization (%)	Weight of nodules (g/plant)	Seed yield (tons/ha)	Total above-ground biomass yield (tons/ha)
S+M0V1	6.1^{c} (5.8^{c})	26.4^{d} (28.0^{c})	0.8^{c} (0.6^{d})	1.0c (1.0^{cd})
S+M0V2	4.8^{c} (5.0^{c})	28.2^{d} (31.6^{c})	1.0^{c} (0.9^{d})	1.4^{c} (1.1^{cd})
S+M0V3	4.9^{c} (4.9^{c})	26.1^{d} (30.4^{c})	1.1^{c} (0.9^{d})	1.5^{c} (1.1^{cd})
S+M1V1	78.4^{a} (76.6^{a})	392.2^{a} (382.2^{a})	3.2^{b} (3.4^{b})	4.3^{ab} (3.8^{b})
S+M1V2	68.2^{a} (71.2^{a})	398.1^{a} (380.6^{a})	4.8^{a} (4.2^{a})	5.0^{a} (4.8^{a})
S+M1V3	64.1^{a} (68.2^{a})	402.1^{a} (390.1^{a})	4.6^{a} (4.0^{a})	5.0^{a} (4.7^{a})
S+M2V1	32.6^{b} (30.9^{b})	128.2^{c} (120.4^{b})	2.7^{c} (2.5^{c})	3.6^{b} (3.5^{b})
S+M2V2	66.9^{a} (70.1^{a})	362.2^{a} (370.2^{a})	4.6^{a} (4.3^{a})	5.0^{a} (4.8^{a})
S+M2V3	68.8^{a} (69.8^{a})	380.4^{a} (369.8^{a})	4.8^{a} (4.4^{a})	5.2^{a} (4.9^{a})
S-M0V1	11.2^{c} (10.4^{c})	24.8^{d} (30.1^{c})	0.9^{c} (0.7^{c})	1.7^{c} (1.6^{cd})
S-M0V2	8.6^{c} (9.2^{c})	32.4^{d} (30.8^{c})	1.2^{c} (1.1^{c})	2.1^{c} (2.0^{cd})
S-M0V3	8.2^{c} (9.2^{c})	21.6^{d} (26.3^{c})	1.1^{c} (1.0^{c})	2.0^{c} (2.1^{cd})
S-M1V1	74.2^{a} (78.1^{a})	390.6^{a} (380.4^{a})	3.0^{b} (3.9^{a})	4.1^{ab} (3.9^{b})
S-M1V2	66.5^{a} (68.6^{a})	396.4^{a} (378.0^{a})	5.1^{a} (4.7^{a})	6.0^{a} (5.4^{a})
S-M1V3	65.2^{a} (65.4^{a})	394.8^{a} (382.4^{a})	4.9^{a} (4.6^{a})	5.3^{a} (5.3^{a})
S-M2V1	34.6^{b} (35.4^{b})	120.9^{c} (130.6^{b})	2.9^{b} (3.4^{b})	3.7^{b} (3.8^{b})
S-M2V2	68.2^{a} (67.6^{a})	388.6^{a} (380.4^{a})	4.4^{a} (4.2^{a})	5.4^{a} (5.1^{a})
S+M2V3	67.6^{a} (69.2^{a})	382.6^{a} (378.2^{a})	4.3^{a} (4.2^{a})	5.2^{a} (5.0^{a})

Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT. M1 = inoculation with *Glomus clarum* and M2 = inoculation with *Glomus mossae*a,V1= Ogbomoso Local or Igboora Local, V2 = TGX2004-10F and V3 = TGX2010-15F, S- = unsterilized soil and S+ = Sterilized soil. Values without parentheses = Ogbomoso. Values in parentheses = Igboora.

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COMPARATIVE EVALUATION OF UREA SUPER GRANULE (USG) AND PRILLED UREA (PU) ON GROWTH AND YIELD OF CHILLI PEPPER (*Capsicum annuum* L.) AT SAMARU, NIGERIA

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ABSTRACT
This study was conducted during the 2018 and 2019 wet seasons to determine the effects of urea super granule (USG) and prilled urea (PU) on growth, yield and yield components of chilli pepper. The experiment was laid down in a randomized complete block design (RCBD) and replicated three times. The treatments consist of the control, unfertilized plot (F1), 100% N-urea super granule (F2), 100% N-prilled urea (F3), 75% N- urea super granule + 25% N-FYM (F4), 75% N-prilled urea + 25% N-FYM (F5), 75% N- urea super granule (F6) and 75% N-prilled urea (F7). Results of the investigation revealed that F2 significantly enhanced the production of fresh fruits yield ha^{-1}, dry fruit yield ha^{-1}, number of fruits $plant^{-1}$, total revenue, gross margin, and cost benefit ratio. From the results, it was observed that application of USG had positive impact on yield of chilli pepper than the conventional PU; and could save about 20% N fertilizer. Therefore, it could be concluded that application of USG, as a source of N showed better performance and found to be more economic viable than the conventional PU for chilli production in the study area.

Keywords: *Pepper, Growth, Yield, Urea Super Granule, Prilled Urea*

INTRODUCTION

Chilli pepper (*Capsicum annuum* (L.) locally called 'tatase' is a very important fruit vegetable in the tropics and is the world second most important vegetable after tomato (Adeniyan and Ojeniyi, 2003). Pepper has increased in popularity, value, and importance over a long period, thus making it an indispensable part of the daily diet of millions of Nigerians. Pepper is normally used as a spice in the preparation of soup and stew when cooked with tomatoes and onions. It can also be used as a condiment and extensively in flavouring of processed meat, colouring certain food preparation and also used for medicinal purposes (Alabi, 2006). Nigeria produces 695,000 metric tons of pepper from total area of 77,000ha (FAO, 2008), making it the largest producer of pepper (*Capsicum spp*) in Africa, accounting for about 50% of African production (Arisha *et al.,* 2003), Although pepper is largely grown in many parts of Nigeria, but the bulk of its production is found in the drier Savanna zone and derived Savanna areas of the Northern Nigeria (Erinle, 1989). Consumption of pepper accounts for about 20% of the average vegetable consumption per person per day in Nigeria (Alegbejo, 2002). Therefore, making it an indispensable part of the daily diet of millions of Nigerians because of its increase in popularity and demand (Stewart *et al.,* 2005). It is used extensively in food flavouring in the daily diet of over 1.2 million Nigerian irrespective of their socio-economic status. Fertilizer is a material that is added to the soil to supply one or more elements required for plant growth and development (Ikeh *et al.,* 2012). Nitrogen, as well as phosphorus, plays an important role in fruiting, seeding and good quality development of plants. Potassium promotes formation of strong straw, with resultant decreased incidence of lodging in plants. However, there is need to increase production as indicated by the demand for pepper throughout the year, but this has been hampered as a result low soil fertility. In order to obtain high yield of pepper, there is need to augment the nutrient status of the soil to meet the crop's need and thereby maintaining the fertility of the soil. One of the ways of increasing the nutrient status is by boosting the soil nutrient content either with the use of organic materials such as poultry manure, animal waste and use of compost or with the use of inorganic fertilizers (Dauda *et al.*, 2008). Nitrogen (N) being one of the essential macro-elements and most limiting nutrient elements required by pepper. Traditionally, farmers in northern Nigeria applied N fertilizer as prilled urea (PU) on surface soil for upland vegetables and this surface application is usually associated

with different kinds of losses such as leaching, volatilization, run-off etc. due to its mobility. Of the applied N for crop growth, only 45–50% is being incorporated into the agricultural products (Houlton *et al*., 2019) and the remaining is subjected to substantial loss (Xu *et al*., 2020) especially, if N is applied by broadcasting or on soil surface. To reduce these losses and improve N use efficiency, urea super granule (USG) is being advocated for especially in rice. It was also hypothesized that application of USG could be economically viable in different upland vegetables such as tomato, cabbage, pepper etc. (Hussain *et al*., 2010) but reports on its efficacy is scanty and the practice is not yet well adopted by farmers particularly, in northern Nigeria. Therefore, the focus of this research is to compare the efficacy of urea super granule (USG) and prilled urea (PU) at different rates on the growth, yield and profitability of chilli pepper in in Samaru, Zaria.

MATERIALS AND METHODS

Site Location: The experiment was conducted during the 2018 and 2019 wet seasons at the Horticultural Section, Samaru College of Agriculture, Ahmadu Bello University, Zaria. The study area lies within latitude 11^0 09'52'-$11^0$10'22' N and longitude 07^o38'05'- $07^0$38'22' E, 684 -697 m above sea level.

Pre-planting and post-harvest soil sampling and analysis: The soil samples were collected using soil auger at 0 – 20 cm depth. The samples collected were bulked to obtain a composite sample. The soil composite sample was air dried, crushed, screened through a 2-mm sieve and stored for soil characterization following standardized procedures described by (Okalebo *et al.*,2002).

Treatments and Experimental Design: The experiment was laid down as a randomized complete block design (RCBD) and replicated three times. The treatments were control, unfertilized plot (F1), 100% N-urea super granule (F2), 100% N-prilled urea (F3), 75% N-urea super granule + 25% N-FYM (F4), 75% N-prilled urea + 25% N-FYM (F5), 75% N- urea super granule (F6) and 75% N-prilled urea (F7).

Data Collection and Statistical Analysis: Data on plant height (cm), number of leaves plant^{-1}, leaf area, number of fruits plant^{-1}, average fruit diameter (cm), fresh fruit yield (kg ha^{-1}) and dry fruit yield (kg ha^{-1}) were recorded. The data collected were subjected to statistical analysis of variance (ANOVA) and treatment means were separated using new Duncan Multiple Range Test (SAS Institute, 2000).

RESULTS

Characteristics of the study soil: Initial physical and chemical properties of the experimental site for both 2018 and 2019 wet seasons are presented in Table 1. The soil type was sandy loam; the soil reaction (pH) in water was slightly acid (5.4 – 6.1), low in organic carbon content (5.5 – 6.2 g kg-^{1}) and total nitrogen (0.9 – 1.2 g kg-^{1}). The available phosphorous (8.00 – 9.8 mg kg-^{1}) and exchangeable bases were relatively moderate according to FMARD (2012) rating.

Plant Height (cm): There was no significant difference (P>0.05) among the treatments on plant height. Although, treatment F7 produced a higher mean value (41.000), which was followed by treatment F2 (39.867), followed by F5 (39.367), followed by F4 (38.717), followed by F6 (37.517), followed by F3 (37.150) followed by F1 (36.417), but all treatments were not significantly different from each other (Table 2).

Number of Leaves Plant^{-1}: There was no significant difference (P>0.05) among the treatments on number of leaves of chilli. Although, F3 produced a higher mean value (172.28), which was followed by F5 (141.59), followed by F4 (137.88), followed by F6 (136.59), followed by F7 (134.00), followed by F2 (132.28), while the control F1 produced the lowest mean value (89.17), but were not significantly different from each other (Table 2).

Leaf Area (cm^2) Plant^{-1}: There was no significant difference (P>0.05) among the treatments on leaf area of chilli as presented in Table 2. Although, F3 produced a higher mean value (45.815), which was followed by F4 (43.043), followed by F7 (38.770), followed by F5 (38.370), followed by F1 (37.080), followed by F6 (30.913), while F2 produced the lowest mean value (29.753), but all treatments were not significantly different from each other.

Fresh Fruit Yield (kg ha^{-1}): There was a significant difference (P<0.05) between F2 and F1 on fresh fruit yield of chilli while the other treatments were comparable to both F2 and F1, as presented in Table 3. F2 produced a higher mean value (1,991), which was followed by F3 (1,717), followed by F4 (1,554), followed by F6 (1,438), followed by F5 (1,421), followed by F7 (1,285), followed by F1 (1,123).

Dry Fruit Yield (kg ha^{-1}): There was a significant difference (P<0.05) among the

treatments on dry fruit yield of chilli as presented in Table 3. F2 produced a higher mean value (1,509), which was followed by F3 (1,234), followed by F6 (1,017), followed by F4 (1,016), followed by F7 (883), followed by F5 (801), followed by F1 (697).

Number of Fruits Plant^{-1}: There was a significant difference (P<0.05) among the treatments on number of fruits plant^{-1} of chilli. F2 produced a higher mean value (18.06), which was followed by F3 (17.66), followed by F4 (15.25), followed by F6 (14.30), followed by F5 (12.66), followed by F1 (12.32), while F7 produced the lowest mean value (10.87) (Table 3).

Average Fruit Diameter (cm): There was no significant difference (P>0.05) among the treatments on average fruit diameter of chilli. F2 produced a higher mean value (1.65), which was followed by F3 (1.42), followed by F5 (1.33), followed by F6 (1.29), followed by F4 (1.26), followed by F7 (1.13), while F1 produced the lowest mean value (0.95) as presented in Table 3.

pH in Water: There was no significant difference (P>0.05) among the treatments on pH (water) in chilli pepper. F2 produced a highest mean value (5.95), which was followed by F1 (5.89), followed by F5 (5.87), followed by F4 (5.81), followed by F4 (5.81), followed by F3 and F7 (5.79) but all treatments were not significantly different from each other (Table 4).

Electrical Conductivity: There was no significant difference (P>0.05) among the treatments on electrical conductivity in chilli. F5 and F7 produced a highest mean value (0.050), which was followed by F2 (0.044), followed by F4 (0.037), followed by F6 (0.030), followed by F1 (0.027), followed by F3 (0.024) but all treatments were not significantly different from each other (Table 4).

Organic Carbon (g kg^{-1}): There was a significant difference (P<0.05) among the treatments on organic carbon in chilli as presented in Table 4. F7 produced a highest mean value (3.650), which was followed by F2 (3.073), followed by F3 (1.600), followed by F5 (1.597) followed by F6 (1.277), followed by F1 (1.213), followed by F4 (0.960).

Total Nitrogen (g kg^{-1}): There was no significant difference (P>0.05) among the treatments on total nitrogen in chilli. F3 produced a highest mean value (2.081), which was followed by F2 and F5 (0.504), followed by F6 (0.467), followed by F7 (0.457) followed by F4 (0.448), followed by F1 (0.373) as presented in Table 4.

Total Revenue (₦ ha^{-1}): There was a significant difference (P<0.05) among the treatments on total revenue of chilli as presented in Table 5. The control treatment F1 produced a lower mean value (108,153.00), which was followed by F5 (137,258.00), followed by F7 (143,151.00), followed by F4 (152,518.00), followed by F6 (160,935.00), followed by F3 (183,734.00), while F2 produced the highest mean value (220,809.00).

Gross Margin (₦ ha^{-1}): There was a significant difference (P<0.05) among the treatments on gross margin of chilli. F2 produced a higher mean value (168,624.00), which was followed by F3 (131,943.00), followed by F6 (110,735.00), followed by F4 (98,816.00), followed by F7 (93,196.00), followed by F5 (83,734.00), while F1 produced the lowest mean value (64,739.00) as presented in Table 5.

Cost Benefit Ratio (₦): There was a significant difference (P<0.05) among the treatments on cost benefit ratio of chilli. F2 produced a higher mean value (3.23), which was followed by F3 (2.55), followed by F6 (2.21), followed by F7 (1.87), followed by F4 (1.84), followed by F5 (1.56), while F1 produced the lowest mean value (1.49) as presented in Table 5.

DISCUSSION

Characteristics of the study soil: The soil of the experimental site is generally low in fertility status especially organic carbon, total nitrogen and available phosphorus which are usually due to low clay content coupled with rapid mineralization, continuous cultivation as common to soils of northern guinea savanna (FMARD, 2012). The significant response of the observed parameters to N, P and K application could be attributed to the role of N, P and K play in enhancing vegetative development in crops especially in soil with low nutrient status similar to the report by Ikeh *et al*. (2012) who claimed that low nutrient status might have contributed to the good performance of the crop.

Effect of urea super granule (USG) and prilled urea (PU) on Growth Characters, Yield and yield components of Chilli : The height of plant is an important growth character directly linked with the productive potential of the plant. Basso and Ritchie (2005) opined that plant height is positively connected with productivity of plants such as increased in number of branches. This accounted for higher

number of leaves in the treated plants over the control plants. More plant height due to better usage of sunlight in competing with weeds have positive effect on fruit yield and total dry matter (Duman, 2006). Urea rates significantly ($P<0.05$) influenced number of leaves compared to control plots. Plants that received USG and PU were outstanding in number of leaves plant, while plants grown without fertilization had the lowest number of leaves plant^{-1}. The enhancement in the number of leaves by urea fertilizer application particularly USG was a precursor to greater amount of assimilate and thus allowing more translocation to the berry. Changes in number of leaves are bound to affect the overall performance of the plant as the leaves serve as the photosynthetic organ of the plant. Increase in number of leaves leads to better utilization of solar radiation (Law-Ogbomo and Remison, 2008). Pepper responded positively to nutrient sources for number of harvested fruits and weight of fruits. Statistically, pepper that received fertilizer application recorded significantly different fruit weight compared to those that did not receive fertilizer application. The influence of nutrient sources on pepper fruit yield might be due to the effect of N in increasing water content of vegetable. The increase in number of fruits could be attributed to the ability of nutrient sources to promote vigorous growth, increase meristematic and physiological activities in the plants due to supply of plant nutrients and improvement in the soil properties, thereby, resulting in the synthesis of more photo-assimilates, which is used in producing fruits (Dauda *et al.,* 2008). The significant effect due to urea application could be attributed to easy dissolution effect of released plant nutrient leading to improved nutrient status of the soil for crop uptake.

The best growth and yield performances were observed from pepper that received urea particularly USG and PU compared to the control. This may be attributed to increased and timely released/ availability of nutrient elements. With the results from this study, we opined that emphasis should be placed on the use of urea as plant nutrient source for sustainable pepper cultivation and agent of soil management to improve soil nutrient status in the study area. However, both fresh and dry fruit yield of pepper was significantly influenced by the application of different doses of USG and PU. It appeared that in general, yield of pepper was increased by the application of USG in comparison with PU and the highest yield (1,509 kg ha^{-1}) was obtained from 100% N-USG. This result was supported by many authors (Yahqub and Tarfa, 2018; Hussain *et al*., 2010) where USG produced the highest paddy yield in rice and head yield in cabbage respectively. This might be due to the fact that higher yield recorded with USG was due to minimum loss of N by leaching and volatilization as reported by Muneshwar *et al*. (1992) and higher use efficiency of nitrogen by the slow releasing property of USG and its deep placement (Hussain *et al*., 2010). It has also been reported that USG provided a zone of concentrated urea solution where the denitrifying bacteria cannot enter; thereby leaving N at the root zone for plant uptake (Mukherjee, 1986).

Effect of urea super granule and prilled urea on selected soil chemical properties after Harvest: Generally, effects of USG and PU resulted in no significant differences with some levels of inconsistencies on most of the observed soil chemical properties except the organic carbon content where application of USG left substantial residual soil organic carbon content compared to that obtained from PU. This might be due its deep placement which limits the volatilization and leaching losses of N as reported by Hussain (2017) where post-harvest soil nutrient status was increased with increasing rates of N as well as USG which was also higher than PU.

Cost and return analysis: Cost and return analysis also revealed that application of all the rates of USG was found to be economically viable (higher total revenue, gross margin and cost benefit ratio) than corresponding values obtained from the same rates of PU. Similar trends of cost and return on cabbage cultivation in Bangladesh was also reported by many researchers (Sarker *et al*., 2012; Hussain *et al*., 2010) who observed higher profitability in the application of USG compared to PU. The higher profitability is due to higher yield, low variable cost especially the labour cost on fertilizer application and cost of fertilizer on USG compared to PU.

CONCLUSION AND RECOMMENDATION:

From the results, it was observed that application of USG had positive impact on both growth and yield of chilli pepper than the conventional PU; and could save about 20% N fertilizer. Therefore, it could be concluded that

application of USG, as a source of N showed better performance and found to be more economic viable than the conventional PU for chilli production in the study area.

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REFERENCES

Adeniyan O.N. and Ojeniyi, S.O. (2003). Comparative effectiveness of different levels of poultry manure with NPK fertilizer on residual soil fertility, nutrient uptake and yield of maize. *Moor Journal of Agricultural Research*, 191-197.

Alabi, D.A. (2006). Effects of fertilizer phosphorus and poultry droppings treatments on growth and nutrient components of pepper (*Capsicum annuum* L). *African Journal of Biotechnology*, 5(8): 671-677.

Alegbejo, M.D. (2002). Evaluation of pepper cultivars for resistance to pepper veinal mottle poly-virus in northern Nigeria. *Journal of Arid Agriculture*,12: 93–103.

Arisha, H.M.E., Gad, A.A. and Younes, S.E. (2003). Response of some pepper cultivars to organic and mineral nitrogen fertilizer under sandy soil conditions. *Zagazig Journal of Agricultural Research*, 30: 1875–99.

Basso, B. and Ritchie, J.T. (2005). Impact of compost manure and inorganic fertilizer on nitrate leaching and yield for a 6-year maize alfalfa rotation in Michigan. *Agriculture, Ecosystems and Environment*, 108: 309 – 314.

Burger, M. and Jackson, L.E. (2003). Microbial immobilization of ammonium and nitrate in relation to ammonification and nitrification rates in organic and conventional cropping systems. *Soil Biology and Biochemistry*, 35: 29-36.

Dauda, S.N., Ajayi, F.A. and Ndor, E. (2008). Growth and yield of water melon (*Citrullus lanatus*) as affected by poultry manure application. *Journal of Agriculture and Social Science*, 4: 121– 124.

Duman I. (2006). Effects of seed priming with PEG and K_3P0_4 on germination and seedling growth in Lettuce. *Pakistan Journal of Biological Science*, 9: 923-928.

Erinle, J.O. (1989). Present status and prospects for increased production of chilli pepper and pepper in Northern Nigeria. In: Chilli pepper and pepper in the tropics AVRDC Shauhua Taiwan, 545pp.

FAO (2008). Food and Agriculture Organization of the United Nations. Chilli pepper Production statistic 2008 www.faostat.fao.org. Accessed on 21/09/2015.

FMARD, (2012). *Fertilizer use and management practices for crops in Nigeria* (4th Edition). Edited by Chude, V.O., Olayiwola, S.O., Daudu, C. K. and A. Ekeoma. Produced by Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja. 229pp.

Hussain, M.J., Ali, M.Y., Rahman, M.A., Quayyum, M.A. and Choudhury, D.A. (2010). Effect of urea super granule on the performance of cabbage in young jomuna and bramaputra floodplain soils of Tangail. *Bangladesh J. Agril. Res.* 35(2): 267 – 272.

Hussain, M. J., A.J.M.S. Karim, A. R. M. Solaiman, M. S. Islam and M. Rahman (2017). Effect of Different Levels of Urea Super Granule and Prilled Urea on the Crop Quality, Nutrient Uptake and Soil Nutrient Status of Broccoli. *The Agriculturists 15(2): 24-39.* A Scientific Journal of Krishi Foundation.

Houlton, B.Z.; Almaraz, M.; Aneja, V.; Austin, A.T.; Bai, E.; Cassman, K.G.; Compton, J.E.; Davidson, E.A.; Erisman, J.W.;Galloway, J.N. (2019). A world of cobenefits: Solving the global nitrogen challenge. *Earth's Future*, 7: 865–872.

Ikeh, A.O., Ndaeyo, N.U., Uduak, I.G., Iwo, G.A., Ugbe, L.A., Udoh, E.I., and Effiong, G.S. (2012). Growth and yield responses of pepper (*Capsicum frutescens* L.) to varied poultry manure rates in Uyo, Southeastern Nigeria. *ARPN Journal of Agricultural and Biological Science*, 7(9):735-742.

Law-Ogbomo, K.E. and Remison, S.U. (2008). Growth and yield of white guinea yam (*Dioscorea rotundata* Poir.) influenced by NPK fertilization on a forest site in Nigeria. *Journal of Tropical Agriculture*, 46(1-2): 9-12.

Mukherjee, S.K. (1986). Chemical technology for producing fertilizer nitrogen in the year 2000. Global aspects of food production. International Rice Research Institute. Tycooly International. pp:227 – 237.

Muneshwar, S.P.N., Takkar, Vi Ben., Choudhury, M.R.., Sidhu, P.S., Pashricha,

N.S. and Bajwa, M.S. (1992). *Proceedings of International Symposium on Nutrient Management for Sustained Productivity*, 2:7 – 8.

Okalebo, J. R., K. W. Gathua, and P. L. Woomer (2002). *Laboratory Methods of Soil and Plant Analysis*: A working manual. 2nd edn. Kenya, 128pp.

Oluwasemire, K.O. and Alabi, S.O. (2004). Ecological impact of changing rainfall pattern, soil processes and environmental pollution in the Nigerian Sudan and Northern Guinea Savanna agro ecological zones. *Nigerian Journal of Soil Resources*, 5: 23 -31.

SAS Institute (2000). SAS Procedures Guide for Computers, Version 8.1. SAS Institute, Cary, 1686p.

Sarker, M.M.R., M.R. Shaheb and M.I. Nazrul (2012). Urea Super Granule: A Good Source of Nitrogen on Growth Yield and Profitability of Cabbage in Sylhet. *J. Environ. Sci. & Natural Resources*, 5(1): 295 – 299.

Stewart, M.W., Dibb, W.D., Johnston, E.A. and Smyth, J.T. (2005). The Contribution of Commercial Fertilizer Nutrients to Food Production. *Agronomy Journal*, 97: 1–6.

Xu, P.; Chen, A.; Houlton, B.Z.; Zeng, Z.; Wei, S.; Zhao, C.; Lu, H.; Liao, Y.; Zheng, Z.; Luan, S. (2020). Spatial Variation of Reactive Nitrogen Emissions from China's CroplandsCodetermined by Regional Urbanization and Its Feedback to Global Climate Change. *Geophys.Res. Lett*., 47, e2019GL086551.

Yahqub, M. and Tarfa, B.D. (2018). Response of Rice (*Oryza sativa* L.) Varieties to DifferentNitrogen Application Methods at Kadawa, northern Nigeria. *Nigeria Journal of Agriculture,Food and Environment*, 14 (1): 40 – 45.

Table 1: Initial physical and chemical soil properties at the Experimental plot, Samaru, Zaria in 2018 and 2019 wet seasons

Soil/Cow dung Parameters/Year	Clay	Silt	Sand	Textural Class	pH in water	O. C	T. N	A. P	K^+	Ca^{++}	Mg^{++}
	← (g kg^{-1}) →					← (%) →		(mg kg^{-1})	← (cmol kg^{-1}) →		
2018	90	150	760	Sandy Loam	5.4	0.62	0.12	9.8	0.74	3.60	0.84
2019	80	200	720	Sandy Loam	6.1	0.55	0.09	8.0	0.68	3.20	0.72
Cow dung (2018)	n. d	n. d	n. d	n. d	n. d	9.40	1.80	2.5×10^4	n. d	n. d	n. d
Cow dung (2019)	n. d	n. d	n. d	n. d	n. d	7.50	1.40	1.9×10^4	n. d	n. d	n. d

O. C = organic carbon, T. N = total nitrogen, A. P = available phosphorus, n. d = not determined

Table 2: Effects of Urea Super Granule (USG) and Prilled Urea (PU) on Growth Characters of Chilli at 8 WAT in 2018, 2019 and both years combined

Treatment	Plant height (cm) 2018	2019	Combined	No. of leaves 2018	2019	Combined	Leave Area (cm^2) 2018	2019	Combined
F1 (Control)	38.733[a]	64.667[ab]	36.417	102.00[ab]	15.433	89.17	72.40	1.270	37.080
F2 (100% N-USG)	36.733[ab]	52.333[b]	39.867	108.00[a]	11.967	132.28	57.57	1.273	29.753
F3 (100% N-PU)	32.400[b]	69.000[ab]	37.150	111.00[a]	11.433	172.28	89.47	1.387	45.815
F4 (75% N-USG + 25% N-FYM)	32.533[ab]	71.567[ab]	38.717	83.33[ab]	16.150	137.88	84.17	1.147	43.043
F5 (75% N-PU + 25% N-FYM)	38.067[ab]	67.233[ab]	39.367	72.33[b]	12.667	141.59	75.00	1.227	38.370
F6 (75% N-USG)	32.800[ab]	66.867[ab]	37.517	110.67[a]	13.633	136.59	60.27	1.610	30.913
F7 (75% N-PU)	38.667[a]	76.933[a]	41.000	90.00[ab]	17.100	134.00	75.30	0.940	38.770
CV	8.8243	16.5626	15.8621	18.8715	34.9472	30.462	28.9109	42.2542	38.1963

Means followed by the same letter(s) within the same column and treatment group are not significantly different at 5% level of probability using DMRT. N = Nitrogen, USG = Urea Super Granules, PU = Prilled Urea, FYM = Farmyard manure

Table 3: Effects of Urea Super Granule (USG) and Prilled Urea (PU) on Yield and Yield Components of Chilli in 2018, 2019 and both years combined

	Fresh Fruit Yield (kg ha^{-1})			Dry Fruit Yield (kg ha^{-1})			No of Fruits plant^{-1}			Average Fruit Diameter (cm)		
Treatment	2018	2019	Combined	2018	2019	Combined	2018	2019	Combined	2018	2019	Combined
F1 (Control)	460.70	1135.0	1123^{b}	202.04	1192.2^{c}	697^{b}	5.655^{b}	7.917	12.318^{bc}	1.158	3.3625	0.95
F2 (100% N-USG)	753.90	2106.7	1991^{a}	327.22	2691.7^{a}	1509^{a}	12.095^{a}	10.500	18.060^{a}	1.100	3.1708	1.65
F3 (100% N-PU)	651.10	2505.6	1717^{ab}	293.70	2175.0^{ab}	1234^{ab}	7.560^{b}	12.000	17.658^{ab}	1.092	3.2500	1.42
F4 (75% N-USG + 25% N-FYM)	550.60	1919.4	1554^{ab}	252.41	1779.4^{abc}	1016^{ab}	7.012^{b}	10.208	15.252^{abc}	1.033	3.3750	1.26
F5 (75% N-PU + 25% N-FYM)	799.10	1996.7	1421^{ab}	339.63	1261.7^{bc}	801^{b}	9.107^{ab}	11.750	12.657^{abc}	1.092	3.3625	1.33
F6 (75% N-USG)	728.70	2608.3	1438^{ab}	321.11	1712.2^{bc}	1017^{ab}	7.310^{b}	12.167	14.302^{abc}	1.100	3.6125	1.29
F7 (75% N-PU)	604.80	1147.2	1285^{ab}	307.22	1457.8^{bc}	883^{b}	8.321^{b}	7.250	10.886^{c}	1.025	3.0667	1.13
CV	29.4769	48.5749	41.365	28.7106	35.4638	43.892	24.6205	44.8262	28.9828	10.3119	9.0985	31.124

Means followed by the same letter(s) within the same column and treatment group are not significantly different at 5% level of probability using DMRT. N = Nitrogen, USG = Urea Super Granules, PU = Prilled Urea, FYM = Farmyard manure

Table 4: Effects of Urea Super Granule (USG) and Prilled Urea (PU) on Selected Soil Properties after Harvesting Chilli in 2018 and 2019 Combined

Treatment	pH water	pH $CaCl_2$	Electrical Conductivity	Organic Carbon (g kg^{-1})	Total N (g kg^{-1})
F1 (Control)	5.89	5.45	0.027	1.213[b]	0.373
F2 (100% N-USG)	5.95	5.48	0.044	3.073[ab]	0.504
F3 (100% N-PU)	5.79	5.42	0.024	1.600[ab]	2.081
F4 (75% N-USG + 25% N-FYM)	5.81	5.44	0.037	0.960[b]	0.448
F5 (75% N-PU + 25% N-FYM)	5.87	5.48	0.050	1.597[ab]	0.504
F6 (75% N-USG)	5.86	5.52	0.030	1.277[ab]	0.467
F7 (75% N-PU)	5.79	5.39	0.050	3.650[a]	0.457
C.V	1.754	1.390	60.779	64.407	51.9553

Means followed by the same letter(s) within the same column and treatment group are not significantly different at 5% level of probability using DMRT. N = Nitrogen, USG = Urea Super Granules, PU = Prilled Urea, FYM = Farmyard manure

Table 5: Effects of Urea Super Granule (USG) and Prilled Urea (PU) on Yield and Profitability of Chilli in 2018 and 2019 Combined

Treatment	Total Revenue (₦ ha^{-1})	Gross Margin (₦ ha^{-1})	Cost Benefit Ratio (₦)
F1 (Control)	108,153.00	64,739.00	1.49
F2 (100% N-GU)	220,809.00	168,624.00	3.23
F3 (100% N-PU)	183,734.00	131,943.00	2.55
F4 (75% N-GU + 25% N-FYM)	152,518.00	98,816.00	1.84
F5 (75% N-PU + 25% N-FYM)	137,258.00	83,734.00	1.56
F6 (75% N-GU)	160,935.00	110,735.00	2.21
F7 (75% N-PU)	143,151.00	93,196.00	1.87

N = Nitrogen, USG = Granular Urea, PU = Prilled Urea, FYM = Farmyard manure

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MORPHOLOGIAL EVALUATION OF TWENTY OKRA ACCESSIONS IN TWO AGRO-ECOLOGICAL ZONES OF NIGERIA

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ABSTRACT
Characterization or evaluation of crops is an essential first process of any crop improvement programme, information on genetic closeness among genetic resources of crops is useful for both breeding and germplasm conservation, and this can be exploited in breeding programmes to develop improved varieties. Twenty (20) okra accessions obtained from the National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, were evaluated in trials conducted in two different locations namely, the National Horticultural Research Institute (NIHORT), Ibadan, and the Federal University Oye - Ekiti Teaching and Research Farm. Each trial was conducted to evaluate the 20 okra accessions for fruit yield production potential across the two locations. The result showed the different performances of the twenty okra accession across the two different locations as it showed that some of the parameters measured had better performance over time when compared to others. In Ibadan, NGB00371 significantly was the tallest, NGB00387 significantly had the largest stem diameter while NGB00469 had the longest leaves. However, NGB00308 had the longest days to 50% flowering, first fruiting and higher fruit yield (32.96 t/ha). The performance trend at Ikole was different from that of Ibadan. However, NGB 00387 significantly had the longest leaves while NGB 00371 had the highest fruit yield. It can thenbe concluded that accessions of okra evaluated showed significant variation in some of the parameters measured. it was observed that accessions NGB00387 and NGB00371 had better fruit yield in respective Ibadan and Ikole respectively.

Keywords: *okra, yield potential, identification and environment (location).*

INTRODUCTION

Okra (*Abelmoschus esculentus* [L.] Moench) is a member of the family Malvaceae. The crop is native to Africa (ECHO, 2003) but it is grown in many parts of the world, especially in tropical and sub-tropical countries (Kumar *et al*., 2010; Saifullah and Rabbani, 2009; Arapitsas, 2008). Okra is an annual crop, which requires warm conditions for growth and is available in almost every market all over Africa (Schippers, 2000). Okra is grown primarily for its young immature green fruits and fresh leaves used in salads, soups and stews. Okra mucilage is suitable for medicinal and industrial applications (Farinde *et al*., 2007). The world okra production increased from 1.65 million tons in 1971 to 10.5 million tons in 2020 growing at an average annual rate of 4.01%. Total area cultivated with okra in 2020 was 2,531,557 ha with an average yield of 4.167 tha^{-1} (FAOSTAT, 2020, https://knoema.com). The West and Central Africa (WCA) region accounts for more than 75% of okra produced in Africa, but the average productivity in the region is very low (2.5 t ha^{-1}) compared to East Africa (6.2 t ha^{-1}) and North Africa (8.8 t/ha) (Kumar *et al*., 2010). Nigeria is the largest producer (1,039,000 tons) followed by Cote d'Ivoire, Ghana and others (FAOSTAT, 2008). Okra production of Nigeria increased from 295,000 tons in 1971 to 1.84 million tons in 2020, growing at an average annual rate of 5.53% (https://knoema.com). Studies on the optimum weather requirements for high yield okra in the tropics show that okra does best when the minimum and maximum temperatures are 18 and 35 ^{0}C respectively (Ezeakunne, 1984). Okra is sensitive to low temperatures and develops poorly below 15^{o}C (Marsh, 1992). Anon. (1982), Welby and McGregor (1997) observed an improvement in the performance of okra when rainfall was about 750 mm, evenly distributed and relative humidity was between 90-95%. Okra can be grown in a wide range of soil types provided the drainage is good. It is intolerant of wet and poorly drained and acidic soils (Incalcaterra and Curatolo, 1997) but will tolerate a soil pH range from 6.0 to 7.5 (Incalcaterra and Curatolo, 1997). In spite of its enormous economic benefits, okra rarely reaches its maximum yield potential due to several constraints. Some of the major factors limiting okra production, amongst several others, include the use of locally unimproved varieties, high incidence of pest and disease burden, a narrow genetic base of existing varieties and sub-optimal planting densities

(Adejonwo *et. al.,* 1989; Dikwahal *et. al.,* 2006 and Das *et. al.,* 2012). The key objectives of okra germplasm characterization have generally been to identify high yielding genotypes, as okra production plays a significant role in the rural economies of most tropical countries where it is cultivated, more attention needs to be directed to the selection of high yielding cultivars for increased production. This study was therefore conducted with the objective to evaluate growth and yield potentials of twenty accessions of okra in two agro-ecologies in Nigeria.

MATERIALS AND METHODS

Experiments were conducted at Vegetable Research Farm of NIHORT, Ibadan, Oyo State ($3^0 56^1$ E and $7^0 33^1$ N; 168 m above sea level) and the Teaching and Research Farm of Federal University, Oye-Ekiti, Ekiti State (5^0 26^1 N and 4^0 50^1 E; 644 m aabove sea level) in 2021. Ibadan site lies within the Rain-forest agro-ecological zone of Nigeria. The soil is dominated by Alfisols (Soil Survey Staff, 1999), belonging to Egbeda soil series, which is derived from fine-grained biotites gneiss (Smith and Montgomery, 1962). The monthly rainfall distribution pattern for Ibadan is bimodal with peaks in June and September. Annual rainfall ranges between 1250 and 1500 mm, spanning eight months (March to October) with dry spell in August. Ekiti State is located between latitude 7^0 30^l and 8^0 15^l north of the equator and longitude 4^0 47^l and 5^0 40^l of the Greenwich Meridian (Ogundele 2011). The relief of Ekiti State consists of undulating plains. The highest contour line of 540 m above sea level is found around the North eastern limit of the State. The rocks are dominated by the crystalline rocks, which form parts of the basement complex geology of the South Western Nigeria. Ekiti State has a total annual rainfall of about 1400 mm with a low co-efficient variation of about 30% during the rainfall peak months, and with an average of about 112 rainy days per annum (Adebayo, 1993). The *rainy* period of the year lasts for *eight to nine months*, from *February* to *November*, while the *rainless* period of the year lasts for about *three months*, from *November* to *February*. The month with the least rain in Ikole-Ekiti is *December*, with an average rainfall of *0.1 inches*.

The experiment which was to evaluate 20 accessions of okra was laid out in a randomized complete block design (RCBD) with three replications in two locations (Ibadan and Ikole-Ekiti). The field was disc-ploughed twice and thereafter harrowed before planting. Plot size was 2 × 1 m while the experimental field size was 24.5 × 11 m. Seeds of okra obtained from NACGRAB (Table 1) were planted at a spacing of 50 × 50 cm corresponding to 40,000 plants per hectare. Weeding was carried out manually at 6 and 8 weeks after sowing using hoe. Agronomic parameters were collected from five randomly selected and tagged plants and subjected to statistical analysis using GENSTAT Statistical Package (12th Edition) as follows;

- Plant height (cm): A meter rule was used to measure the height from ground level to the last apical bud
- Number of leaves: Numbers of leaves on each of the tagged plant were counted
- Stem diameter (mm): Digital vernier caliper was used to measure the diameter of the stem at 5 cm above soil level.
- Internode length (cm): A meter rule was used to measure the distance between two nodes on the stem.
- Leaf length (cm): By using meter rule to measure the mid-rib length of the leaves.
- Number of days to 50% flowering: Number of days from planting to when half of the plants in a plot has flowered was calculated.
- Number of days to first fruiting: Number of days from planting to when the first fruit was produced in a plot was calculated.
- Fruit yield (t/ha); Fruits harvested from the tagged plants were weighed and converted to weight per hectare.

Analysis of variance (ANOVA) was performed to establish significant effect ($p<0.05$; F-test) of the treatments on all parameters and significant means were separated using $LSD_{0.0}$).

RESULTS

Growth parameters and fruit yield of twenty okra accessions: Result from the analysis of variance (ANOVA) showed that significant varietal difference existed between the accessions of okra evaluated at Ibadan (Table 2). During the initial growth stage of observation (i.e. 4WAP), accessions NGB00371 and NGB00356 were observed to be the tallest among the accessions (16.42cm and 15.85cm respectively) while accession NGB00331 was the shortest (7.89cm). Plant height ranged from 16.42cm to 7.89cm with the mean of 11.69cm (Table 2). At 6WAP, plant height ranged from 36.81cm to 17.71cm with average height of 24.80cm. Accession NGB00371 and NGB00302 were observed to be the tallest and the shortest respectively (Table 2). At Ikole, significant

varietal evaluation also existed among the accessions of okra evaluated in terms of plant height (Table 3). At the early stage of the plant (4WAP), plant height ranged from 30.33cm to 7cm with average of 16.02cm. Accession NGB00466 was significantly (P<0.05) taller (30.33cm) than other accessions except NGB00438 while accession NGB00356 was the shortest with height of 7cm (Table 3). Observation at 6WAP revealed that plant height ranged from 56.87cm to 18.37cm with average of 32.34cm. Accession NGB00387 was significantly (P<0.05) taller (56.87cm) than other accessions but comparable to accessions NGB00396 and NGB00378 (53.6cm and 52.87cm respectively) while accession NBG00346 was observed to be the shortest plant with height of 18.37cm (Table 3). At Ibadan the analysis of variance on the number of leaves of okra at the Ibadan trial showed significant (P<0.05) varietal differences between the 20 okra accessions (Table 2). At 4WAP the number of leaves ranged from 5.8 to 3.4 as the average leave number at 4WAP was 5. Okra accessions of NGB00331 and NGB00438 significantly (P<0.05) had the highest number of leaves (5.7 respectively) as NGB 00356 significantly (P<0.05) had the smallest number (3) of leaves (Table 2). However, at 6WAP NGB00308 significantly (P<0.05) had the highest number (8.6) number of leaves while NGB00356 and NGB00378 significantly (P<0.05) had smallest (4.7 and 4.6 respectively) number of leaves. It was also observed that the number of leaves at 6WAP ranged from 8.6 to 4.6 as its average number of leaves was 6.2. At Ikole, the trial significantly (P<0.05) showed varietal differences among the 20 okra accessions at 4 and 6WAP. At 4WAP, NGB00466 significantly (P<0.05) had the highest number (8.3) of leaves as NGB 00438 and NGB 00342 significantly (P<0.05) had the smallest (4.6) number of leaves (Table 3), the average number of leaves observed at 4WAP was 6.4 (Table 3). At 6WAP the maximum number of leaves observed was 19.3 while the minimum was 4.3 while on the average the number of leaves observed was 6.8 (Table 3). Also, NGB00308 was observed to have had the highest number of leaves (19) and NGB00398 significantly (P<0.05) had the smallest number of (43) of leaves at 6WAP. The table 2 showed the significant (P<0.05) varietal differences in the stem diameter of the twenty okra accessions as at 4 and 6WAP NGB00387 significantly (P<0.05) had the largest (6.5 and 11.5 cm) stem diameter while NGB00302 significantly (P<0.05) had the smallest (3.7 and 6.2 cm) stem diameter. However, the average stem diameter from its early stage (4WAP) to 6WAP ranged from 5.1 cm to 9.4 cm (Table 2). At the Ikole trial the analysis of variance result showed significant (P<0.05) varietal differences among the 20 okra accessions (Table 3). At 4WAP NGB00356 (3.2 cm), NGB00308 (3.1 cm) and NGB00413 (3 cm) significantly (P<0.05) had the largest stem diameter while, NGB00371 (0.9 cm) and NGB00356 (0.97 cm) significantly (P<0.05) had the smallest stem diameter. While at 6WAP NGB00397 (15.33cm) significantly (P<0.05) had the largest stem diameter as NGB00469 (5.1 cm) significantly (P<0.05) had the smallest stem diameter (Table 3). The significant variations among the 20 okra accessions at Ibadan trial from the analysis of variance (Table 2) ranged from 2.72 to 1.20 cm with an average range length of 1.9 cm as it was observed that NGB00342-1 significantly (P<0.05) had the longest (2.72 cm) inter node length, while NGB00371 significantly (P<0.05) had the shortest (1.2 cm) inter node length (4WAP). At its later stage of growth (6WAP) inter node length ranged from 8.9 to 3.07 cm with the average length of 4.81 cm (Table 2). NGB00398 significantly (P<0.05) had the longest (8.93 cm) inter node length while NGB00438 significantly (P<0.05) had the shortest (3.07 cm) inter node length (Table 2). At Ikole, the significant variation among the 20 okra accessions (Table 3) showed that at its early stage of growth NGB00398 significantly (P<0.05) had the longest (4 cm) inter node length as NGB00356 significantly (P<0.05) had the shortest (1.13 cm) inter node length with an average mean 2.15 cm. However, at 6WAP the average mean of 4.08 cm was observed just as NGB00308 significantly (P<0.05) had the longest (10 cm) inter node length while NGB00469 significantly (P<0.05) had the shortest (1.2 cm) inter node length (Table 3). The analysis of variance of table 2 showed the significant variations in the 20 okra accessions leave length as this ranged from 5.18 cm to 13.43 cm in 4WAP and 10.03 cm to 17.14 cm in 6WAP. The leave length of NGB00469 significantly (P<0.05) had longest leave length (13.43 cm) at 4WAP and at 6WAP (17.14 cm), while NGB00356 significantly (P<0.05) had the shortest leave length (5.18 cm) at 4WAP and (10.03 cm) 6WAP (Table 2). At Ikole, the analysis of variance of table 3 showed that at 4WAP, NGB00322 (13.7 cm), NGB00308 (13.0 cm) and NGB00387 (13.47 cm) significantly (P<0.05) had the longest leave length while

NGB00356 significantly (P<0.05) had the shortest (3.13 and 7.30 cm) leave length at 4 and 6WAP. However, at 6 WAP NGB00387 (20.37 cm) significantly (P<0.05) had the longest leave length. The average leave length from the ANOVA ranged between 8.72 and 11.4 cm at 4 and 6WAP respectively.

The analysis of variance showed that the 20 okra accessions showed varietal differences. At Ibadan trial, NGB00308 significantly (P<0.05) had the longest (97 days) days to 50% flowering and days to first fruit (105 days). NGB00397 and NGB00466 significantly (P<0.05) had the shortest (52.6 days) days to 50% flowering and days to first fruit (Fig 1). The days to 50% flowering ranged from 97 to 52 days with the average mean of 72 days, as days to first fruit ranged from 105 to 56 days with a mean of 79 days (Figure 1). The fruit yield of the twenty okra accessions showed significant variations as three accessions significantly (P<0.05) had the highest fruit yield (NGB00308 (32.96 t ha^{-1}), NGB00378 (32.80 t ha^{-1}) and NGB00387 (35.17 t ha^{-1}) as NGB00342 significantly (P<0.05) had the smallest fruit yield of 12.11 t ha^{-1} (Figure 2). The fruit yield of okra at Ibadan ranged from 35.17 t ha^{-1} - 12.11 t ha^{-1} with average fruit yield of 23.26 t ha^{-1}. At Ikole, the analysis of variance showed that NGB00308 and NGB00322 significantly (P<0.05) had the longest (96 days) days to 50% flowering and longest days to first fruit (106 days) (Figure 1). Also, in fig 1 the shortest days to 50% flowering and days to first fruit was with NGB00397 (51 and 58 days respectively). The result on fruit yield showed varietal differences as NGB00371 significantly had the highest fruit yield (50.47 t ha^{-1}) while the lowest fruit yield was produced by NGB00342 (5.81 t ha^{-1}), average fruit yield was 21.46 t ha^{-1} (Figure 2).

DISCUSSION

Variation is an important attribute in breeding programs (Hazra and Basu, 2000 and Omonhinmin and Osawaru, 2005). Variation in okra species has been investigated by several researchers (Bish, *et. al.*, 1995; Akinyele and Oseikita, 2006 and Duzyaman, 2005). The okra accessions evaluated showed a broad variation for most traits, which allows for the identification of promising accessions for okra breeding. According to Osawaru, *et. al.* (2013), morpho-agronomic characteristics of okra can be used to describe the plant. These characteristics complement the molecular and biochemical basis of characterizing the plant germplasm. These characteristics are the raw materials for crop breeding on which selection acts upon to evolve superior genotypes. Thus, the higher the amount of variation expressed for a character in the breeding material, the greater the scope for its improvement through selection (Osawaru, *et. al.*, 2013; Osawaru, *et. al.*, 2014 and Aladele *et. al.*, 2008). In this study, different accessions exhibited different growth parameters which could be as a result of previous selection or a natural adaptation mechanism. Plant height ranged from 18 cm to 57 cm indicating variation in plant height. The height of the plant can potentially affect yield, taller plants are usually more prone to lodging which could lead to loss of dry matter and subsequent decrease in fruit yield. Plant height is a good index in measuring plant vigour which might also contribute towards higher productivity. This might be the reason NGB00387 which was observed to be the tallest plant had higher stem diameter and consequently higher fruit yield of okra. Variation was also observed in the number of leaves of the cultivars. Since leaves serve as the sites for photosynthetic activities in any plant, an increase or a decrease in their number may have very serious implications for production of assimilates in the crop. Consequently, a greater number of them in any particular variety would be assumed to produce a better crop yield due to the higher photosynthetic capacity that is brought to bear by an increased leaf area index and a resultant higher fraction of intercepted radiation and its utilization efficiency (Ahiakpa *et. al.*, 2013). The better performance of NGB00308 compare to most of the accessions in terms of fruit yield production, amongst other reasons, can thus be attributed to the higher number of leaves which may have enabled these accessions to produce greater assimilates during their photosynthetic activities thereby resulting in an increase in dry matter production and a subsequent increase in fruit yield.

The fruit yield of okra plant has been reported by Simon *et al*. (2013) and Singla *et al*. (2018) to be directly related with high number of branches which is also as reported consisted of high number of nodes as a result of the inter node length. Similar results were also observed in this study as the inter nodes of okra plant were longer. The better fruit yield performance of NGB00371 at Ikole could be attributed to the better adaptability to the environment. NGB00387 had better performance in the two locations (Ikole 31.49 t ha^{-1} and Ibadan 35.16 t ha^{-1}).

CONCLUSION

The twenty accessions of okra evaluated showed variation the parameters measured, it was observed that NGB00387 and NGB00371 had better fruit yield in respective of its location. However, environmental factor is a key factor in which NGB00371 is of better accession for Ikole while NGB 00387 is better for Ibadan.

REFERENCES

Adebayo, W. O. (1993) Weather and Climate. In Ebisemiju, F.S. (ed) Ado-Ekiti Region. A Geographical Analysis and Master Plan. Lagos: Alpha Prints, Pages 11-14

Adejonwo KO, Ahmed MK, Lagoke STO, Karikari SK (1989) Effects of variety, nitrogen and period of weed interference on growth and yield of okra (Abelmoshus esculentus). Nigeria Journal of Weed Science 2: 21-27.

Ahiakpa J.K, Kaledzi P.D, Adi E.B, Peprah S, Dapaah H.K (2013) Genetic diversity, correlation and path analyses of okra (Abelmoschus spp. (L.) Moench) germplasm collected in Ghana. *International Journal of Development and Sustainability* 2: 1396-1415.

Akinyele B.O and Oseikita O.S. (2006). Correlation and path coefficient analyses of seed yield attributes in okra (*Abelmoschus esculentus* (L.) Moench). *Afr. J. Biotechnol.*14:1330-1336.

Aladele, S.E., Ariyo, O.J. and Lapena, R. (2008). Genetic relationships among West African okra (*Abelmoschus esculentus*). *Indian. J. Biotechnol.* 7(10): 1426–1431.

Anonymous (1982) Guide to the Production of Okra. Extension Guide No 61, AERLS, Ahmadu Bello University, Zaria, 10pp.

Arapitsas P (2008): Identification and quantification of polyphenolic compounds from okra seeds and skins. Food Chem. 110: 1041-1045

Bish I.S, Mahajan R.K and Rana R.S. (1995). Genetic diversity in South Asian okra (*Abelmoschus esculentus*) germplasm collection. *Ann. Appl. Biol.* 126:539-550.

Das S, Chattopadhyay A, Chattopadhyay SB, Dutta S, Hazra P (2012) Genetic parameters and path analysis of yield and its components in okra at different sowing dates in the Gangetic plains of eastern India. African Journal of Biotechnology 11: 16132-16141.

Dikwahal HD, Haggai PT, Aliyu L (2006) Effects of sowing date and plant population density on growth and yield of two okra (Abelmoschus esculentus L.) varieties in the northern guinea savanna of Nigeria. Nigerian Journal of Horticultural Science 11: 56-62.

Duzyaman E. (2005). Phenotypic diversity within a collection of distinct okra (*Abelmoschus esculentus*) cultivars derived from Turkish landraces. *Genet. Res. Crop Evol.* 52:1019-1030.

ECHO. (2003). Plant information sheet, N. FT. Meyers, USA. http.www.echonet.org.

Ezeakunne, C.O. (1984) Large scale fruit and vegetable production in Nigeria. Short Communication. Department of Agronomy, Ahmadu Bello University, Zaria, 8pp.

FAOSTAT (2020). Food and Agricultural Organization Statistics. https://www. fao.org/faostat/en/#data/QCL (assessed May 2022).

FAOSTAT 2008. Food and Agricultural Organization of the United Nations. On-line and Multilingual Database, http://faostat. fao.org/foastat

Farinde, A., Owolarafe, O., & Ogungbemi, I. (2007). "An overview of production, processing, marketing and utilisation of "Okra" in egbedore local government area of Osun State, Nigeria,"Agricultural Engineering, vol.4, pp.1–17.

Hazra P. and Basu D. (2000). Genetic variability, correlation and path analysis in okra. *Ann. Agric. Res.*;21(3):452-453. 16.

Incalcaterra, G. and Curatolo, G. (1997). Biodiversità di una popolazione siciliana di melone d'inverno (Cucumis melo Var .Inodorus naud.). Atti Del 3° Convegno Nazionale Biodiversità - Tecnologie - Qualità. Reggio Calibria Giugno, 16-17.

Kumar, S., Dagnoko, S., Haougui, A., Ratnadass, A., Pasternak, N., and Kouame, C. (2010). Okra (Abelmoschus spp.) in West and Central Africa: potential and progress on its improvement. Afr. J. Agric. Res. 25, 3590–3359.

Marsh, L. (1992) Emergence and seedling growth of okra genotypes at low tempetaures. Hortscience 27:1310-12.

Ogundele, J.A and Jegede, A.O (2011). Environmental impact of climate change on agricultural production in Ekiti State, Nigeria. Journal of environmental issues and agriculture in Developing Countries. Vol 3: No 2, pp 72 - 78

Omonhinmin C.A and Osawaru M.E. (2005). Morphological characterization of two species of Abelmoschus: *Abelmoschus esculentus* and *Abelmoschus caillei*. *Genet. Resour. Newsl*. 144:51-55.

Osawaru, M.E., Ogwu, M.C. and Dania-Ogbe, F.M. (2013). Morphological assessment of the genetic variability among 53 accessions of West African Okra [*Abelmoschus caillei* (A. Chev.) Stevels] from South Western Nigeria. *Nigerian J. Basic. Appl. Sci.* 21(3): 227-238

Osawaru, M.E., Ogwu, M.C. and Omologbe, J. (2014). Characterization of three Okra [Abelmoschus (L.)] accessions using morphology and SDS-PAGE for the basis of conservation. *Egyp. Academic. J. Biol. Sci.* 5(1): 55–65

Saifullah M, Rabbani MG (2009): Evaluation and characterization of okra (Abelmoschus esculentus L. Moench.) genotypes. SAARC J. Agric. 7: 92-99

Schippers RR (2000). African indigenous vegetable: an overview of the cultivated species. Chaltham, U.K. National Resource Institute A.C.D.E.U. Technical Centre for Agricultural and Rural Crop pp. 105-117

Simon, S. Y., Gashua, I. B. and Musa, I. (2013). Genetic variability and trait correlation studies in okra (*Abelmoschus esculentus* (L.) Moench). *Agric. Bio. J. North Ame.* 10: 532-538 (2013).

Singla, R., Kumari, P. and Thaneshwari. (2018). Evaluation of growth and yield parameters of okra (*Abelmoschus esculentus*) genotypes. *International Journal of Pure Applied Bioscience.* 6(5): 84-89.

Smith and Montgomery (1962). "Soil and Land Use in Capital Western Nigeria," Ministry of Agriculture and Natural Resources, Ibadan, Nigeria.

Soil Survey Staff 1999. Soil Taxonomy. A Basic System of Soil Classification for Making and Interpreting Soil Surveys, Second Edition. United States Department of Agriculture, Agriculture Handbook No. 436, Washington D.C.

Welby, E.M. and McGregor, B. (1997) Agricultural export transportation handbook. USDA Agricultural Handbook, United States Department of Agriculture (URL: http:/www.ams Usda.gov./tmd/export/index.htm. 10pp.

Table 1: Identity of okra accessions evaluated

Accessions	Status	Location	Source
NGB 00302	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00308	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00322	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00331	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00342	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00342-1	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00343	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00346	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00356	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00371	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00378	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00387	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00396	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00397	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00398	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00413	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00438	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00466	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00469	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan
NGB 00514	Landrace	7.4^0N and 3.84^0E	NACGRAB Ibadan

Table 2: Growth parameters of twenty okra accessions grown in Ibadan

Accessions	Plant height (cm)		Number of leaves		Stem diameter (cm)		Internode length (cm)		Leaf length (cm)	
	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP
NGB 00302	8.82	17.71	4.28	5.32	3.70	6.23	1.41	3.63	6.27	10.51
NGB 00308	8.67	22.09	5.45	8.67	5.63	10.44	2.13	3.77	8.68	12.29
NGB 00322	11.10	22.64	5.33	5.94	4.13	9.57	2.52	4.08	10.63	14.97
NGB 00331	7.89	22.02	5.71	8.15	4.97	9.89	1.44	4.73	10.31	14.51
NGB 00342	13.47	27.04	4.27	5.00	5.36	9.85	2.04	5.62	9.28	14.12
NGB 00342-1	15.35	28.71	5.27	6.77	6.25	8.01	2.72	5.69	9.69	14.79
NGB 00343	12.16	24.47	5.20	6.38	5.82	9.39	1.73	5.94	10.34	14.80
NGB 00346	8.79	23.99	4.56	5.94	4.43	9.37	1.58	3.63	9.64	13.56
NGB 00356	15.85	21.59	3.47	4.72	4.78	8.28	1.52	3.26	5.18	10.03
NGB 00371	16.42	36.81	5.02	5.95	4.72	10.29	1.20	4.81	9.18	12.83
NGB 00378	12.48	22.00	4.34	4.67	4.55	7.87	2.54	6.45	10.53	14.31
NGB 00387	8.37	28.19	4.93	5.27	6.58	11.55	2.10	4.82	10.11	14.39
NGB 00396	13.68	27.58	5.03	6.63	5.53	9.69	1.68	5.48	13.24	16.86
NGB 00397	12.33	27.97	5.00	5.08	4.38	8.84	2.19	5.33	8.66	13.30
NGB 00398	12.39	28.48	5.27	6.73	5.19	11.20	2.47	8.93	11.93	15.49
NGB 00413	12.65	21.61	4.73	5.37	5.23	8.81	1.64	4.81	9.03	13.23
NGB 00438	8.33	18.47	5.78	7.06	5.54	9.26	1.43	3.07	9.52	13.77
NGB 00466	9.87	20.80	5.07	6.53	5.37	9.40	1.65	3.61	10.43	13.87
NGB 00469	14.03	22.85	5.80	7.67	6.35	11.17	1.79	4.39	13.43	17.14
NGB 00514	11.04	31.01	5.62	6.89	3.91	10.46	2.15	4.15	10.72	14.80
Maximum	16.42	36.81	5.80	8.67	6.58	11.55	2.72	8.93	13.43	17.14
Minimum	7.89	17.71	3.47	4.67	3.70	6.23	1.20	3.07	5.18	10.03
Mean	11.69	24.80	5.00	6.24	5.12	9.48	1.90	4.81	9.84	13.98
LSD	3.10	9.13	1.31	2.13	1.45	3.36	1.11	1.87	2.85	3.07
CV (%)	16.03	22.27	15.80	20.63	17.17	21.44	35.45	23.48	17.49	13.30
F sig.	**	*	ns	*	**	ns	ns	**	**	**

Table 3: Growth parameters of twenty okra accessions grown in Ikole-Ekiti

Accessions	Plant height (cm)		Number of leaves		Stem diameter (cm)		Internode length (cm)		Leaf length (cm)	
	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP
NGB 00302	7.97	18.73	5.33	6.67	1.53	6.00	1.97	2.53	8.87	10.07
NGB 00308	19.93	22.62	8.00	19.33	3.12	6.68	2.22	10.02	13.08	17.30
NGB 00322	19.00	50.72	7.67	10.33	3.27	5.86	3.00	4.21	13.70	14.19
NGB 00331	14.33	31.10	7.00	8.67	2.10	7.63	3.05	8.75	7.58	10.50
NGB 00342	12.17	31.67	4.67	5.67	1.03	6.22	1.95	2.62	6.02	7.50
NGB 00342-1	10.00	19.47	5.67	7.67	1.40	5.37	2.07	2.50	7.63	9.40
NGB 00343	10.00	23.17	5.00	7.67	1.13	6.23	2.23	3.17	9.67	10.40
NGB 00346	10.17	18.37	6.33	7.33	1.37	5.53	1.97	2.37	8.17	10.00
NGB 00356	7.00	18.83	5.00	5.67	0.97	4.10	1.13	3.00	3.13	7.30
NGB 00371	9.17	23.63	6.67	6.67	0.90	5.85	2.17	3.13	5.07	8.69
NGB 00378	15.23	52.87	5.67	7.67	1.22	9.97	2.13	3.28	7.22	14.79
NGB 00387	25.33	56.87	6.67	9.33	2.17	12.39	2.27	7.13	13.47	20.37
NGB 00396	20.13	53.60	7.33	10.67	2.20	10.73	2.37	4.47	10.43	15.90
NGB 00397	16.00	46.13	7.33	11.33	2.13	15.33	1.17	5.57	9.40	10.90
NGB 00398	25.33	34.17	6.33	4.33	2.00	6.70	4.00	5.20	9.87	10.13
NGB 00413	14.67	21.97	6.33	10.67	3.00	5.97	3.27	5.27	11.20	12.93
NGB 00438	27.67	39.80	4.67	6.67	1.37	7.13	1.45	1.92	7.33	9.86
NGB 00466	30.33	36.23	8.33	10.67	1.20	9.63	2.17	3.23	10.00	12.13
NGB 00469	8.23	24.93	7.33	6.00	1.93	3.10	1.20	1.20	6.07	8.52
NGB 00514	17.67	21.90	7.67	9.33	1.80	5.93	1.17	1.97	6.43	7.97
Maximum	30.33	56.87	8.33	19.33	3.27	15.33	4.00	10.02	13.70	20.37
Minimum	7.00	18.37	4.67	4.33	0.90	3.10	1.13	1.20	3.13	7.30
Mean	16.02	32.34	6.45	8.62	1.79	7.32	2.15	4.08	8.72	11.44
LSD	2.85	4.18	1.37	1.42	0.39	1.09	0.75	0.66	1.24	2.04
CV (%)	10.75	7.83	12.89	9.93	13.30	9.00	21.21	9.75	8.58	10.77
F sig.	**	**	**	**	**	**	**	**	**	**

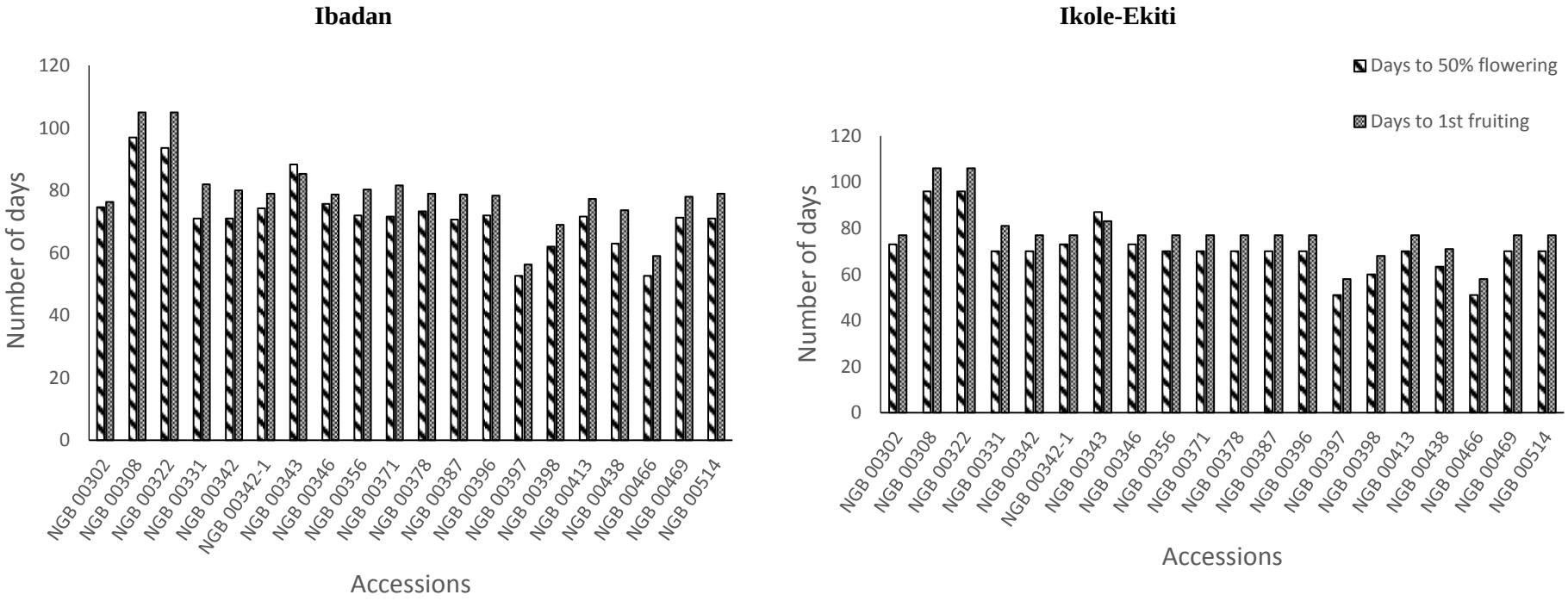

Figure 1: Number of days to 50% flowering and first fruiting of twenty okra accessions in Ibadan and Ikole

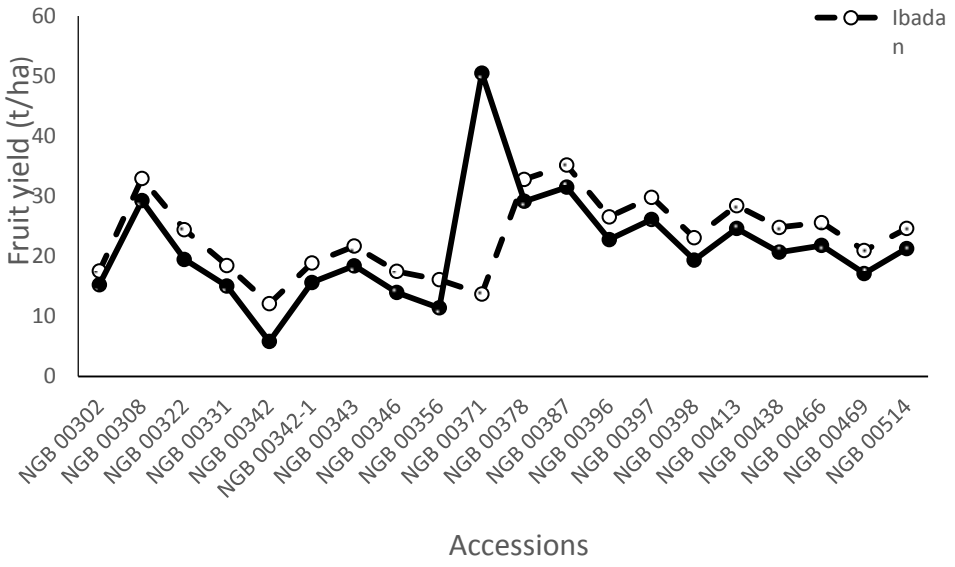

Figure 2: Fruit yield (t/ha) of twenty okra accessions

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EFFECTS OF MULCH AND STAKING ON THE YIELD AND POSTHARVEST QUALITY OF CUCUMBER

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ABSTRACT
This research was carried out at the Vegetable Research Farm, National Horticultural Research Institute (NIHORT), Idi- Ishin, Ibadan, Oyo State, Nigeria to determine the effects of different mulch materials and staking on the yield and post-harvest quality of Cucumber (*Cucumis sativus L.*). The experimental design was 2x4 factorial, laid out in a Randomized Complete Block Design with eight treatments replicated 3 times: Staked Cucumber with Black Polypropylene Mulch, Staked Cucumber with White Polypropylene Mulch Staked Cucumber With organic Mulch (Dried plant materials), Staked Cucumber without mulch, Unstaked Cucumber with Black Polypropylene Mulch, Unstaked Cucumber With white Polypropylene Mulch, Unstaked Cucumber with Organic Mulch (Dried plant materials), Unstaked Cucumber without mulch. Data on vine length, number of leaves, leaf length and fruit yield were collected. The fruit quality parameters were total soluble solids, phenolic acid, ascorbic acid (Vitamin C) and the determination of scavenging activity of 2,2-diphenyl-1-picrylhydrazyl (DPPH) at 1, 5, 10 and 15 days in storage. Data was subjected to analysis of variance at ($P<0.05$) while means were separated using Duncan Multiple Range Test. The staked cucumber plants mulched with black polythene mulches had the highest growth rate and resulted in subsequently higher yield (21.01t/ha) of cucumber fruit compared to other mulch materials. There were significant ($P>0.05$) differences in yield of staked cucumber with white Polypropylene mulch (15.35t/ha) and unstaked Cucumber with black Polypropylene mulch (14.78t/ha). The unstaked Cucumber planted without mulch had the lowest yield (4.93 t/ha). Result from this research showed that staked cucumber planted on white Polypropylene mulch produce fruit with the highest vitamin C, total soluble solids, phenolic acid and DPPH.

Keywords: *Cucumber, mulch materials, growth and yield and post-harvest quality.*

INTRODUCTION

Cucumber (*Cucumis sativus* L) is an important vegetable and one of the most popular members of the family cucurbitaceae. It is one of the oldest vegetables cultivated by man with historical record dating back to 5000 years (Wehner and Gunner, 2004). In Nigeria, production is mainly from the northern states (Adetula and Denton, 2003). Cucumber production in most part of Nigeria is fast becoming popular. Cucumbers contain rutin and ascorbic acid oxidase, which function as free radical scavengers; it helps to protect the skin against damage (Katiyar *et al.,* 2014). Research indicated that phytochemicals, such as triterpenes in cucumber contains important cyto-protective capabilities which provides cutaneous barrier function and cellular immunity (Rios, 2010). Cucumbers also hydrate, fortify and regenerate the body. Cucumbers also remediate wrinkles, sunburns, moisturize and brighten the skin by inhibiting tyrosinase (Hooda, 2015). Cucumber slices helps the eyes and surrounding tissues through the hydrating properties and high levels of vitamin K that helps to reduce dark circles, and the lignans that reduces inflammation (Lopes *et al*., 2007). It reduces chronic stress and aging process from environmental sources or cultural stress resulting in cell-deteriorating processes such as inflammation and oxidative stress. Cucumber is an alkaline food and because it contains triterpenes, it regulates diseases that are associated with the immune system (Rios, 2010). It helps in healing diseases of urinary bladder and kidney; digestive problem like heartburn, acidity, gastric ulcer (Garcia-Closes *et al.,* 2004). The ascorbic acid and caffeic acid contained in cucumber help to reduce skin irritation (Okonmah, 2011). Mulching is the practice of covering the soil with materials such as dry grasses, litter or plastic sheets while staking involves supporting growing plants with standing poles to keep them off the ground.

Mulch helps in moisture preservation, weeds control, promotes root growth, enhance soil stabilization and porosity, microbial population activities are increased (Benito *et al.,* 2006, Duppong *et al*., 2004). Plastic film can be used to aid crop production in many ways (Arin and Ankara, 2001). Polyethylene and other materials can be formulated to control or utilize more effectively the heat and light energy from the sun, and also heat energy emitted from the soil (Arin and Ankara, 2001). Plastic mulches directly affect the microclimate around the plant by modifying the radiation budget of the surface and decreasing the soil water loss, resulting in more uniform soil moisture (Ngouajio *et al.,* 2007). The soil under plastic mulch remains loose, friable and well - aerated. Roots have access to adequate oxygen, and microbial activity is enhanced (Parmar *et al.,* 2013). Despite the high health benefit of Cucumber and the beneficial roles of mulch and stake, Cucumber production is limited due to weed competition, inadequate moisture supply and pest and diseases due to fruits direct contact with the soil. Therefore, the study aims at assessing the effect of mulching and staking in Cucumber production and postharvest fruit quality.

MATERIALS AND METHOD

The experiment was conducted at the Vegetable Research Farm, National Horticultural Research Institute (NIHORT), Ibadan, Oyo State (7^0 33´N and 3^0 56´E; 168 m above sea level). Pre-cropping soil analysis for physical and chemical properties of the soil was done. . The field was cleared, harrowed and ridged; field layout was done in preparation for planting. Plot size was 2 x 2 m while the experimental field size was 23m x 8m ($148m^2$). Seeds of cucumber variety (MARKETER) was obtained from seed store and planted at a spacing of 50 x 50 cm. Management practices were: removal of extra seedlings, regular weeding at 2 weeks interval, staking and plant trailing. The experiment was a 2x4 factorial experiment in a randomized complete block design (RCBD) replicated three times. There were Eight (8) treatment combinations: Staked Cucumber with Black Polypropylene mulch, Staked Cucumber with White Polypropylene mulch, Staked Cucumber with organic Mulch, Staked Cucumber without mulch, Unstaked Cucumber with Black Polypropylene mulch, Unstaked Cucumber With white Polypropylene mulch, Unstaked Cucumber with Organic Mulch, Unstaked Cucumber without mulch. The following data were collected for growth and yield: Vine length (cm), Number of leaves, Leaf length (cm), Leaf breadth (cm), Stem diameter (cm), Fruit length (cm), Fruit diameter(mm), Average fruit weight (g), Fruit yield (t/ha).

Postharvest evaluations: 8 Freshly harvested Cucumber fruits were sorted according to freedom from diseases and defects. Infected fruits and those with defects were discarded. fruits were kept at ambient conditions for 15 days at (21.9 ^{0}C – 33.5 ^{0}C; 58 – 62 %RH), Standard laboratory chemical analysis of the fruit was conducted at the 1st, 5th, 10th and 15th days after harvesting to determine total Phenolics and scavenging Assay (McDonald *et al*., 2001)**,** vitamin C (Egan *et al*., 1981) and total Soluble Solid (TSS) according to (Quartey *et al*., 2012). Data collected were subjected to analysis of variance (ANOVA) treatment means were separated using the Duncan Multiple Range Test (DMRT) at 5% probability level.

RESULTS

Effect of Different Mulching Materials and Staking on Cucumber growth: Table 1, showed the effect of different mulching materials and staking on cucumber growth, At 4 and 5 weeks after sowing, Staked Cucumber with Black Polypropylene mulch had longer vine length and leaves this was followed by Staked Cucumber on White Polypropylene mulch; Staked cucumber planted on organic mulch (Dried plant materials) had the shortest vine length and leaves. It was observed that there were no significant differences in the number of leaves produced by cucumber planted on organic mulch and no mulch. Staked cucumber produced significantly higher number of leaves than the unstaked plants.

Effect of Different Mulching Materials and Staking on Fruit Length, width and total yield of Cucumber: Table 2, showed the effects of mulching and staking on yield of cucumber, Cucumber fruit length was significantly affected by different mulching materials and staking. It was observed that there were significant different between the Staked Cucumber with Black Polypropylene Mulch and white Polypropylene mulch, so also there were no significant difference between cucumber planted on organic mulch and no mulch. There was significant difference between the fruit length of staked cucumber over the unstaked cucumber. Result showed that cucumber fruit width was

significantly affected by different mulching materials and staking.

Effect of Different Mulching Materials and Staking on nutritional composition of cucumber

At first day of Storage, fruit harvested from white polythene mulch were significantly higher in vitamin C (24.50), total soluble solid (3.56) and antioxidant (42.21). Cucumber harvested on organic mulch had the least vitamin C content. Cucumber fruit harvested from black polythene mulch had the highest phenolic content 528.46 and least total soluble solid (3.37) with fruits harvested from plots with no mulch (3.43). Unstaked cucumber had higher vitamin C (21.68) and phenolic content (518.83) compared to staked cucumber. Staked cucumber had high antioxidant assay compared to unstaked cucumber. At 15 day of storage, cucumber harvested from black polythene mulch had the highest vitamin C content, while the cucumber harvested on organic mulch had the least vitamin C Content.

DISCUSSION

Result from this study indicated that vertical training of cucumber plant increased yield could be attributed to reduction in fruit rot on the vertically trained vines than untrained ones. Polypropylene mulch significantly influenced all the growth and yield parameters of cucumber in this experiment, the fruit yield obtained on black and white mulches were higher than the yield from plot with no mulch. Also black polythene mulched plots gave heavier fruit yield than white polythene mulched plots, and also had higher fruit length and width than the white plastic mulch. This result agreed with the report of Anikwe *et al.* (2007) who noted that yields were higher in tilled black plastic mulched cocoyam plots when compared to tilled clear plastic mulched plots, no-till black plastic mulched plots and no-till clear plastic mulched plots by 29, 47 and 59%, respectively. The staking of plants significantly improved the growth and yield of cucumber. The observation agrees with (Adetula and Denton, 2003) who reported that staking generally improves the growth and yield of climbing plants. Also, Hirataand Tilliato (2000) found that trellised cucumber gave greater yield (55%) over the non-trellised ones (45%). According to Hannada *et al.(*1987) staking led to early anthesis, improved photosynthetic efficiency and was also reported to have influenced yield in cucumber. Rowell *et al.* (2002) affirmed that staking improves the color and lower the incidence of yellow bellies in cucumber. The result also agreed with the findings of Hardy and Rowell (2002) who observed that the yield of super select cucumbers were higher for the trellised treatment than for the non-trellised treatment. The total soluble solids (TSS) of cucumber fruit decreased as storage days prolong to day 15. This agreed with the report of Moalemiyan and Ramaswamy (2012) where there is a decrease in TSS of cucumber fruits (coated and control) at the end of the experiment. Also, Nadim *et al.* (2015) noted that the total soluble solids of strawberry fruits coated with methylcellulose-based edible coating decreased at the end of storage. Similar results were recorded for tomato (Ali *et al.,* 2011) and for banana fruits coated with cellulose edible coatings (Jafarizadeh *et al.,* 2011). The decrease in TSS observed during storage might be due to the breakdown of starch into simple sugars. In general, sugars are the primary constituents of soluble solid concentration of a product which are consumed during respiration. Decreased respiration rates slow down the synthesis and use of metabolites and this result in lower total soluble solid due to the slower hydrolysis of carbohydrates to sugars (Yaman and Bayoindirli, 2002). The vitamin C content (Vit. C) of cucumber fruit decreased as the length of storage increased. The result showed a decrease in the vitamin content as the days of storage increases across all the treatment. The decrease is associated with storage period, this agreed with the report of (Monica *et al.,* 2017) in which the length of storage significantly affected the vitamin C content in the Japanese quince fruit. After one and two weeks of Japanese quince fruit storage a decrease in the vitamin C content was observed in all the genotypes studied. Vitamin C is highly sensitive to oxidation and leaching during storage (Davey *et al.,* 2000; Franke *et al.,* 2004). According to Monica *et al.* (2017), vitamin C content may vary under the condition of high humidity and low temperature. Fruit maturity at harvest and the harvesting method, as well as postharvest handling condition also affect vitamin C content in the fruit (Kadar 1988). The total phenolic content of cucumber fruit decreased as the length of storage increased. The result showed a decrease in the total phenolic content as the days of storage increases across all the treatment. This agrees with the report of Vallverdu *et al*. (2011) which state that there was decrease in total phenolic

content of tomato juices after 3, 6 and 9 months of storage. The antioxidant activity of cucumber fruit decrease as the length of storage increased. The result showed a decrease in the antioxidant activity as the days of storage increases across all the treatment. According to Klimczak *et al.* (2007) decrease in antioxidant activity may be linked to a decrease in total phenolic content and vitamin C during storage. Antioxidant activity of orange juices decreased by 45 percent after 6 months of storage at 28^0C (Klimczak *et al*., 2007).

CONCLUSION

Result from this research showed that staked cucumber planted on plot with black polythene mulch produced cucumber plants with improved vegetative growth and yield. At the end of the experiment it was observed that cucumber fruit harvested from plot with white polythene mulch had the highest nutritional composition compared to fruit planted on black polythene mulch.

REFERENCES

Adetula O, Denton L. (2003) Performances of vegetation and yield accessions of cucumber *(cucumis sativa L.)* horticulture society of Nigeria (HORTSON) proceedings of 21st annual conferences 10-12 Nov, 2003.

Adetula, O. and Denton, L., (2003). Performance of vegetative and yield accessions of cucumber (Cucumis sativa L.), Proceedings of the 21st annual conference of Horticultural Society of Nigeria (HORTSON), 10-13 November.

Ali A, Noh NM, Mustafa MA (2015). Antimicrobial activity of chitosan enriched with lemongrass oil against anthracnose of bell pepper. Food Packag. Shelf Life 3:56-61.

Anikwe, M.A.N., Mbah, C.N., Ezeaku, P.I. and Onyia, V.N., (2007). Tillage and plastic mulch effect on soil properties, growth and yield of cocoyam (Colocasia esculenta) on an ultisol in Southeastern Nigeria. Soil and Tillage Research 93, 264-272.

Arin L, Ankara S (2001). Effect of low-tunnel, mulch and pruning on the yield and earliness of tomato in unheated glasshouse. *J. Appl. Hort*., 3(1):23-27.

Arjenaki O. O., Moghaddam P. A., and Motlagh A. M., (2013) "Online tomato sorting based on shape, maturity, size, and surface defects using machine vision," *Turkish Journal of Agriculture and Forestry*, vol. 37, no. 1, pp. 62–68.

Benito, M., Masaguer, A., Moliner, A. and De Antonio, R. (2006) Chemical and physical properties of pruning waste compost and their seasonal variability, Bioresour technol 97:20712076

Duppong, L.M., Delate, K., Liebman, L. and Horten, R. (2004) The effect of natural mulches on crop performance, weed suppression and biochemical constituents of catnip and St. John's wort. *Crop Science.* 44: 861-869).

Egan, H., Kirk, R.S., and Sawyer, R. (1981). Pearson's Chemical Analysis of Food. 8th ed. New York Churchill Livingstone, pp 539

Garcia-Closes, R., Berenguer, A., Sanchez, M.J., (2004). Dietary sources of vitamins C, vitamins E and specific cartenoids in Spain. British J. Nutr. 91, 1005-1011.

Hannada, T., Adams, A.J. and Stony, R.N., (1987). Increased yield in slicing cucumbers with vertical trainings of plants and reduced plant spacing. HortScience, vol. 22, no. 1, pp 32-34.

Hardy, C. and Rowell, B. (2002). Trellising slicing cucumber in Western Kenturcky Hort bulletin Vol.3 PP 15-18

Hirata, L.S. and Tilliato, R., (2000). Comparative cost of tee-pee trellised cucumber production. American Research Center, vol. 3, no. 32, pp 1-6.

Hooda, R. Antiwrinkle herbal drugs. Journal of Pharmacognosy and Phytochemistry. 2015; 4(4): 277-281

Jafarizadeh MH, Osman A, Tan CP, Abdul Rahman R (2011) Evaluation of effectiveness of three cellulose derivative-based edible coatings on changes of physico-chemical characteristics of 'Berangan' banana (Musa sapientum cv. Berangan) during storage at ambient conditions. Int. Food Res. J. 18(4):1381-1386.

Katiyar, S., Saify, K., Singh, S, and Rai, M. (2014) Botanical study of skin lightening agents.

Klimczak I., Matecka M., Szlachta M. and Gliszczynska- Swiglo A., Effect of storage on the content of polyphenols, Vitamin C and the antioxidant activity of orange juices, *Journal of Food Composition and Analysis*, 20, 2007, 313-22.

Lopes, L., Speretta F., Bentley M. Enhancement of skin penetration of vitamin K using

monoolein-based liquid crystalline systems. European Journal of Pharmaceutical Sciences. 2007; 32(3):209-215.

Lamont W.J. ,(1993). Plastic mulches for the production of vegetable crops. Hort Tech 3, 35-39.

McDonald S, Prenzler PD, Autolovich M, Robards K: Phenolic content and antioxidant activity of olive extracts. Food Chem 2001, 73:73–84.

Moalemiyan M, Ramaswamy HS (2012). Quality Retention and Shelflife Extension in Mediterranean Cucumbers Coated with a Pectinbased Film. *J. Food Res.* 1(3):159-168.

Nadim Z, Ahmadi E, Sarikhani H, Chayjan RA (2015). Effect of methylcellulose-based edible coating on strawberry fruit's quality maintenance during storage. *J. Food Process* Press 39:80-90.

Ngouajio M, Goldy R, Zandstra B, Warncke D (2007) Plasticulture for Michigan Vegetable Production. Extension Bulletin E-2980 January 2007. Michigan State University, East Lansing, p 20

Okonmah, L.U. (2011). Effects of different types of staking and their cost effevtiveness on the growth, yield and yield components of cucumber *(cucumis sativus L.) Int .J. of Agric. Sci*. Vol.1

Parmar H. N., Polara N. D., Viradiya R. R., (2013). Effect of mulching materials on growth, yield and quality of watermelon (Citrullus lanatus thunb) Cv Kiran."Univ. *J. Agric. Res*., 1: 30-37. 2013.

Quartey, E.K., Amoatey, H.M., Achel, D.G., Kulu, G.Y.P., and Mba, R. (2012). Induced mutations for improved lycopene, total antioxidant properties and other quality factors in wild tomato (Solanum Pimpinellifolium L). *Advance Journal of Food Science and Technology* 4(4): 182-188

Rios JL. Effects of triterpenes on the immune system. J Ethnopharmacol. 2010; 128(1):1-14.

Solaiman AHM, Kabir MH, Uddin AFM, Mirza H (2008). Black plastic mulch on flower production and petal coloration of Aster (*Callistephos chinensis*). *Am-Eur. J Bot*. 1(1):5-8.

Vallverdu-Queralt A, Arranz S., A. MedinaRemon, I. Casals-Ribes and R. M. Lamuela- Raventos, Changes in phenolic content of tomato products during storage. *Journal of Agricultural Food Chemistry*, 59(17), 2011, 9359-9365.

Wehner TC, Guner N (2004). Growth stage, flowering pattern, yield and harvest date prediction of four types of cucumber tested at 10 planting dates. Proc. xxvi IHC. Advances in Vegetable Breeding (Eds) J.D McCreight and E. J Ryder Acta. Hort., 637, ISHS 2004

Yaman O, Bayoindirli L (2002). Effects of an edible coating and cold storage on shelf-life and quality of cherries. *Food Sci. Technol.* 35:146-150.

Table 1: Effects of Mulching and Staking on Growth of Cucumber

	Vine length(cm)		Leaf Length(cm)		Leaf Breadth(cm)		No of leaf		Stem Girth(mm)	
	4WAS	5WAS	4WAS	5WAS	4WAS	5WAS	4WAS	5WAS	4WAS	5WAS
Staked black mulch	31.00^{a}	92.40^{a}	12.40^{a}	24.69^{a}	15.11^{a}	18.44^{a}	14.00^{a}	24.00^{a}	7.83^{a}	10.26^{a}
Staked white mulch	26.23^{bc}	56.13^{c}	10.48^{bc}	20.96^{b}	13.49^{b}	16.60^{b}	11.00^{b}	19.00^{b}	7.13^{b}	9.63^{ab}
Staked organic mulch	21.67^{cd}	48.43^{cd}	9.15^{cd}	18.84^{bc}	11.69^{c}	14.75^{c}	9.00^{c}	14.00^{cd}	6.53^{bc}	7.66^{c}
Staked nomulch	31.93^{a}	57.90^{c}	8.59^{d}	14.67^{de}	12.10^{bc}	13.78^{c}	9.00^{c}	13.00^{cd}	6.53^{bc}	7.63^{cd}
Unstaked black mulch	33.57^{a}	82.67^{b}	11.57^{ab}	20.66^{b}	13.54^{b}	17.17^{ab}	12.00^{b}	15002^{c}	6.61^{bc}	10.08^{ab}
Unstaked white mulch	22.77^{dc}	50.23^{cd}	10.60^{bc}	17.50^{cd}	12.79^{bc}	14.01^{c}	9.00^{c}	12.00^{de}	6.43^{cd}	9.39^{b}
Unstaked organic mulch	15.86^{e}	31.43^{e}	8.99^{d}	14.69^{de}	9.86^{d}	11.14^{d}	8.00^{c}	9.00^{c}	4.98^{e}	7.52^{d}
Unstaked no mulch	20.63^{de}	41.63^{d}	8.39^{d}	13.71^{e}	9.83^{d}	11.03^{d}	8.00^{c}	10.00^{e}	6.77^{d}	7.66^{cd}

Means in the same column followed by the same letter are not significantly different using Duncan multiple range test (DMRT) at $p < 0.05$.

KEY: WAS- Weeks After Sowing

Table 2: Effect of Mulching and Staking on yield of Cucumber

INTERACTION	Fruit Width(mm)	Fruit Length(cm)	Fruit Yield(t/ha)
Staked black mulch	56.81[a]	18.59[a]	21.01[a]
Staked white mulch	55.04[a]	17.40[ab]	15.35[b]
Staked organic mulch	51.49[b]	16.33[bc]	10.95[cd]
Staked no mulch	49.54[b]	15.84[cd]	8.80[de]
Unstaked black mulch	55.53[a]	16.16[bc]	14.77[b]
Unstaked white mulch	51.53[b]	15.72[cd]	11.47[c]
Unstaked organic mulch	49.72[b]	15.71[cd]	6.65[ef]
Unstaked no mulch	46.49[c]	14.73[d]	4.93[f]

Means in the same column followed by the same letter are not significantly different using Duncan multiple range test (DMRT) at $p < 0.05$.

Table 3: Effect of Different Mulching Materials and Staking on nutritional composition of cucumber

TREATMENT	TSS 1	Vit C 1	Phenolic 1	DPPH 1	TSS 5	Vit C 5	Phenolic 5	DPPH 5	TSS 10	Vit C 10	Phenolic 10	DPPH 10	TSS 15	Vit C 15	Phenolic 15	DPPH 15
Mulching																
White Mulch	3.56^{a}	24.50^{a}	384.32^{b}	42.21^{a}	3.37^{a}	16.75^{a}	349.38^{c}	38.38^{a}	3.50^{b}	8.93^{c}	291.15^{c}	32.03^{a}	3.05^{a}	6.57^{b}	266.44^{b}	25.95^{a}
No Mulch	3.43^{c}	20.25^{b}	445.77^{ab}	30.33^{d}	3.37^{a}	16.67^{a}	405.24^{b}	27.57^{d}	3.50^{b}	16.31^{a}	337.70^{b}	19.83^{d}	3.10^{a}	8.05^{a}	292.30^{a}	16.59^{d}
Black Mulch	3.37^{c}	19.25^{b}	528.46^{a}	33.47^{c}	3.44^{a}	16.37^{a}	480.41^{a}	30.42^{c}	3.44^{b}	10.94^{b}	400.34^{a}	22.52^{c}	2.91^{b}	8.15^{a}	227.35^{c}	20.12^{c}
Organic Mulch	3.50^{ab}	16.62^{c}	518.83^{a}	38.44b	3.50^{a}	8.62^{b}	403.86^{b}	34.95^{b}	3.87^{a}	6.68^{d}	336.53^{b}	25.97^{b}	2.96^{b}	5.45^{c}	212.41^{d}	23.39^{b}
Staking																
Staked	3.59^{a}	18.62^{b}	424.15^{b}	39.36^{a}	3.34^{b}	14.93^{a}	385.58^{b}	35.78^{a}	3.53^{a}	12.00^{a}	321.32^{b}	28.70^{a}	2.99^{a}	7.65^{a}	258.39^{a}	24.47^{a}
Unstaked	3.34^{b}	21.68^{a}	514.54^{a}	32.87^{b}	3.50^{a}	14.25^{a}	433.86^{a}	29.88^{b}	3.62^{a}	9.43^{b}	361.55^{a}	21.48^{b}	3.01^{a}	6.46^{b}	240.86^{b}	18.56^{b}

Means in the same column followed by the same letter are not significantly different using Duncan multiple range test (DMRT) at $p < 0.05$.
TSS- Total Soluble Solid
Vit. C- Vitamin C
DPPH- 2,2-diphenyl-1-picrylhydrazyl
Phenolic- Total Phenolic

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FARMER'S UNSEEN ENEMY: SOILBORNE PATHOGENS AND ITS' MANAGEMENT

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ABSTRACT
Soil borne pathogens such as fungi, bacteria, viruses, nematodes and phytoplasmas are increasingly becoming the unseen enemy to robust crop productivity in the tropics with particular emphasis on sub-Saharan Africa. Significant yield losses are regular occurrence in major producing parts of the region owing to damage from pathogenic infections. The ubiquitous nature of endemic pathogens, their extensive host ranges, and the inability to fully understand their biology and conditions that favour their multiplication and pathogenicity are major reasons why they thrive. A teaspoon of mature grassland soil for instance, contains several millions of bacteria, fungi and nematodes belonging to differing species. Unlike nutrient deficiency and pesticide toxicity symptoms that may be easily identified by mere visual observations, symptoms of pathogenic infections are not easily recognized, and are sometimes mistaken for other causes like drought, soil compaction, pesticide toxicity, and nutrient deficiency. To link a disease symptom to a pathogen, it is pertinent that both soil and root samples must be collected and thoroughly analyzed. Hence, this article aims to highlight the major pathogenic organisms that cause significant economic losses in crop production in the tropics, disease symptoms and protocols for identifying symptoms as well as management strategies for keeping the pathogens population below the economic threshold.

Keywords: *pathogens, disease management, biological control, yield losses, and integrated control*

INTRODUCTION

Soils are complex mixes of minerals, water, air, organic materials, and innumerable creatures that are the decomposed remnants of once-living species (Gilluly *et al.*, 1975). Soil is necessary for life on earth because it can support plant life. Soil is a product of several factors: the influence of climate, relief (elevation, orientation, and slope of terrain), organisms, and the soil's parent materials (original minerals) interacting over time (Gilluly *et al.*, 1975). In biology, a pathogen is anything that may cause illness in the widest meaning. It can also mean infectious agents such as virus, bacterium, protozoan, viroid, or fungus. The scientific study of microscopic organisms, particularly tiny pathogenic organisms is termed microscopy, whereas pathology is the study of illness caused by these pathogens (Cotter, 2017). A teaspoon of native grassland soil contains between 600 and 800 million unique bacteria belonging to 10,000 different species. Per teaspoon of soil, there are millions of fungus and maybe 5000 different species. There are 20 to 30 helpful nematodes, with up to 100 different species (Coleman *et al.*, 2004). In healthy soils, root-feeding nematodes are rare. They exist, but in such small quantities that finding them is difficult. Because the food they require is no longer fed back into the system after just one ploughing, a few species of bacteria and fungus die extinct locally. However, the majority of suppressive organisms, nutrient cyclers, decomposers, and soil organisms that restore healthy soil structure are still there and trying to do their tasks (David and Paul, 2004). Aerial or above-ground illnesses and pathogens have received greater attention and priority over the years, with soil-borne infections receiving minimal attention. A soil-borne disease is one in which the inoculum is found in the soil and the plant is infected from the ground up. The long smut of sorghum *Tolyposporium erhenbergii* is an exception, as it is an airborne disease that infects the ground as well. Damping off, stem rot, root rot, collar rot, stem canker, leaf blight, wilts, and other soil-borne diseases are prevalent, while frequent soil infections include Pythium, Phytopthora, Botrytis, *Rhizoctonia, Aspergillus*, Clavibacter, *Meloidogyne, Pennicilum*, *Sclerotium*, and other fungi (Garrett, 1956). Soil-borne diseases or organisms must spend the majority of their life cycle in the soil environment, or a significant portion of their life cycle in the soil environment. i.e., the ecology found inside the soil environment must support its biology, physiology, and reproduction (Garrett, 1956). Because the soil environment is a living system, a soil pathogen is inextricably linked to the events that occur there. Not all organisms in the soil environment are pathogenic or cause

diseases; pathogenicity develops only when competing variables become insufficient (Alegbeleye *et al*., 2018). According to Singleton *et al.* (1996), soil pathogens are difficult to research because of the environment in which they are located, for example, an infected root is not easily recognized or immediately apparent compared to aerial disease signs, Furthermore, disease symptoms are often mistaken for those produced by other causes like as floods, drought, nutrient shortage, soil compaction, pesticide damage, and so on (Kennelly *et. al*., 2012).

As a result, both soil and root samples must be collected, analyzed, and studied thoroughly before a particular symptom can be definitively linked to a soil transmitted plant pathogen. Fungi, bacteria, viruses, nematodes, phytoplasmas, and other soil-borne plant diseases are examples. Soil borne viruses wreak havoc on agricultural productivity, resulting in huge financial losses. They have an impact on crops from the time they are planted in nurseries until they are harvested. *Rhizoctonia* spp., *Fusarium* spp., *Verticillium* spp., *Sclerotinia* spp., *Pythium* spp., and *Phytophthora* spp. produce plant diseases that damage wheat, cotton, vegetables, and temperate fruits, among other crops. For many crops, the economic losses caused by Fusarium wilt infections are estimated to be 50-75 percent of the achievable yield (Lewis and Papavizas, 1991). Fungi and nematodes-caused soil-borne diseases are important yield-limiting factors that are difficult to manage. Plant parasitic nematodes alone have been estimated to take away ten percent of worldwide agricultural output, resulting in annual economic losses of more than $125 billion (Chitwood, 2003). The symptoms of several pathogens that cause soil borne diseases are remarkably similar. Root rot, root blackening, wilt, yellowing, stunting or seedling damping-off, bark cracking, and twig or branch dieback are some of the problems that can occur. In the absence of a host plant, soilborne species can persist for years by producing resistant structures such as microsclerotia, sclerotia, chlamydospore, or oospores. As a result, predicting, detecting, diagnosing, and controlling these diseases are extremely challenging (Astrom and Gerhardson, 1988). Pathogens that are ‘soil residents,' have extensive host ranges that include weeds, and develop long-lived survival structures are responsible for some of the most serious soil-borne diseases (Baysal-Gurel *et al*., 2012). Fusarium, Rhizoctonia, Verticillium, Sclerotinia, and *Macrophomina phaseolina* are among the fungi that cost billions of dollars in losses each year. Many soil-borne fungus survive in the soil for extended periods of time by generating chlamydospores, oospores, and sclerotia, which are resistant survival structures. Ralstonia, Pectobacterium, Agrobacterium, and Streptomyces are all important soil-borne bacterial pathogens (Baysal-Gurel *et al*., 2012). Pseudomonas and Xanthomonas pathogens generally only stay in the soil for a short period of time (Alegbeleye *et al.*, 2018). . Soil-borne viruses that infect vegetables are rare, because they usually only live in the host plant's living tissues or in the insects, nematode, or fungal vectors that transfer them (Alegbeleye *et al.*, 2018). *Meloidogyne* spp. (root-knot nematodes) are a severe and economically significant pest of many cultivated crops across the world (Youssef and Lashein, 2013). Sedentary endoparasites, root-knot nematodes are among the most destructive agricultural pests, infecting a wide range of crops. Vegetables are severely damaged in tropical and subtropical regions (Adam *et. al*., 2014), with losses of up to 80% in strongly infected fields. The most significant soil-borne fungal infections, *Fusarium solani* and *R. solani*, cause damping-off and root rot diseases in a wide range of vegetable and agricultural plants, including tomato. They develop in both cultured and non-cultured soils (Szczechura *et al.*, 2013). With rising *R. solani* inoculum levels, the frequency of damping-off increased from 19 to 90%, whereas the incidence of root rots caused 10 to 80% losses in several plants. *Rhizoctonia solani*, a damaging soil borne pathogen, causes pre-emergence and post-emergence damping-off, root rot, and stem canker in agricultural and horticulture crops. Alfalfa, peanut, soybean, lima bean, cucumber, papaya, eggplant, corn, and a variety of other plants are among its hosts (Keijer *et al.*, 1997).

The presence of the host, as well as other biotic and abiotic factors, has a significant impact on the activities of disease-causing soil borne pathogens. The pathogen, host, and surrounding microorganisms are constantly influenced by one another, as well as by the biotic and abiotic components of the environment, in the zone of influence of plant roots (rhizoplane and rhizosphere). Sequential infection processes occur when the pathogen and the host are compatible and the environmental circumstances are favourable. Fungistasis and the formation of root exudates are two processes

that occur in the root zone that affect the pathogens live and capacity to begin infection. Fungistasis is a characteristic of natural soils that prevents propagules from germinating (Lockwood, 1977). Fungistasis (mycostasis) is an exogenous, temporary dormancy imposed on propagules by natural soil that may be reversed by a variety of methods. It is a ubiquitous phenomenon that has been proven to inhibit the germination of numerous fungi in soils with normal biological activity (Lockwood, 1997). Other soil microorganisms, such as soil bacteria (soil microbiostasis), are also affected by this phenomena (Ho and Ko, 1985). In the absence of potentially colonizable substrates like plant roots, dormant propagules are less susceptible to the soil's hostile action, and fungistasis prevents the propagule from germinating (katan, 2017). As a result, soil fungus benefit greatly from fungistasis. It's linked to soil microbial activity that's typical. Soil sterilization, addition of organic nutrients (e.g., glucose and amino acids) to the soil, or the presence of root exudates can all be used to counteract it (Inderjit and Weston, 2003). Fungistatic methods mediated by soil microorganisms include the presence of volatile or soluble inhibitory compounds that impede germination, as well as nutritional shortages that are required for germination. Root exudates (also known as root excretions) are chemicals discharged into the surrounding media by plant roots (Curl and Truelove, 1986). The effect of the roots decreases with distance because nutritional and microbial components follow a diminishing gradient from the root surface into the soil. Sugars, amino acids, and a variety of other chemicals in root exudates influence the activity of soil microbes and pathogens (Gamliel and Katan, 1992). Soil borne diseases are difficult to control because they are caused by pathogens that may live for extended periods of time without a typical crop host and frequently have a wide range of hosts, including weeds (Gamliel and Katan, 1992). Chemical management is frequently ineffective, inconvenient, or prohibitively expensive, and developing resistant plant types is challenging. These diseases are notoriously difficult to diagnose, and infections can be difficult to grow in culture and correctly identify. Soil borne organisms are out of sight and out of mind for farmers and plant protection personnel due to their tiny size and lack of identifiable signs of infection. Only a comprehensive research of the mechanisms of survival and dispersion of soil borne pathogens, influence of environmental variables, function of cultural practices, and host resistance and vulnerability would be able to effectively control soil borne diseases.

Soilborne Pathogens Management: The majority of soil-borne diseases are difficult to manage using traditional methods such as resistant cultivars and synthetic insecticides (Weller *et al*., 2002). Fungicide treatment to the soil is costly and harmful to non-target microorganisms. The specific characteristics of soil borne pathogens, particularly their presence in soil, provide both challenges and opportunities for treatment. The presence of pathogens in soil makes it harder to use control tools, yet the presence of inoculum in soil prior to planting allows for disease level prediction when appropriate instruments are available (Katan *et al*., 2012). The host, pathogen, and each of the biotic and abiotic components of the soil and ambient environment interact to cause disease (katan,2017).. To achieve an economic decrease of the plant diseases, the fundamental management approach should incorporate interference, disruption, or manipulation of one or more of these components, or their interconnections. Soil type, texture, pH, moisture, temperature, and nutrient levels are only a few of the variables that impact the activity of soil borne pathogens and diseases. Soils with poor drainage are more conducive to the survival and spread of soil borne diseases including Pythium, Phytophthora, and Aphanomyces. Wet soils can also cause more severe Fusarium and Verticillium wilts than dry soils. Drier soils are only beneficial to a few root diseases (for example, common scab of potato caused by *Streptomyces scabies*) (Veena *et al.*, 2014). This, however, must be done with the least possible impact on the environment and natural resources. As a result, inhibiting or eliminating the pathogen is just one of several possible disease-control strategies. As a result, a holistic approach to management is required. Chemical, physical, biological, cultural, and induction or integration of physiological or genetic resistance in the host are the most common disease management (strategies). Soil disinfestation (SD), breeding for resistant cultivars and grafting, organic amendments (OA), biocontrol, sanitation, insecticides, induced resistance, crop rotation, biofumigation, and many other tactics are among the methods (tactics). Only a few of these methods are successful in preventing post-planting inoculum of soil borne pathogens from external sources,

such as polluted water, aerial propagules, or soil re-infestation.

Cultural Practices:

Crop production success necessitates the combination of a variety of cultural techniques that result in high yield and weed, insect, and plant disease removal or suppression. Avoidance, crop rotation, tillage and residue management, water management, crop management, and sanitation have all been shown to be effective in limiting diseases caused by pathogens, particularly soil borne pathogens.

Rotation of crops: Crop rotation, in general, has a lot of advantages for crop productivity. Improved soil fertility, greater soil tilt and aggregate stability, improved soil water management, and reduced erosion have all been linked to it (Ball *et al*., 2005). Crop rotation is an excellent strategy for controlling plant diseases. However, it is ineffective in decreasing diseases caused by soil borne pathogens such sclerotia, oospores, and chlamydospores, which have a wide host range and create long-living survival structures (Panth *et al*., 2020). Small grains, particularly barley, are highly suggested for increasing organic matter content and reducing onion issues such as pink root and Fusarium basal rot. Crop sequences of oat-potato, annual ryegrass-potato, or clover-potato have been observed to lower *Rhizoctonia solani* inoculum levels in soil while also suppressing disease development in a potato crop (Peter *et al*., 2003).

Organic additives: Essential oils, such as terpenes, as well as phenols, alcohols, organic acids, and other biocidal chemicals, are found in many herb species (Paret *et al.*, 2010). Brassicaceae crops (cabbage, broccoli, kale, turnip, radish, canola, cauliflower, rapeseed, and different mustards) contain compounds linked to decreased levels of soil borne diseases and pests (Larkin and Griffin, 2007). Glucosinolates are sulfur compounds produced by brassica plants. During enzymatic hydrolysis, they release biologically active compounds. The primary products of glucosinolate hydrolysis, isothiocyanates, are vapour molecules that are poisonous to many soil organisms. In a procedure known as biofumigation, they have been effectively employed to decrease populations of soil borne diseases (Larkin and Griffin, 2007). Organic amendments are not commonly used for the control of soil borne diseases due to concerns about potential side effects such as non-selective action, cost efficacy, and scale practicality (Colla *et al.*, 2012).

Hydroponics and soilless growth systems are two types of soilless growing systems. To substitute methyl bromide for soil borne disease management, plant development in hydroponics and soilless culture is an effective and ecologically acceptable alternative. Over the last 20 years, these systems have grown more popular across the world for growing high-value crops in glasshouses (Savvas and Neocleous, 2019). Soil borne disease issues are greatly reduced when crops are grown in inert media, which has been the typical practice in Western Europe. Hydroponics is now used in a limited number of planting sites, but it is projected to account for 30-40% of greenhouse output in the future years. Every year, the greenhouse area on artificial substrates grows by around 10-20 hectares (Neshev, 2008). This technique is high-yielding, yields high-quality food, improves phytosanitary management, and is simple to apply (Gruda, 2009). On the other hand, this cultivation method has certain drawbacks, such as high starting costs, difficult fumigation of the spent substrate, and problems recycling the nutritious substrate solutions (Pardossi *et al*., 2011).

Solarization of the Soil: Soil solarization is a non-chemical method of soil disinfestation that is one of the most promising ways to manage soil borne diseases. After appropriate watering, polyethylene sheets are placed over the soil surface. During the hot season, high temperatures and heavy wetness inactivate soil borne diseases, pests, and weeds. Solarization may successfully manage a wide range of soil borne diseases and pests under the right climatic circumstances (Katan and DeVay, 1991). Because soil solarization is a climate-dependent metric, it should only be used in certain areas and seasons (Katan, 1999). It is unlikely to be successful in most parts of Serbia due to the mild climate (Katan, 1999) Solarization is a complicated mechanism of action that includes direct heat destruction of propagules, changes in microbial populations and activity, and changes in soil physical and chemical properties. Solar heating is the use of heat as a deadly agent for pest management by trapping solar radiation and accumulating heat through the use of translucent plastic film (Katan, 2000). At a depth of 5 cm, 5 days of sun heating was enough to kill 100 percent of *V*erticillium. *dahliae sclerotia*, but at a depth of 25 cm, just a little death was seen. However, after an additional 8 days of

solarisation, the sclerotia were completely killed at a depth of 25 cm (Katan *et al.*, 1976). Similarly, after 19 days of solarisation, death rates of *Sclerotium rolfsii sclerotia* at 5 and 20 cm depths were 100 percent and 25%, respectively, while after another 21 days, the rates were 100 percent and 80 percent, respectively (Elad *et al*., 1980).

Grafting: Grafting vegetable cultivars onto rootstocks of less sensitive genotypes is an essential method for controlling diseases and pests that live in the soil. Grafting is mostly employed in the production of fruits and nuts, but it is also used in the development of high-value crops. The main goal of using it in vegetable cultivation was to control soilborne diseases. This technique is now widely used in Japan, Korea, and a number of European nations (Edelstein Menahem, 2004). Verticillium wilt is widely managed by grafting in tomato and eggplant production systems, and less typically in cucurbit production systems (Miles *et. al*., 2015). Due to accessible rootstock resistance genes and the pathogen's biology, Fusarium infections have been the subject of effective grafting methods in a variety of crops (Miles *et. al.*, 2015). . Host resistance in solanaceous crops is frequently shown as significant gene resistance. Thus, resistant rootstocks have provided good control of several tomato soilborne diseases, notably *F. oxysporum* f. sp. *lycopersici*, *F. oxysporum* f. sp. *radicis-lycopersici*, *P. lycopersici*, and *Meloidogyne* spp (Jabnoun-Khiareddine *et al*., 2019). In addition to the control of soil borne pathogens, tomato grafting has also many other purposes, such as growth promotion and yield increase, low temperature tolerance, growth period extension and fruit quality (Lee *et al.*, 2010).

Disease Suppressive Soils: A soil is termed suppressive when a pathogen cannot get established, establishes but generates no disease, or develops and causes disease for a brief period and then declines, despite ideal circumstances for disease to occur (Schneider, 1982). According to Chandrashekara *et al*. (2012) The types and quantities of soil organisms, the degree of fertility, and the composition of the soil itself all have a role in suppressiveness (drainage and texture). Induced resistance, direct parasitism (one organism eating another), nutrient competition, and direct suppression through antibiotics released by beneficial organisms are some of the methods by which disease organisms are inhibited in these soils (Ratnadass *et al.,* 2012). Suppressiveness is further aided by the reaction of plants growing in the soil. When the rhizosphere (soil around plant roots) is infected with a mildly virulent pathogen, this is known as "induced resistance." The plant acquires the ability for future successful response to a more virulent disease after being challenged by the weak pathogen. Adding mature compost to a soil usually results in disease resistance in a wide range of plants (Van Loon *et al.*, 1998).

Natural Compounds and Biological Control

In an effort to decrease pesticide use, there is growing interest in introducing biological agents and using plant components as natural commercial solutions to manage soil borne diseases (Cook, 1993). Biocontrol agents including *Trichoderma viride, Trichoderma harzianum*, fluorescent Pseudomonas, and *Bacillus subtilis* were applied to the soil and significantly decreased root rot caused by soil borne pathogens in different crops (Loganathan *et al*., 2010). Fungi hazardous metabolites are reported to be produced in significant amounts by *Trichoderma* spp. *Trichoderma* spp inhibitory impact might be due to direct mycoparasitism as well as nutritional competition (Sharon *et al*., 2001; Afzal *et al.*, 2013). *Trichoderma* spp. are active mycoparasites that have been studied for their ability to biocontrol foliar and soil-borne diseases, as well as plant parasitic soil-borne nematodes (Deacon, 1991).). *Trichoderma* spp. have shown to be effective against root-knot nematodes such *T. harzianum* (Sharon *et al.*, 2001), and are being considered as potential biocontrol agents.

Antagonistic microorganisms: According to Neshev (2008) several studies have demonstrated that adding fungal or bacterial antagonists to soils reduces disease incidence in several crops. Because such diseases develop in dynamic settings at the root-soil interface known as the rhizosphere, biocontrol of soil borne diseases as an alternative to synthetic pesticides is particularly difficult. The region around a root that is influenced by it is known as the rhizosphere. It's worth noting that bioagents can lower the detrimental effects of some diseases below a specific level while leaving the soil microbiological balance untouched, which isn't the case when chemical pesticides are used (Neshev, 2008). The production of secondary metabolites (antibiotics, hydrolytic enzymes, volatile extracellular metabolites, hydrogen cyanide), parasitism, competition for nutrients, promotion of plant growth, and finally, induced

resistance within the plants are all involved in the biological control of fungal pathogens (Moeinzadeh *et al*., 2010). Biological control agents are significantly more sensitive to environmental circumstances than synthetic pesticides since they are live creatures. On the other hand, soil is a complex ecosystem in which numerous variables such as soil structure, pH, and moisture might restrict the effectiveness of biocontrol agents that have been introduced. As a result, many of these biological control agents can be successful, but only under certain environmental circumstances (Cook and Baker, 1983). Several studies have shown that established biocontrol agents, including as Bacillus, Pseudomonas, Sphingomonas, Stenotrophomonas, and Serratia strains, may inhibit vascular or soil borne fungal infections (Berg *et al*., 2000). Pseudomonas fluorescens is a frequently used soil borne disease biocontrol agent. The bacterium is a soil-dwelling antagonist with a variety of mechanisms for combating harmful bacteria. It prefers wet soils with lots of organic materials and can be mulched (Cook and Baker, 1983). Plant extracts, particularly volatile essential oils from medicinal plants, have been shown to exhibit antibacterial action against a wide range of plant diseases and pests (Kalemba and Kunicka, 2003). Essential oils and their components are increasing popularity due to their relatively safe status, widespread consumer acceptance, and potential multi-purpose applications (Jobling, 2000). Under experimental circumstances, oregano, fennel, and laurel oils showed antibacterial action against soilborne bean fungus (Türkölmez and Soylu, 2014).

Chemical Management

Non-chemical alternatives to methyl bromide for soil fumigation are ineffective against soil borne diseases, therefore farmers will have to resort to one or more of the known chemical alternatives to methyl bromide (Labrada, 2008). Because of the complexity of the soil environment and biological variations among pathogens, chemical management of soil borne pathogens in vegetable crops is extremely difficult. Furthermore, there are only a limited amount of registered items accessible. Fungicides in the dicarboximide, benzimidazole, and triazole chemical families successfully decrease soil borne diseases of various crops through soil and plant treatments. Under field and greenhouse circumstances, strobilurins, particularly azoxystrobin, were highly efficient in reducing the severity of Verticillium wilt in eggplant (Bubici *et al*., 2006). Azoxystrobine fungicides are also commonly used to control *R. solani*. Long-term use of pesticides, on the other hand, has a detrimental impact on microbial development and activity, resulting in decreased soil fertility and production (Wang *et al*., 2006). In pesticide-contaminated soils, nitrogen-fixing and phosphorus-solubilizing microorganisms are inactivated (Kyei-Boahen *et al*., 2001). Similarly, pesticides have been demonstrated in several studies to decrease the activity of soil enzymes, which are important markers of soil health (Antonious, 2003). Many metabolic processes, such as organic matter mineralization, nitrification, denitrification, ammonification, redox reactions, and so on, may be affected by pesticides. All of these side effects of long-term pesticide usage render this policy ecologically undesirable and unsustainable (Nannipieri *et al*., 2017).

Resistance

Plant disease resistance works in two ways to defend plants from pathogens: pre-formed structures and chemicals, and immune system responses triggered by infection (Andersen *et al*, 2018). Disease resistance refers to the reduction of pathogen development on or in a sensitive plant (and therefore a reduction of disease), whereas disease tolerance refers to plants that show little disease damage despite high pathogen levels (Andersen *et al*, 2018). The virus, plant, and environment interact in three ways to influence the disease's outcome (an interaction known as the disease triangle). Defense-activating chemicals can go from cell to cell and across the plant's vascular system in a systematic manner. Plants, on the other hand, lack circulating immune cells, thus most cell types contains a diverse set of antimicrobial defenses (Andersen *et al*., 2018). . Although obvious qualitative differences in disease resistance can be seen when comparing multiple specimens (allowing classification as "resistant" or "susceptible" after infection by the same pathogen strain at similar inoculum levels in similar environments), quantitative differences in disease resistance are more commonly seen between plant strains or genotypes (Andersen *et al*., 2018). . Plants consistently resist some infections while succumbing to others; resistance is generally limited to a single pathogen species or strain. Treatment with a number of abiotic and biotic inducers can cause plants to acquire increased resistance to pathogen infection. Infections with necrotizing pathogens and plant-growth-promoting

rhizobacteria, as well as treatment with non-pathogens or cell wall fragments, are all examples of biotic inducers (Ramamoorthy *et al*., 2001). Chemicals that operate at various points in the signaling pathways involved in disease resistance, as well as water stress, heat shock, and pH stress, are examples of abiotic inducers. Resistance elicited by these drugs is broad-spectrum and long-lasting, although it seldom offers total infection control, with many resistance elicitors offering between 20% and 85% disease control (Isah, 2019). There have also been several cases of resistance elicitors failing to manage plant diseases effectively (Isah, 2019). . The environment, genotype, and crop nutrition are likely to impact the expression of induced resistance in the field (Walters *et al*., 2005). Unfortunately, little is known about the impact of these variables on the expression of induced resistance. A better knowledge of these interactions is necessary to enhance the efficacy of resistance elicitors.

Integrated Management/ Combined Control Methods

In crop protection, there is a growing trend toward combining diverse management approaches. The heart of integrated pest management is the combination of control techniques, which can have either an additive or synergistic impact. This technique is intended to result in enhanced and long-term pest and disease management. The objective of IPM approaches is to minimize pesticide use by using measures that are more efficient, healthier, and ecologically beneficial in the long term (Katan, 1999). One strategy for controlling some soil borne diseases may be to employ biocontrol agents in combination with fungicides. *Bacillus megaterium* in conjunction with carbendazim has proven to be efficient in controlling Fusarium crown and root rot in tomatoes (Omar *et al*., 2006). Steam disinfection can be used with other disease management techniques, such as soil additives and biological control agents like *Trichoderma* spp., to improve disease control and horticultural crop yield. Furthermore, in recent years, the use of organic amendments to improve soil characteristics, plant health, and production has increased. Crop health might be improved by using organic amendments in conjunction with soil heating or solarization (Klein *et al*., 2007; Gamliel and Katan, 2009). Similarly, heating soils wrapped in plastic film and supplemented with suitable organic material triggers a chain reaction of chemical and microbiological degradation, resulting in the production of antimicrobial chemicals (Nizam *et al.,* 2021).

CONCLUSION

The Montreal Protocol's phase out of methyl bromide for soil fumigation sends a message throughout the world that pesticides that harm the environment will no longer be allowed in agriculture (Anonymous, 2009). This was a watershed moment in science since it prompted a huge hunt for a suitable successor. There is currently no one answer to the numerous issues that producers face. When used alone, non-chemical methods such as soil solarization, crop rotation, biological management, soil amendments, and steaming may be deemed excessively hazardous and/or ineffective. All of them, however, are feasible as part of an IPM approach when used in combination, even if they do not entirely remove pathogens from the soil. Initial findings achieved by integrating diverse techniques for the management of soil borne diseases indicate that further study is needed in this area to ensure long-term crop protection sustainability (Schneider, 1982). Soils should be tested for pathogens because effective control of soil borne diseases requires a detailed study of pathogen survival and dissemination; the effect of environmental conditions, the role of cultural practices, and host resistance and susceptibility will all play a role in disease management. Growers have responded with newer and stronger pesticides as plants and soils have gotten "stickier," in an attempt to kill off the troublesome diseases. Chemical intervention, while it may appear to be the appropriate line of action, only helps to exacerbate the problem over time. Many pesticides limit the variety of soil life even further, favouring diseases that are resistant to them. Methyl bromide has a long and illustrious history. This fumigant was once extremely effective when applied just once every five years. It must now be applied considerably more often on the same soils to keep diseases under control. We'll be stuck on the pesticide treadmill until soil life improves.

REFERENCES

Adam, M., Heuer, H. and Hallmann, J. (2014). Bacterial antagonists of fungal pathogens also Control Root-Knot Nematodes by Induced Systemic Resistance of Tomato Plants. *PLoS ONE*, 9(2), 90402.

Afzal, S., Tariq, S., Sultana, V., Ara, J., and Ehteshamul-Haque, S. (2013). Managing the

root diseases of okra with endo-root plant growth promoting *Pseudomonas* and *Trichoderma viride* associated with healthy okra roots. *Pakistan Journal of Botany* 45(4): 1455–1460.

Alegbeleye, O. O., Singleton, I. and Sant'Ana, A. S. (2018). Sources and contamination routes of microbial pathogens to fresh produce during field cultivation: A review. *Food microbiology*, 73: 177–208. doi:10.1016/j.fm.2018.01.003.

Andersen, E., Ali, S., Byamukama, E.,Yen, Y and Nepal, M. (2018). Disease Resistance Mechanisms in Plants. *Genes*, 9(7): 339.

Anonymous (2009). European Community Management Strategy for the Phase-out of Critical uses of Methyl Bromide. European Union-Ozone Secretariat-UNEP.

Antonious, G. F. (2003). Impact of soil management and two botanical insecticides on urease and invertase activity. *Journal of Environmental Science and Health, Part B*, 38(4): 479-488.

Astrom, B and Gerhardson, B. (1988). Differential reactions of wheat and pea genotypes to rootinoculation with growth-affecting rhizosphere bacteria. *Plant and Soil*, 109(2): 263-269.

Ball B.C., Bingham I., Rees R.M., Watson C.A., Litterick A. (2005). The role of crop rotations in determining soil structure and crop growth conditions. *Canadian Journal of Soil Science*, 85 (5): 557–577.

Baysal-Gurel F., Gardener, B.M., and Miller, S.A. (2012). Soilborne disease management in organic vegetable production. Available on: www. extension.org/pages/64951. [Accessed: February 28, 2022].

Berg, G., Kurze, S., Buchner, A., Wellington, E.M and Smalla, K. (2000). Successful strategy for the selection of new strawberry-associated rhizobacteria antagonistic to *Verticillium* wilt. *Canadian Journal of Microbiology*, 46(12): 1128-37.

Bubici, G., Amenduni, M., Colella, C., D'amico, M., & Cirulli, M. (2006). Efficacy of acibenzolar-S-methyl and two strobilurins, azoxystrobin and trifloxystrobin, for the control of corky root of tomato and verticillium wilt of eggplant. *Crop Protection*, 25(8): 814-820.

Chandrashekara, C., Bhatt, J. C., Kumar, R and Chandrashekara, K. N. (2012). Suppressive soils in plant disease management. *Eco-Friendly Innovative Approaches in Plant Disease Management, ed A Singh (New Delhi: International Book Distributors)*, 241-256.

Chitwood, D. J. (2003). Research on plant-parasitic nematode biology conducted by the United States Department of Agriculture - Agricultural Research Service. *Pest Management Science*, 59(6-7): 748-753.

Coleman, D. C., Crossley, D. A. and Hendrix, P. F. (2004). Secondary Production: Activities of Heterotrophic Organisms—The Soil Fauna. *Fundamentals of Soil Ecology*, 79–185.

Colla, P., Gilardi, G. and Gullino, M. L. (2012). A review and critical analysis of the European situation of soilborne disease management in the vegetable sector. *Phytoparasitica*, 40(5): 515-523.

Cook, R. J. (1993). Making greater use of introduced microorganisms for biological control of plant pathogens. *Annual Review of Phytopathology*, 31(1): 53-80.

Cook, R. J., and Baker, K. F. (1983). *The nature and practice of biological control of plant pathogens*. St. Paul, MN: American Phytopathological Society.

Cotter P.D. (2017). Microbiology. Reference Module in Life Sciences. Teagasc Food Research Centre and APC Microbiome Institute, Cork, Ireland.

Curl, E.A. and Truelove, B. (1986). The Rhizosphere. Springer Verlag, Berlin.

David, C. C., Mac, A., Callaham, Jr. and Crossley, D. A Jr. (2004). In: Fundamentals of Soil Ecology (Second Edition). Elsevier Inc 2004.978-0-12-179726-3

Deacon, J. W. (1991). Significance of ecology in the development of biocontrol agents against soil borne plant pathogens. *Biocontrol Science and Technology*, 1(1): 5-20.

Edelstein Menahem. (2004). Grafting vegetable-crop plants: Pros and cons. *Acta Horticulturae*. 659: 235-238.

Elad, Y., Katan, J. and Chet, I. (1980). Physical, biological, and chemical control integrated for soilborne diseases in potatoes. *Phytopathology*, 70(5): 418-422.

Gamliel, A. and Katan, J. (2009). Control of plant disease through soil solarization. In D. Walters (Ed.), *Disease Control in Crops*. (pp 196-220). Edinburgh, UK: Wiley- Blackwell Publishing Ltd.

Gamliel, A., and Katan, J. (1992). Influence of seed and root exudates on fluorescent pseudomonads and fungi in solarized soils. *Phytopathology* 82: 320–327.

Garrett, S. D. (1956). Biology of root infecting fungi. Cambridge University Press., London.

Gilluly, J., Waters, A. C and Woodford, A.O. (1975). *Principles of geology* (4th ed.). San Francisco, California: W.H. Freeman and Co.1975. ISBN 978-0-7167-0269-6.

Gruda, N. (2009). Do soilless culture systems have an influence on product quality of vegetables *Journal of Applied Botany and Food Quality*, 82: 141-147.

Ho W. C., Ko W. H. (1985). Soil microbiostasis: effects of environmental and edaphic factors. *Soil Biology Biochemistry* 17: improving the control of soilborne pathogens. *Phytopathology* 90: 751-757.

Inderjit, and Weston, L. A. (2003). Root Exudates:An Overview. *Ecological Studies*, 235–255.

Isah, T. (2019). Stress and defense responses in plant secondary metabolites production. *Biological Research*, 52(1): 39.

Jabnoun-Khiareddine, H., Aydi Ben Abdallah, R., Nefzi, A., Fakher, A and Daami-Remadi, M. (2019). grafting-tomato-cultivars-for-soil-borne-disease-suppression-and-plant-growth-and-yield-improvement. *J Plant Pathol Microbiol* 10(1): 1-8.

Jobling, J. (2000). Essential oils: A new idea for postharvest disease control. *Good Fruit and Vegetables Magazine*, 11(3): 50-54.

Kalemba, D. and Kunicka, A. (2003). Antibacterial and antifungal properties of essential oils. *Current Medicinal Chemistry*, 10(10): 813-829.

Katan, J. (1999). The methyl bromide issue: Problems and potential solutions. *Journal of Plant Pathology*, 81: 153- 159.

Katan, J. (2000). Soil and substrate disinfestation as influenced by new technologies and constraints. *Acta Horticulturae*, 532: 29-38.

Katan, J. and DeVay, J. E. (1991). Soil solarization: historical perspectives, principles, and uses. Soil solarization, 2.

Katan, J.., Greenberger, A., Alon, H. and Grinstein, A. (1976). Solar heating by polyethylene mulching for the control of diseases caused by soil-borne pathogens. *Phytopathology*, 66(5): 683-688.

Katan,J. (2017). Diseases caused by soilborne pathogens: biology, management and challenges. *Journal of Plant Pathology*, 99(2): 305-315.

Keijer, J., Korsman, M. G., Dullemans, A. M ., Houterman, P. M ., De Bree, J and Van Silfhout, C. H. (1997). In vitroanalysis of host plant specificity in *Rhizoctonia solani*. Plant Pathology, 46(5): 659–669.

Kennelly, M.., O'Mara, J. ., Rivard, C. ., Miller, G.L. and Smith, D. (2012). Introduction to abiotic disorders in plants. *The Plant Health Instructor*.

Kennelly, Megan and O'Mara, Judith & Rivard, Cary & Miller, Gerald & Smith, Damon. (2012). Introduction to Abiotic Disorders in Plants. *The Plant Health Instructor*. 10.1094/PHI-I-2012-10-29-01.

Klein, E ., Katan, J., Austerweil, M. and Gamliel, A. (2007). Controlled laboratory system to study soil solarization and organic amendment effects on plant pathogens. *Phytopathology*, 97(11): 1476-1483.

Kyei-Boahen, S., Slinkard, A. E. and Walley, F. L. (2001). Rhizobial survival and nodulation of chickpea as influenced by fungicide seed treatment. *Canadian Journal of Microbiology*, 47(6): 585-589.

Larkin, R. P., and Griffin, T. S. (2007). Control of soilborne potato diseases using Brassica green manures. *Crop Protection*, 26(7): 1067-1077.

Labrada, R. (2008). Non-chemical alternatives to methyl bromide for soil-borne pest control. p 3-14. In *Workshop on Non-chemical Alternatives to Replace Methyl Bromide as a Soil Fumigant - Report*, Budapest, Hungary.

Lee, J. M., Kubota, C., Tsao, S. J., Bie, Z., Echevarria, P. H., Morra, L. and Oda, M. (2010). Current status of vegetable grafting: Diffusion, grafting techniques, automation. *Scientia Horticulturae*, 127(2): 93-105

Lewis, J. A. and Papavizas, G. C. (1991). Biocontrol of cotton damping-off caused by *Rhizoctonia solani* in the field with formulations of *Trichoderma* spp. and *Gliocladium virens*. *Crop Protection*, 10(5): 396-402.

Lockwood J.L. (1977). Fungistasis in soil. *Biological Revi*ews 51: 1-43.

Loganathan, M., Sible, G. V., Maruthasalam, S., Saravanakumar, D., Raguchander, T., Sivakumar, M and Samiyappan, R. (2010). *Trichoderma* and chitin mixture based bioformulation for the management of head rot (*Sclerotinia sclerotiorum* (Lib.) de Bary) – root-knot (*Meloidogyne incognita* Kofoid and White., Chitwood) complex diseases of cabbage. *Archives of Phytopathology and Plant Protection*, 43(10): 1011–1024.

Miles, C. Wimer, J. and Inglis, D. (2015). Grafting eggplant and tomato for *Verticillium wilt* resistance. *Acta Horticulturae*. 1086: 113-118.

Nannipieri, P., Greco, S and Ceccanti, B. (2017). Ecological significance of the biological activity in soil. *Soil biochemistry*, 6: 293-356.

Neshev, G. (2008). Major soil-borne phytopathogens on tomato and cucumber in Bulgaria, and methods for their management. p 1-14. In Labrada, R. (ed), *Alternatives to replace methyl bromide for soil-borne pest control in East and Central Europe*, FAO, UNEP.

Nizam, N. H. M., Rawi, N. F. M., Ramle, S. F. M., Abd Aziz, A., Abdullah, C. K., Rashedi, A and Kassim, M. H. M. (2021). Physical, thermal, mechanical, antimicrobial and physicochemical properties of starch based film containing aloe vera: A review. *Journal of Materials Research and Technology*, 15: 1572-1589.

Omar, I., O'neill, T.M and Rossall, S. (2006). Biological control of fusarium crown and root rot of tomato with antagonistic bacteria and integrated control when combined with the fungicide carbendazim. *Plant Pathology, 55*(1): 92-99.

Panth, M., Hassler, S. C. and Baysal-Gurel, F. (2020). Methods for Management of Soilborne Diseases in Crop Production. Agriculture, 10(1); 16.

Pardossi, A., Carmassi, G., Diara, C., Incrocci, L., Maggini, R. and Massa, D. (2011). Fertigation and substrate management in closed soilless culture. *Pisa: University of Pisa*.

Paret, M. L., Cabos, R., Kratky, B. A. and Alvarez, A. M. (2010). Effect of plant essential oils on *Ralstonia solanacearum* race 4 and bacterial wilt of edible ginger. *Plant Disease*, 94(5): 521-527.

Peters, R.D., Sturz, A.V., Carter, M.R and Sanderson, J.B. (2003). Developing disease-suppressive soils through crop rotation and tillage management practices. *Soil and Tillage Research*, 72(2): 181-192.

Ramamoorthy, V., Viswanathan, R., Raguchander, T., Prakasam, V and Samiyappan, R. (2001). Induction of systemic resistance by plant growth promoting rhizobacteria in crop plants against pests and diseases. *Crop protection*, 20(1), 1-11.

Ratnadass, A., Fernandes, P., Avelino, J. and Habib, R. (2012). Plant species diversity for sustainable management of crop pests and diseases in agroecosystems: a review. *Agronomy for sustainable development*, 32(1): 273-303.

Savvas, D., & Neocleous, D. (2019). Developments in soilless/hydroponic cultivation of vegetables. p. 211-244. In Achieving sustainable cultivation of vegetables. Burleigh Dodds Science Publishing.

Schneider, R. W. (1982). Sup-pressive Soils and Plant Disease. The American Psychopathological Society. St. Paul, MN. p 88.

Sharon, E., Bar-Eyal, M., Chet, I., Herrera-Estrella, A., Kleifeld, O and Spiegel ,Y. (2001). Biological control of the root-knot nematode *Meloidogyne javanica* by *Trichoderma harzianum. Phytopathology* 91(7): 687–693.

Singleton, L. L., Mihail, J. D and Rush, C. M. (1993). Methods for research on soilborne phytopahogenic fungi. 2nd Ed. American Phytopathological Society. St. Paul, MN.

Szczechura, W., Staniaszek, M and Habdas, H. (2013). *Fusarium oxysporum* f. sp. *radicis-lycopersici* – the cause of *Fusarium* crown and root rot in tomato cultivation. *Journal of Plant Protection Research* 53 (2): 172–178.

Türkölmez, S. and Soylu, E. M. (2014). Antifungal efficacies of plant essential oils and main constituents against soil-borne fungal disease agents of bean. *Journal of Essential Oil Bearing Plants*, 17(2): 203-211.

Van Loon, L. C., Bakker, P. A. H. M and Pieterse, C. M. J. (1998). Systemic resistance induced by rhizosphere bacteria. *Annual review of phytopathology*, 36: 453-483.

Veena, D.R., Priya, H. R., Raheesa, M.K and Divya, J. (2014). Soilborne Diseases in Crop Plants and Their Management. Research & Reviews: *Journal of Agriculture and Allied Sciences*, 3(2): 12-18

Walters, D., Walsh, D., Newton, A. and Lyon, G. (2005). Induced resistance for plant disease control: maximizing the efficacy of resistance elicitors. *Phytopathology*, 95(12): 1368-1373.

Wang, M.C., Gong, M., Zang, H.B., Hua, X.M., Yao, J., Pang, J.Y. and Yang, Y.H. (2006). Effect of methamidophos and urea application on microbial communities in

soils as determined by microbial biomass and community level physiological profiles. *Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes,* 41(4): 399-413.

Weller, D. M., Raaijimakers, J. M., Gardener, B. B. M and Thomashow, L. S. (2002). Microbial populations responsible for specific soil suppressiveness to plant pathogens. *Annual Review of Phytopathology* 40: 309–348.

Youssef, M. M. A. and Lashein, A. M. S. (2013). Effect of cabbage (*Brassica oleracea*) leaf residue as a biofumigant, on root knot nematode, *Meloidogyne incognita* infecting tomato. *Journal of Plant Protection Research* 53(3): 271–274.

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ASSESSMENT OF THE UTILISATION LEVEL OF FADAMA II PROJECT COMPONENTS AMONG CROP FARMER BENEFICIARIES IN SOUTH WEST, NIGERIA

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ABSTRACT
The study assessed utilisation of Fadama II project components among crop farmer beneficiaries in South West, Nigeria.Multi-stage sampling technique was used to select 159 crop farmer beneficiaries of Fadama II project from Ogun State, 156 from Oyo State and 152 respondents from Lagos state respectively. This produced 467 crop farmer beneficiaries of Fadama II project. Structured interview schedule was used to collect data on the level of access and utilization of Fadama II project components namely; capacity building, pilot asset acquisition rural infrastructure and demand-driven advisory services. Data were analyzed using frequency distribution, percentages and mean while Analysis of Variance was used to test hypotheses at $p \leq 0.05$ level of significance. Results indicate that utilisation of Fadama II project components was low (59.3%) among crop farmer beneficiaries in the study area. Demand-driven advisory service was the most accessed Fadama II components (x=2.25) while utilization of pilot asset acquisition ranked first (x=2.26). Furthermore, there existed significant differences among crop farmer beneficiaries' level of access ($F=4.51$; $p<0.05$). Also, utilization of Fadama II project components ($F=5.38$; $p<0.05$) differed significantly across the study area. Fadama II project components recorded low utilisation among crop farmer beneficiaries. The study recommended the need for more accessibility of intervention projects for improved utilisation among beneficiaries in the study area.

Keywords: *Utilisation, access and Fadama II project components*.

INTRODUCTION

Utilisation of agricultural projects is an integral part of rural transformation and agricultural development. It is the extent to which specified users can use a product, a device, extension service, environment and project to achieve specified goals with effectiveness, efficiency, convenience, and satisfaction. Limited access to social and economic infrastructure such as education, health, potable water, and sanitation consequently limits individual advancement in welfare and capabilities. Utilisation of development projects has been found to be of the greatest importance not only to the urban settings but to rural areas in the area of socio-economic amenities provision (Samson and Raphael, 2015). As explained by Akinleye *et al.* (2005), Fadama II project was born out of the need to cater adequately for individual farmer to meet social and economic obligations, gainful employment, skills, assets, and self-esteem. The components of the second National Fadama Development Project (NFDP II) centered basically on the welfare and income of rural people (Simonyan and Omolehin, 2012). These components are capacity building, rural infrastructure investment, pilot productive asset acquisition support, demand-responsive advisory service, project management, monitoring, and evaluation.

Capacity building component supports measures to build the capacity of Fadama project beneficiaries so that they are equipped to access project advisory services and financing (Adegbite, *et al.*, 2008). The training also gives them the skills and know-how to carry out participatory planning as well as to implement, operate and maintain sub-projects. Rural infrastructure investment strengthens the creation of economic infrastructure and local public goods to improve the productivity of the beneficiaries. Through this component, the construction or rehabilitation of small-scale infrastructure sub-projects considered priorities by the community, was financed. The overall objective of pilot productive asset acquisition was to improve Fadama users' productivity and income by facilitating the acquisition of productive assets by individuals or Fadama associations. Under this, priority is given to the client's enterprise management skills, their capacity to mobilize their funds, and the provision of matching grants for income-generating activities to Fadama user groups or associations. Demand-responsive advisory service enables Fadama users to adopt output-

enhancing techniques and more profitable marketing practices in their Fadama enterprises. The project finances advisory services that accompany new investment activities in Fadama areas on request by the user groups and advisory services that support ongoing activities by Fadama users. Also the establishment of monitoring and evaluation mechanisms and consultant services that develop and implement studies (Girei *et al.*, 2013). These studies evaluated the sub-projects' impact and provided feedback to improve project implementation performance (Kudi *et al.,* 2008; World Bank, 2014), including an impact assessment for mid-term review and another at the end of the project. Crop farmers differ in their access to and utilization of agricultural projects from extension services and other sources (Samson and Raphael, 2015). Such differences and diversity among farmers could be related to various personal, social, economic, or institutional factors. Understanding such diversity is of paramount importance. Fadama II project was characterized by social inclusiveness and had components such as advisory services, capacity building, assets acquisition, and rural infrastructure facilities. All these Fadama II components were aimed at reducing poverty but were either poorly accessed, under-utilized, or non-existent. Consequently, the study aimed to provide answers to the following research questions:

(i) What is the crop farmer beneficiaries' level of access to Fadama II project in the study area?
(ii) What is the crop farmer beneficiaries' level of utilisation of Fadama II project in the study area?

Objectives of the Study: The broad objective of the study was to assess the level of utilisation of Fadama II project components among crop farmer beneficiaries in South West, Nigeria.

The specific objectives of the study were to:

(i) examine crop farmer beneficiaries' level of access to Fadama II project in the study area;
(ii) investigate crop farmer beneficiaries' level of utilization of Fadama II project in the study area;

Hypotheses of the Study: The research hypotheses that guided the study are as follows:

$H0_1$: There is no significant difference among crop farmer beneficiaries' level of access to Fadama II project across the study area.

$H0_2$: There is no significant difference among crop farmer beneficiaries' level of utilisation of Fadama II project across the study area.

METHODOLOGY

Sampling Procedure and Sample Size

The Second National Fadama Development Project (Fadama II) was implememted in Oyo, Ogun and Lagos states out of the six South West states (World Bank, 2014). Multi-stage random sampling technique was used in the selection of 50 percent Fadama Community Associations (FCAs), 40 percent Fadama User Groups (FUGs), 25 percent Crop Fadama User Groups (CFUGs) and 50 percent crop farmer beneficiaries of Fadama II project. This brought about the selection of 159 crop farmer beneficiaries of Fadama II project from Ogun State, 156 from Oyo State and 152 respondents from Lagos state. Therefore, 467 crop farmer beneficiaries of Fadama II project selected from Ogun, Oyo and Lagos States constituted sample size for the study.

Measurement of Variables

Access to Fadama II Components: Respondents were asked to indicate appropriately the level of access to Fadama II project components, namely; capacity building, pilot asset acquisition, rural infrastructure, and demand-driven advisory by ranking them in order, using 3-for good, 2-for average, 1-for poor and reversal in that order. The minimum and maximum obtainable access scores were 4 and 12, respectively. A composite access score was calculated and the weighted average was determined. The access scores above or equal mean access score were high, while accessscores below the mean score were low.

Utilisation of Fadama II Components: Utilisation of Fadama II Components was measured by asking respondents to indicate their level of utilization of Fadama II project components; capacity building, pilot asset acquisition, rural infrastructure, and demand-driven advisory. Based on the indicators, beneficiaries of Fadama II responded by ranking them in order, 3 for high, 2 for average and 1 for low. The minimum and maximum obtainable utilisation scores were 4 and 12, respectively. Composite score was calculated for utilisation and the weighted average for utilisation score was computed. The utilisation scores were then categorized into high and low utilisation scores respectively. Utilisation scores that were equal to or above the mean utilisation score were high, while scores below were categorised as low.

Analytical Techniques: The analytical tools employed were descriptive statistics such as frequency distribution, percentages, means, median, mode, and standard deviation, while Analysis of Variance (ANOVA) was used as an inferential tool.

RESULTS AND DISCUSSION

Table 1 reveals that demand-driven advisory services (x=2.25) was the most accessed component, followed by pilot asset acquisition (x=2.24), capacity building (x=2.07) and rural infrastructure (x=1.19). However,, access to Fadama II components was averagely rated (x=2.188) among sampled respondents in the study area. Access to capacity building component of Fadama II was rated poor among 21.0 percent of respondents, adjudged average among 50.5 percent beneficiaries, while 28.5 percent submitted that they had good access to capacity building strategy of the project as indicated in Table 1. Also, access to asset acquisition was recorded as poor among 10.7 percent of respondents, averagely rated by 53.1 percent beneficiaries, while 15.0 percent were of the view that the level of access to Fadama II project was good. Access to rural infrastructure was poorly rated among 51.4 percent of respondents indicating that rural areas were still seriously suffering from critical infrastructure. The infrastructural deficit may be instrumental to increased perishability of farm produce among rural dwellers whose sources of income were mainly from agriculture. Furthermore, access to demand-driven advisory was averagely ranked among 50.1 percent of the respondents. Virtually all Fadama II project components recorded average except access to infrastructure, which was generally rated below average.

Distribution of Crop Farmer Beneficiaries Based on Utilisation Level of Fadama II Project

Utilisation of Fadama II project components by crop farmer beneficiaries is shown in Table 2. From the table, pilot asset acquisition (x=2.26) was the most utilised, followed by capacity building (x=2.25), demand-driven advisory services (x=2.09) and rural infrastructure (x=1.22) in that order. Utilisation of Fadama II component was adjudged average (x=2.205) among respondents in the study area. Capacity building strategy of the project was poorly utilized by 12.4 percent respondents, 50.3 percent utilized it averagely, while 37.3 percent recorded high utilization of capacity building component. Utilisation of pilot asset acquisition was poor among 10.9 percent respondents, averagely utilised among 52.7 percentof respondents, and rated high among 36.4 percent beneficiaries. Also, 51.8 percentof infrastructure users rated it poor, 35.1 percent of the beneficiaries had an average utilisation level, while 13.1 percentof respondents recorded high utilization of rural infrastructure. Utilisation of rural infrastructure was indifferent to access to rural infrastructure in Table 1. As shown in Table 3, there was low utilization of Fadama II project among majority (59.3%) of the respondents in the study area.This implies low access translates to poor utilization, which invariably impacts significantly on crop production activities. This strengthens Oni and Olaniran (2013)'s position that access to development projects influences utilization and vice-versa.

Hypothesis testing

$H0_1$: There is no significant difference in crop farmer beneficiaries' level of access to Fadama II project across the study area. This hypothesis was tested using Analysis of Variance (ANOVA) and Scheffe's Post Hoc tests (Table 4). The result indicates a significant difference in crop farmer beneficiaries' level of access to Fadama II project across the study area (F=4.506, p-value<0.05). Scheffe's Post Hoc test reveals that mean access scores were significantly different in Lagos (x=8.9803), Ogun (x=7.8050) and Oyo (x=6.5192).

$H0_2$: There is no significant difference in crop farmer beneficiaries' ¬level of utilisation of Fadama II project across the study areas. This hypothesis was tested using Analysis of Variance (ANOVA) and Scheffe's Post Hoc tests. The result of the analysis is presented in Table 5. Result indicates that there is a significant difference in crop farmer beneficiaries' level of utilization of Fadama II project across the study areas (F=5.380, p-value<0.05). Scheffe's Post Hoc test reveals that mean utilization scores were significantly different in Ogun (x=9.0189), Oyo (x=8.8718) and Lagos (x=8.5263) in that order.

CONCLUSION

There was low level of utilisation of Fadama II project components among respondents in the study area. Fadama II project components that were accessed and utilised were capacity building, demand-driven advisory services, and pilot asset acquisition, while rural infrastructure was poorly utilised. Access and utilisation of

Fadama II differed significantly across the states.

RECOMMENDATIONS

Based on the findings of this research study, the following recommendations are suggested for combating poor utilization of development projects among crop farmer beneficiaries:

Governments at all levels and non-government organisations should prioritize access to relevant resources and not white elephant projects which does not have a direct bearing on farmers' well-being and invariably results in or poor utilization of development projects.

Beneficiaries of developmental projects should be enlightened on how best to utilise the projects,and enhance their full-fledged benefits, which will, in turn,significantly impact their living conditions.

Access to infrastructure, which had hitherto remained the bane of development in most rural areas, should be addressed to make lives more meaningful to the crop farmers, who are mostly ruraldwellers for enhanced crop production activities.

REFERENCES

Adegbite, D. A., Oloruntoba, A. O, Adubi, K. O, Oyekunle, O. and Sobanke, S B., (2008). Impact of National Fadama Development Project II on Small Scale Farmers in Ogun State: Implication for Agricultural Financing in Nigeria, *Journal of Sustainable Development in Africa*: 10(3):456-472.

Akinleye, S. O. Awoniyi S. M. and Fapojuwo E. O (2005). Evaluation of the National Fadama Development Project,Approach to Rural Development, a paper presented at the Farm Management Association of Nigeria Conference, Asaba, Nigeria.Pp1-9

Girei A.A., Dire B., Iliya M.M. and Salihu M. (2013). analysis of impact of National Fadama II facility in alleviating poverty on food crop farmers in Adamawa State, Nigeria. *Global Journal of Agricultural Research*: 1(3)8-15.

Kudi, T. M., Usman, I., Akpo, J. G. and Banta, A. L. (2008). Analysis of the Impact of National Fadama Development Project II (NFDP-II) in Alleviating Poverty Among Farmers in Giwa Local Government of Kaduna State, Nigeria, *Ozean Journal of Applied Science* 1(2),1-8.

Oni, O. A. and Olaniran O.T. (2013). Analysis of Poverty Status of Fadama II and Non Fadama II Beneficiaries in Rural Oyo State, Nigeria. *Journal of Economics and Rural Development*. 17(1):45-61.

Samson, A. and Raphael A. (2015). Utilization Pattern of Community Driven Development Projects (CDDP) in Southwestern, Nigeria, *International Journal of Sustainable Development* 8(2):111-120. Available at http://www.ssrn.com/link/OIDA-Intl-Journal- Sustainable-Dev.html

Simonyan, J.B. and Omolehin, R.A. (2012). Analysis of Impact of Fadama II Project on Beneficiary Farmers Income In Kaduna State: A Double Difference Method Approach, *International Journal of Economics and Management Sciences,* 1(11),1-08.

World Bank (2014). Project Performance Assessment Report of the Second National Fadama Development Project. IDA-38380, pp 1-107.

Table 1: Distribution of Crop Farmer Beneficiaries Based on Level of Access to Fadama II Project

Level of Access to Fadama II Components		States				
		Lagos State Freq (%)	Ogun State Freq (%)	Oyo State Freq (%)	Total Freq (%)	Mean-Values
Access to Capacity building	Poor	25(16.4)	40(25.2)	33(21.2)	98(21.0)	2.07**
	Average	78(51.3)	79(49.7)	79(50.6)	236(50.5)	
	Good	49(32.2)	40(25.2)	44(28.2)	133(28.5)	
Access to Pilot asset acquisition	Poor	18(11.8)	14(8.8)	18(11.5)	50(10.7)	2.24**
	Average	80(52.6)	84(52.8)	84(53.8)	248(53.1)	
	Good	54(35.5)	61(38.4)	54(34.6)	169(36.2)	
Access to Rural infrastructure	Poor	81(53.3)	79(49.7)	80(51.3)	240(51.4)	1.19*
	Average	55(36.2)	61(38.4)	41(26.3)	157(33.6)	
	Good	16(10.5)	19(11.9)	35(22.4)	70(15.0)	
Access to Demand-driven advisory services	Poor	12(7.9)	20(12.6)	26(16.7)	58(12.4)	2.25**
	Average	78(51.3)	80(50.3)	76(48.7)	234(50.1)	
	Good	62(40.8)	59(37.1)	54(34.6)	175(37.5)	
Mean-Value						1.94**

Field Survey, 2016. 1* = poor, 2** = average, 3 *** = good

Table 2: Distribution of Crop Farmer Beneficiaries Based on Utilisation of Fadama II Project Components

Utilisation of Fadama II Components	Projects	States				
		Lagos Freq.(%)	Ogun Freq.(%)	Oyo Freq.(%)	Total Freq.(%)	Mean- Values
Utilisation of Capacity building	Poor	26(17.1)	13(8.2)	19(12.2)	58(12.4)	2.25**
	Average	75(49.3)	82(51.6)	78(50.0)	235(50.3)	
	High	51(33.6)	64(40.3)	59(37.8)	174(37.3)	
Utilisation of Pilot asset acquisition	Poor	19(12.5)	19(11.9)	13(8.3)	51(10.9)	2.26**
	Average	80(52.6)	83(52.2)	83(53.2)	246(52.7)	
	High	53(34.9)	57(35.8)	60(38.5)	170(36.4)	
Utilisation of Rural infrastructure	Poor	79(52.0)	85(53.5)	78(50.0)	242(51.8)	1.22*
	Average	41(27.0)	60(37.7)	63(40.4)	164(35.1)	
	High	32(21.1)	14(8.8)	15(9.6)	61(13.1)	
Utilisation of Demand-driven advisory services	Poor	31(20.4)	26(16.4)	38(24.4)	95(20.3)	2.09**
	Average	78(51.3)	80(50.3)	79(50.6)	237(50.7)	
	High	43(28.3)	53(33.3)	39(25.0)	135(28.9)	
Mean-value						1.955**

Field Survey, 2016. 1*=poor, 2**=average, 3 ***=good

Table 3: Distribution of Crop Farmer Beneficiaries Based on Utilisation Level of Fadama II Project

Utilisation Level	Df	%	Minimum	Maximum	Mean	Std. Deviation
High	190	40.7%	5.00	12.00	8.8094	1.36796
Low	277	59.3%				

Table 4: One Way Analysis of Variance Showing Difference among Crop Farmer Beneficiaries' Level of Access Across to Fadama II project in the Study Areas.

Access Level	Sum of Squares	Df	Mean Square	F	p-value	Scheffe's Post Hoc tests
Between Groups	16.720	2	8.360	4.506	.012	Lagos 8.9803
Within Groups	860.839	464	1.855			Ogun 7.8050
Total	877.559	466				Oyo 6.5192 7.7681

Field Survey, 2016. *Significant at 0.05 level.

Table 5: One Way Analysis of Variance Showing Difference among Crop Farmer Beneficiaries' Level of Utilization of Fadama II project Across the Study Area

Utilization	Sum of Squares	Df	Mean Square	F	Sig.	Scheffe's Post Hoc tests	
Between Groups	19.765	2	9.882	5.380	.005	Lagos	8.5263
Within Groups	852.274	464	1.837			Ogun	9.0189
Total	872.039	466				Oyo	8.8718 8.8094

Field Survey, 2016. *Significant at 0.05 level of significance

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MYCOPESTICIDES AND ITS APPLICATION IN AGRICULTURE: AN ALTERNATIVE TO THE GROWING CONCERNS IN THE USE OF CHEMICAL PESTICIDES

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ABSTRACT
The rise in global concern over the negative consequences of agrochemicals in agriculture cannot be overemphasized. Over-reliance on chemical pesticides for pests control, is not without its accompanying side effects. Chemical pesticides are known to cause varying degrees of health and environmental damages if not properly handled. These consequences can be indispensable with continuous use of chemical pesticides in agriculture irrespective of how meticulous one is, since pesticides can migrate by air, soil, or water, outside of its intended area of use, contaminating soil, air, and water, and causing significant damages to plant and human health. In recent times, there is an increased emphasis on production of safe, nutritious and healthy foods. As such, research has been geared towards the use of biological control measures that does not leave behind chemical residues. Mycopesticides or biological control fungus is one aspect of biological control that has proven to be very effective in the control of pests. This article attempts to highlight some proven biological control fungus such as *Ampelomyces quisqualis, Trichoderma spp, Beauveria spp, Metarhiziumanisopliae, Verticillium spp* etc., that have been effectively utilized in control of pathogens, insects, and weeds in agriculture, and some advantages and disadvantages of biological control fungus.

Keywords: *biological pest control, pesticides, fungi, weeds control, and insect management*

INTRODUCTION

Growing public concern over pesticide misuse in agriculture and its consequences on the environment has prompted studies into the use of safe and environmentally friendly technologies to manage pests and pathogens (Aktar *et. al.*, 2009). To ensure the quality and availability of food, feed, and fibre across the world, plant diseases must be controlled. Plant disease mitigation has taken a variety of forms. Producers frequently use chemical fertilizers and insecticides in addition to sound agronomic and cultural practice methods. However, contamination produced by the unintentional use and abuse of agrochemicals, such as pesticides, has resulted in significant shifts in people's attitudes regarding pesticide usage in agriculture. Today, there are rigorous laws for the use of chemical pesticides, as well as a concerted effort to eliminate the most dangerous compounds from the market. As a result, scientists have focused their efforts on creating alternate techniques to replacing synthetic pesticides in the management of plant pests and diseases. Biological management of pests and illnesses is the favoured eco-friendly option among a few potent alternatives. The words "biological control" and "bio-control" have been used in several domains of biology, most notably in entomology and plant pathology **(**Prajapati *et. al*., 2020**)**. It is said to be a natural way of employing living creatures to manage pests such as insects, mites, weeds, and plant diseases **(**Prajapati *et. al*., 2020**)**. Biological control, in a broader sense, refers to the utilisation of natural compounds extracted or fermented from a variety of sources **(**Alemu, 2014**).** Biological control, in its broadest sense, is the suppression of one organism's harmful actions by one or more other species, sometimes referred to as natural enemies. Due to their broad range activity against disease-causing microorganisms and pests, fungi have acquired widespread recognition as bio-control agents alongside bacteria (most notably, *Bacillus thuringiensis*) because of their broad spectrum effect on disease-causing microorganisms and pests (Jyoti and Singh, 2017).

Bio-Control Agents of Fungi: As seen by the growing number of commercial treatments available or in development, fungi are increasingly being used to manage invertebrate pests and illnesses. Plant productivity, animal and human health, and food production are all affected by fungal biological management, which is a fascinating and fast increasing study subject. Fungi are particularly appealing as biocontrol agents because of their widespread

distribution, high degree of host specificity, host death, persistence, dispersion effectiveness, and simplicity of culture and laboratory maintenance. The control of rush skeleton weed in *Chondrilla juncea* by *Puccinia chondrillina* is well documented, as is the success story of fungi, particularly rusts, in bio-control programmes (Hasan, 1972; Cullen, *et al*., 1973; Hasan and Wapshere, 1973; Emge, *et al*., 1981). The first time a fungal agent was used to control a pest was in Russia in 1888, when the fungus *Metarhizium anisopliae* was used (Metschn.) For the control of the beet weevil *Cleonus punctiventris* (germar), Sorokin was bulk manufactured on beer mash and sprayed in the field (Lord, 2005). In 1965, the former Soviet Union developed Boverin, a *Beauveria bassiana*-based mycoinsecticide for the control of the Colorado potato beetle and codling moth (Kendrick, 2000). The US Environmental Protection Agency gave full registration of Mycar, a mycoacaricide based on *Hirsutella thompsonii* Fisher, in 1981 for control of the citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), in the United States (McCoy, 1986). Insect and acarine (mites and ticks) biopesticides have been created for control of insects and acarines (mites and ticks) in agricultural, urban, forest, livestock, and aquatic habitats, with a significant number of fungus-based biopesticides produced in recent years **(**de Faria, 2009**)**.

Fungi-Mediated Bio-Control Mechanisms

Direct Antagonism: Biological control is the result of a variety of interactions between organisms. It has been revealed that some fungus may parasitize other fungi. The most direct sort of antagonism attributable to the activity of no other organism would be hyper-parasitism by obligatory parasites of a plant pathogen. *Ampelomyces quisqualis* is a naturally occurring deuteromycete hyper-parasite that infects powdery mildew hyphae, conidiophores, and cleistothecia to generate pycnidia (fruiting bodies) within powdery mildew hyphae, conidiophores, and cleistothecia (the closed fruiting bodies of powdery mildews). The mildew colony's development is slowed and subsequently killed by hyperparasitism. According to Weindling (1932), *Trichoderma lignorum* (T. viride) parasitizes the hyphae of *Rhizoctonia solani*. There are several fungal parasites of plant pathogens, including those that attack sclerotia (e.g., *Coniothyrium minitans*) and those that attack living hyphae (e.g., *Pythiumoli gandrum*), and a single fungal pathogen can be attacked by multiple hyperparasites. For example, *Acremonium alternatum, Acrodontium crateriforme, Ampelomyce squisqual* (Kiss, 2003).

Antibiosis: Antibiosis is the process of antagonist fungus secreting antimicrobial chemicals to inhibit or kill pathogenic fungi in the vicinity of their development region **(**Schirmbock *et.al*., 1994; Ghisalberti 2002). Most fungi are capable of secreting one or more antibiotic-active chemicals and secondary metabolites, which are typically linked to certain stages of morphological differentiation and the active growth phase (Ghisalberti, 2002**)**. Some fungal secondary metabolites have the ability to alter plant growth and metabolism, while others appear to target particular fungal processes like sporulation and hyphal extension **(**de Faria, 2009**).** Menendez and Godeas (1998) reported on a bio-control study of *T. harzianum* against *Sclerotinia sclerotiorum*, a soil-borne plant pathogen that affects many economically important crops, including soybean, as well as antibiosis of *T. harzianum* against the pathogen, assuming that the beneficial effect was due to concurrent mycoparasitism and competition (Inbar, *et al*., 1996; Ghisalberti, 2002). In another experiment, despite close contact between *Trichoderma* spp. hyphae and *Fusarium moniliforme, Aspergillus flavus* hyphae during co-culturing, hyphal penetration was not detected, suggesting that mycoparasitism was not the only source of the inhibitory effects reported (Calistru, 1997). As a result, metabolites generated by *Trichoderma* spp. (e.g., volatiles, extracellular enzymes, and/or antibiotics) were thought to be likely antibiosis components. *Trichoderma* spp. has been shown to be effective against a wide range of hosts and to reduce the lifetime of pathogenic fungi's sclerotia (Verma *et. al*., 2007)

Competition: Starvation is one of the most prevalent cause of mortality for microorganisms, fungal phytopathogens are biologically controlled by competition for finite resources (Chet et al., 1997). Blakeman (1978) discovered that a lack of readily available nutrients causes open nutritional competition among microorganisms, particularly those living in soil and on plant surfaces (Sivan, 1986; Lewis, 1991). It has been discovered that bio-control is based on competition for rare but necessary micronutrients, such as iron, which is particularly scarce in the rhizosphere, and is affected by soil pH. Iron is found in highly oxidised and aerated soil in ferric form

(Lindsay, 1979), which is insoluble in water (pH 7.4) and can be as low as 10-18M. This concentration is insufficient to sustain the development of microbes, which require 10-6M or higher concentrations. To live in such an environment, organisms have been discovered to release siderophores, which are iron-binding ligands with a high affinity for sequestering iron from the micro-environment. To mobilise ambient iron, most filamentous fungi ingest iron as an important mineral for viability and under iron deficiency, and most fungi excrete low-molecular-weight ferric-iron specific chelators, known as siderophores (Eisendle, *et al*., 2004). Iron is then retrieved from the ferri-siderophore complexes via specialised uptake processes. Some *Trichoderma* biocontrol agents create extremely effective siderophores that chelate iron and prevent other fungi from growing (Chet and Inbar, 1994). As a result, the biocontrol efficiency of Pythium by Trichoderma is influenced by soil composition and iron availability. *Trichoderma harzianum* T35 also controls *Fusarium oxysporum* by competing for rhizosphere colonisation and nutrients, with biocontrol becoming more effective as nutrient content drops (Tjamos, *et al*., 1992), preventing illnesses such as fusarium wilt in plants. Competition has proven to be crucial in the biocontrol of phytopathogens like *Botrytis cinerea*, the most common pathogen. The commensal microorganisms' higher iron absorption efficiency is suggested to be a significant element in their capacity to aggressively colonise plant roots and help in the displacement of harmful organisms from potential infection sites. As a result, the given cases proved the importance of nutrient competition for fungal development as a bio-control agent.

Pest Biocontrol Mediated by Fungi: Many pests of agricultural crops are known to be natural adversaries of entomopathogenic fungi (Hajek and Leger, 1994). Entomopathogenic fungi have life cycles that are synchronised with the phases of insect hosts and environmental variables. Fungal pathogens may harm insects at every stage, from egg to larval to nymphal to adult (Jyoti and Singh, 2017). Fungi, unlike viruses and bacteria, do not require the ingestion of the host to infect and kill it. As a result, sap sucking phytophagous insects like sucking pests (green mirids and silverleaf whiteflies) are targets for fungi, either through direct contact with fungal spores or through secondary uptake of spores from sprayed crops (Moore and Prior, 1993). Entomopathogenic fungi were the first organisms to be utilised for biological pest management and are key control agents for a variety of herbivorous insects (Jyoti and Singh, 2017). Some entomopathogenic fungi have narrow host ranges, such as *Aschersoni aaleyrodes*, which only infects scale insects and whiteflies, but others have a broader host range, with particular isolates being more specialised to target pests (Jyoti and Singh, 2017). Entomopathogens like *M. anisopliae* and *B. bassiana* have been employed as biological control agents for crop pests all over the world because of their pathogenicity to a variety of insects (Jyoti and Singh, 2017).

***Metarhizium anisopliae*:** *Metarhizium anisopliae* is a possible insect pathogen that has been used for fungal bio-control of a number of pests (Sandhu and Mishra 1994). The species is employed to manage significant pests such as locusts, grasshoppers, cockroaches, and termites in both industrialised and developing nations such as the United States, Australia, and Africa as reported by Jyoti and Singh (2017). The fungus can germinate and develop in areas of the insect where the cuticle is weak, such as the back of the neck or beneath the wing, where the green spores are easily distributed (Jyoti and Singh, 2017). The fungus is quite effective; for example, depending on the amount of infecting spores, it can kill 90 percent of locusts after 7-21 days of treatment. Because it can be cultivated on rice grains, the agent is simple to bulk manufacture. Hasan *et al*. (2002) used solid state fermentation to assess *M. anisopliae* spore production (Jyoti and Singh, 2017). *Metarhizium anisopliae*entire bio-activity was examined on the teak skeletonizer *Eutectona machaeralis*, and *M. anisopliae* was shown to be a promising fungal bio-control agent of teak pests (Sandhu *et al*., 2000).

***Trichoderma spp*.**: *Trichoderma* spp. have evolved into commercial biological control products used in field crops and greenhouse systems (Harman et al., 2004) and are known to control a wide range of soil-borne diseases, including those caused by *P. ultimum* Trow. (Naseby *et al*., 2000), *S.sclerotiorum* (Lib.) de Bary (Inbar, et al., 1996), and *Fusarium oxysporum* Schlechtend (Sivan and Chet, 1993). *Trichoderma aure oviride* Rifai may develop coiled hyphae structures around filamentous pathogen hyphae (Jyoti and Singh, 2017). Mycoparasitism is characterised by coiling, which is commonly followed by cell wall penetration and cytoplasm breakdown, as seen

by increased cellular vacuolization in the host (Calvet *et al*., 1989). The development of enzymes that accelerate the breakdown of chitin, a fundamental component of fungal cell walls, is thought to be the reason for *T. harzianum* Rifai's penetration into other fungi's cell walls (Zeilinger *et al*., 1999). *Trichoderma. harzianum* can cause cytoplasm disintegration and grow within empty host hyphae after penetrating the cell wall (Inbar *et al*., 1996).

Beauveria spp: Beauveria strains have evolved to be highly suited to certain host insects (Jyoti and Singh, 2017). *B. bassiana* spp. have been isolated and reported from a wide range of insects across the world, many of which are important in the medical and agricultural areas. *Beauveria bassiana* is an entomopathogenic fungus that grows naturally in soils and is known as a pathogen on several insect species, causing white muscardine illness (Sandhu, *et. al*., 2001; Thakur, *et. al*., 2005; Jain, *et al*., 2008). *Beauveria bassiana* is a widespread fungus that is thought to be the most prevalent cause of illness in dead and moribund insects in nature (Mcleod, 1954). It has been explored as a microbial control agent for hypogeous species all over the world (Ferron, 1981). In a related development, Hamlen (1979) and McNeil Donald (2005) reported that *Beauveria. bassiana* was employed as a biological pesticide to treat a wide range of pests, including termites, whiteflies, and malaria-carrying mosquitoes . As an insecticide, the spore has to be sprayed on affected crops as an emulsified suspension or wettable powder.

Verticillium lecanii: Another extensively dispersed entomopathogenic fungus, *Verticillium lecanii*, can produce huge epizootics in tropical and subtropical regions, as well as in warm and humid conditions (Nunez et al., 2008). *Verticillium lecanii* is an efficient biological control agent against *Trialeurodes vaporariorum* (greenhouse whitefly) in South Korean greenhouses, according to Kim *et al* (2002). *Verticillium lecanii* was created in the 1970s to control whitefly and aphids, notably green peach aphids (Myzuspersicae), for use in greenhouse chrysanthemums (Hamlen, 1979). *Verticillium lecanii* is a significant parasite that can cause a huge decline in cereal-cyst nematode populations in sensitive crops monocultures (Kerry, *et al*., 1982). Another *Verticillium* species, *V. chlamydosporium*, has a wide spectrum of cyst and root-knot nematode hosts. It's highly variable, and only a few isolates may have economic biological control potential (Jyoti and Singh, 2017).

Nomuraea spp.: *Nomuraea rileyi*, a dimorphic hyphomycete that may induce epizootic death in many insects and arthropods, is another effective entomopathogenic fungal bio-control agent. Many Lepidoptera species, especially *Spodoptera litura*, and certain Coleoptera species are reported to be very vulnerable to *N. rileyi* (Ignoffo, 1981). The host specificity of *N. rileyi*, as well as its environmental friendliness, encourages its usage in insect pest management (Jyoti and Singh, 2017). While the route of infection and development for various insect hosts, including *Trichoplusiani*, *Heliothiszea*, *Plathypenascabra*, *Bombyxmori*, *Pseudoplusia includens*, and *Anticarsia gemmatalis*, has been effectively investigated and published according to Jyoti and Singh, 2017. *Nomuraea rileyi* has been found to attack another insect, Spilosoma, and is being explored as a fungal bio-control agent (Mathew *et al*., 1998).

***Paecilomyces spp*. :** Paecilomyces is a nematophagous fungus whose pathogenesis has been shown to kill hazardous worms and induce illness in them. As a result, the fungus can be utilised as a bio-nematicide to control nematodes in the soil (Jyoti and Singh, 2017). Following its discovery in 1979, Paecilomyces became known as an important biological control research. *Paecilomyces lilacinus* is a worm that primarily infects and assimilates root-knot and cyst nematode eggs (Jyoti and Singh, 2017). Hyphomycetes is one of the most significant natural enemies of whiteflies on the planet, and it is responsible for the illness known as "Yellow Muscardine" (Nunez, *et al*., 2008).

In general, a few species of fungus have been known for their ability to induce significant levels of mortality and the formation of natural epizootics that are influenced not only by environmental factors, but also by agricultural production techniques (Jyoti and Singh, 2017). Strong epizootic capability against Bemisia and *Trialeurodes* spp. has been shown in both greenhouse and open field situations, and *P. lilacinus* is widely acknowledged as the best bio-control agent in subtropical and tropical agricultural soils (Jyoti and Singh, 2017). The potential of this fungus to spread fast through whitefly populations is enhanced by its propensity to grow broadly throughout the leaf surface in humid circumstances (Wraight *et al*., 2000). *Bemisia tabaci* populations are severely reduced by *Paecilomyces fumosoroseus*

epizootics in the field or in the greenhouse following wet seasons or even lengthy periods of cold, humid weather (Faria and Wraight, 2001). According to Kim *et al.* (2002), *P. fumosoroseus* is the best fungus for controlling whitefly nymphs because it can wrap the entire whitefly's body with mycelial threads and glue them to the underside of the leaves. Mycelia and conidia surround the nymphs, giving them a "feathery" appearance (Nunez, *et al*., 2008). *Paecilomyces furiosusis* is also being researched for use as a mosquito biocontrol agent against *Culex pipiens* sp (Sandhu and Mishra, 1994).

Weed Biocontrol Mediated by Fungi: Weeds are everywhere, and they are becoming a major barrier to global agricultural productivity. As a novel management method, fungal bio-logical control agents (BCAs) can be utilised for weed management employing fungal pathogens, and hence risk assessments and safety problems can still be in the learning phase. There are two broad methods: (i) traditional biological control for exotic or alien weeds, which involves the introduction and release of coevolved pathogens from the target weeds' origin, and (ii) inundative control for endemic weeds, which involves mass production and application of indigenous pathogens as formulated products (myco-herbicides) (Jyoti and Singh, 2017).

Classical biological control method : includes, the capacity of a pathogen to govern host populations into which it has been introduced is determined by its ability to reproduce and spread, and extra care should be given to pick agents that are both severely pathogenic to plants and eco-climatically suited for the target location **(**Watson, 1991**;** Jyoti and Singh, 2017). The pathogen must be unique to the host weed; near relatives might be included if they are not economically or environmentally significant. The following are some instances of fungi harmful to plants that have been effectively employed to manage economically important weeds: The introduction of *Puccinia chondrillina*, which attacks rush skeleton weed and reduces its population (Wapshere *et al*., 1976). Plants, especially younger plants, die prematurely as a result of infection of the basal leaves in the fall and spring. Wilting occurs as a result of an open lesion on the plant, which lowers photosynthesis and contributes to a decline in overall plant health. Stems infected with the disease are stunted and malformed, with few branches or blooms (McCaffery *et al*., 1996; Coombs *et al*., 2004).

From spring through fall, this fungus produces spores in the form of circular rust-colored patches (uredia) on all aboveground sections of the plant, which release infective urediospores. In the fall, open lesions (telia) grow at the base of stems, producing teliospores that slumber until spring. These spores germinate on rosette leaves and grow into yellowish clusters called pycnia, which release additional spores (McCaffery *et al*., 1996; Coombs *et al*., 2004).

Phragmidium violaceum, a rust fungus from Europe, has been introduced into Chile for the biological control of weedy blackberry *Rubus constrictus* and *R. ulmifolius*. *Rubus constrictus* was seriously afflicted by the rust, and infestations in various sections of Chile began to decline rapidly (Oehrens and Gonzalez, 1974, 1977).

Cercosporella ageratina, a fungal pathogen from Jamaica, was brought to Hawaii for the biological control of *Hamakwa pamakani*, *Ageratina riparia* (*Eupatorium riparium*), a composite weed of Mexican provenance that was causing issues in the rangelands and pastures of the island (Trujillo, 1985).

Use of *Uromycladium tepperianum*, an Australian gall rust, to combat the invasion of Port Jackson willow (*Acacia saligna*) in South Africa (Morris, 1997)

In Queensland, Australia, the rust *Maravalia cryptostegiae* was released to combat rubbervine weed (*Cryptostegia grandiflora*) (Evan et al., 2001; Tomley and Evans, 2004). Foreign exploration, agent selection, screening, introduction and release, and monitoring are the procedures followed by a typical classical bio-control programme, and they are all uniformly successful (McFadyen, 1998; Evans *et al*., 2001).

Fungi As Bio-Control Agents: Benefits: Bio-control fungi have a number of characteristics that help them get public approval. The most essential aspect is that they significantly reduce the need for chemical products, many of which are harmful to both humans and the environment. Fungi are excellent biological control agents for a variety of reasons: they self-generate within or on the surface of the plant and may effectively provide continuous protection as the plant matures; they seldom affect humans or other mammals, making them exceedingly safe to employ (Jyoti and Singh, 2017). Because hyphomycete group fungi, which are parasitic on insects, are relatively easy to manufacture huge numbers of spores, they are comparable in price to other biological

control agents. The majority of commercial fungal products are spores, which are simple to adapt to modern application technologies, such as spray rigs. Because fungi have such a wide range of hosts, they may often be used to manage various pests with the same product (Jyoti and Singh, 2017).

Disadvantages: When helpful insects (i.e., predators, parasitoids, and pollinators) are present in a crop, the problem arises, and non-target mortality in these populations of beneficial insects can have a negative impact on the overall biological control program's performance. Environmental conditions can also play a key impact in the effectiveness of bio-control fungus. Moist conditions or high relative humidity in the canopy of the crop are typically essential for control to be successful. In addition, prolonged exposure to sunshine can inactivate spores, lowering their permanence in the crop. Natural outbreaks of fungus in the environment are intermittent due to these environmental constraints, which might restrict their usefulness in pest management.

CONCLUSIONS AND OUTLOOK FOR THE FUTURE

If scientists can effectively generate resting spores and competent mycelia, the application of bio-control fungus will grow in the future. The use of genetic modification to increase the virulence of fungus is becoming more common, but it is still less studied than bacteria and viruses. To establish the best dose and time for fungi, a better knowledge of their abiotic and biotic interactions is required. The vulnerable host stage, climatic factors, and agricultural techniques must all be taken into account while applying the vaccine (e.g., avoid fungicides). By minimising the negative effects of pests and weeds and so improving crop quality, fungal biological management might play a critical role in sustainable agriculture.

REFERENCES

Aktar, M. W., Sengupta, D., Chowdhury, A (2009). Impact of pesticides use in agriculture: their benefits and hazards. *Interdiscip Toxicol*. 2(1):1-12. doi: 10.2478/v10102-009-0001-7. PMID: 21217838; PMCID: PMC2984095.

Alemu, N. (2014). Review on Concepts in Biological Control of Plant Pathogens. *Journal of Biology, Agriculture and Healthcare*, 4(27): 33-55.

Auld, B. A., McRae, C. F. and Say, M. M. (1988) Possible control of *Xanthium spinosum* by a fungus. Agric. *Ecosyst. Environ.* 21: 219-223.

Bakers, K. F. and Cook, R. J. (1974). Biological control of plant pathogens. *Am. Phytopathol. Soc.*, 11(4): 433.

Barton, J. (2004). How good are we at predicting the field host-range of fungal pathogens used for classical biological control of weeds? – *Biol. Control*, 31: 99-122.

Blakeman, J. P. (1978). Microbial competition for nutrients and germination of fungal spores. *Ann. Appl. Biol.* 89:151–155.

Calistru, C., McLean, M. and Berjak, P. (1997). In vitro studies on the potential for biological control of *Aspergillus flavus* and *Fusarium moniliforme* by *Trichoderma* species 1. Macroscopical and microscopical observations of fungal interactions. *Mycopathologia*, 139: 115–121.

Calvet, C., Pera, J. and Barea, J. M. (1989). Interactions of *Trichoderma* sp. with *Glomus mosseae* and two wilt pathogenic fungi. *Agric. Ecosyst. Environ.*, 29: 59–65

Chet, I. and Inbar, J. (1994). Biological control of fungal pathogens. *Appl. Biochem. Biotechnol*. 48:37-43.

Chet, I., Inbar, J. and Hadar, I. (1997). Fungal antagonists and mycoparasites. p. 165-184. In: The Mycota IV, Environmental and microbial relationships (eds. Wicklow DT, Söderström B) Springer-Verlag, Berlin.

Coombs, E. M., Clark, J. K. Piper, G. L.and Cofrancesco, A. F. (2004). Biological Control of Invasive Plants in the United States. Western Society of Weed Science, Oregon State Univ. Press, Corvallis.

Cullen, J. M., Kable, P. F. and Catt, M. (1973). Epidemic spread of a rust imported for biological control. *Nature* 244: 462-464.

De Faria, M. R. (2009). Studies on entomopathogenic fungi:evaluations of germination protocols for assessing Conidial quality and modified atmosphere packaging for enhancing high-temperature shelf life. A Dissertation Degree of Doctor of Philosophy Presented to the Faculty of the Graduate School of Cornell University.

Eisendle, M., Oberegger, H., Buttinger, R., Illmer, P. and Haas, H. (2004). Biosynthesis and uptake of siderophores is controlled by the PacCmediated ambient-pH regulatory system in *Aspergillus nidulans*. *Euk. Cell*, 3: 561-56.

Emge, R. G., Melching, J. S. and Kingsolver, C. H. (1981). Epidemiology of *Puccinia chondrillina*, a rust pathogen for the biological control of rush skeleton weed in the United States. *Phytopathol*.7: 839-843.

Evans, H. C., Fröhlich, J. and Shamoun S. F. (2001). Biological control of weeds. p. 349-401. In: BioExploitation of Filamentous Fungi (eds. Pointing SB and Hyde KD). Fungal Diversity Press: Hong Kong,

Faria, M. de. and Wraight, S. P. (2001) Biological control of *Bemisia tabaci* with fungi. *Crop Prot*. 20(9): 767–778.

Ferron, P. (1981). Pest control by the fungi Beauveria and Metarhizium. p. 465-482. In: Microbial Control of Insects and Mites (Ed. H. D. Burgess). Academic Press, New York, NY, USA.

Ghisalberti, E. L. (2002). Anti-Infective Agents Produced by the Hyphomycetes Genera Trichoderma and Gliocladium. Current Medicinal Chemistry - Anti-Infective Agents. 1: 343-374. 10.2174/1568012023354695.

Ghisalberti, E. L. (2002). Anti-infective agents produced by the Hyphomycetes genera Trichoderma and Gliocladium. Curr. Med. Chem. *Anti-Infect.Agents*, 1: 343–374.

Hajek, A. E. and Leger, R. J. (1994). Interactions between fungal pathogens and insect hosts. *Annu. Rev. Entomol.*, 39: 293–32.

Hamlen, R. A. (1979). "Biological control of insects and mites on European greenhouse crops: research and commercial implementation." Proce. Florida State Hort. Soci., 92: 367–368.

Harman, G. E., Howell, C. R., Viterbo, A., Chet, I. and Lorito, M. (2004). *Trichoderma* species opportunistic, a virulent plant symbionts. *Nat. Rev. Microbiol.*, 2: 43–56.

Hasan, S. (1972). Specificity and host specialization of *Puccinia chondrillina*. *Ann. Appl. Biol*. 72:257-263.

Hasan, S. and Wapshere, A. J. (1973). The biology of *Puccinia chondrillina*, a potential biological control agent of skeleton weed. *Ann. Appl. Biol.*, 74: 325–332.

Ignoffo, C. M. (1981). "The fungus *Nomuraea rileyi* as a microbial insecticide. p. 513-538. In: Microbial Control of Pests and Plant Diseases (Ed. H. D. Burges). Academic Press, London, UK.

Inbar, J., Menendez, A. and Chet, I. (1996). Hyphal interaction between *Trichoderma harzianum* and *Sclerotinia sclerotiorum* and its role in biological control. *Soil Biol. Biochem.* 28: 757–763.

Jain, N., Rana, I. S., Kanojiya, A. and Sandhu, S. S. (2008). Characterization of *Beaveria bassianas* strains based on protease and lipase activity and their role in pathogenicity. *J. Basic Appl. Mycol.*, I-II: 18–22.

Jyoti, S. and Singh, D. P. (2017). Fungi as biocontrol agents in sustainable agriculture. p. 344. In: Microbes and Environmental Management. Jyoti, S. and Singh, D. P. (eds.). Studium Press, New Delhi, India.

Kendrick, M. (2000). The Fifth Kingdom, 3rd ed. Mycologue Publications, Sidney, Australia.

Kerry, B. R., Crumph, D. and Mullen, A. (1982). Studies of the cereal cyst nematode, *Heterodera* avenue under continuous cereals 1975–1978. II. Fungal parasitism of nematode females and eggs. *Ann. Appl. Biol.*, 100: 489–499.

Kim, J. J., Lee, M. H., Yoon, C.S., Kim, H. S., Yoo, J. K and Kim, K. C (2002). Control of cotton aphid and greenhouse whitefly with a fungal pathogen, *J. Nat. Institute Agric. Sci. Technol*., 7–14.

Kiss, L. (2003). A review of fungal antagonists of powdery mildews and their potential as biocontrol agents. *Pest Manag., Sci.*, 59: 475–483.

Lewis, J. A and Papavizas, G. C. (1991). Biocontrol of plant diseases: the approach for tomorrow. *Crop Prot.*10: 95–105.

Lindsay, W. L. (1979). Chemical Equilibria in Soils. John Wiley and Sons, Inc., New York.

Lo, C. T. (1997). Biological control of turfgrass diseases using *Trichoderma harzanium*. *Plant Pro. Bull.* 39: 207–225.

Lord, J.C. (2005). From Metchnikoff to Monsanto and beyond: the path of microbial control. *Journal of Invertebrate Pathology*, 89: 19-29.

Mathew, S. O., Sandhu, S. S. and Rajak, R..C (1998). Bioactivity of *Nomuraea rileyi* against *Spilosoma obliqua*: effect of dosage, temperature and relative humidity. *J. Indian Bot. Soci*. 77: 23–25.

McCaffery, J. P., Piper, G. L., Callihan, R. L. and Coombs, E. M. (1996). Collection and redistribution of biological control agents of rush skeletonweed. University of Idaho Extension Publications. Bulletin 782.

McCoy, C.W. (1986). Factors governing the efficacy of *Hirsutella thompsonii* in the field. p. 171-174. In: Samson, R.A., Vlak, J.M., Peter, D. (Eds.), Fundamental and Applied Aspects of Invertebrate Pathology.

Foundation of the Fourth International Colloquium of Invertebrate Pathology. Wageningen, The Netherlands.

McFadyen C. R .E. (1998). Biological control of weeds. *Annu. Rev. Entomol*.43: 369393.

Mcleod, D.M. (1954). Investigations on the genera *Beauveria Vuill* and *Tritirachium Limber*, Can. *J. Bot.,* 32: 818–890.

McNeil, D. G. Jr. (2005). Fungus fatal to mosquito may aid global war on malaria," The New York Times.

Menendez, A. B and Godeas, A. (1998). Biological control of *Sclerotinia sclerotiorum* attacking soybean plants. Degradation of the cell walls of this pathogen by *Trichoderma harzianum* (BAFC 742). *Mycopathologia*, 142: 153–160.

Naseby, D. C., Pascual, J. A. and Lynch, J. M. (2000) Effect of bio-control strains of *Trichoderma* on plant growth, Pythiumultimum populations, soil microbial communities and soil enzyme activities. *J. Appl. Microbiol.,* 88: 161–169.

Nunez, E., Iannacone, J. and G´omez, H. (2008). Effect of two entomopathogenic fungi in controlling *Aleurodicus cocois* (Curtis, 1846) *Hemiptera: Aleyrodidae*. *Chilean J. Agric. Res*. 68(1): 21–30.

Oehrens, E. B and Gonzalez, S. M. (1977). Dispersion, ciclo Biologico y danos causdos por *Phragmidium violaceum* (Schulz) Winter en zarzamora (*Rubus constrictus* Lef. et M. y *R. ulmifolius Schott*.). '*Agro Sur' (Chile)* 5: 73–85.

Prajapati, S., Kumar, N., Kumar, S., Iakharan, L., Maurya, S. (2020). Biological control a sustainable approach for plant disease management: A review. *J. Pharmacogn. Phytochem* 9: 1514–1523.

Sandhu, S. S and Mishra, M. (1994). Larvicidal activity of fungal isolates *Beaveria bassiana, Metarhizium anisopliae* and *Aspergillus flavus* against mosquito sp. *Culex pipiens*. pp. 145–150. In Proceedings of the National Symposium on Advances in Biological Control of Insect Pests, Muzaffarnagar, India.

Sandhu, S. S. Rajak, R. C. and Hasija, S. K. (2000). Potential of entomo pathogens for the Biological management of medically important pest: progress and prospect. *Glimpses Plant Sci*. 2000: 110–117.

Sandhu, S. S., Rajak, R. C. and Agarwal, G. P. (1993). Studies on prolonged storage of B*eauveria bassiana* conidia: effects of temperature and relative humidity on conidial *via*bility and virulence against chickpea borer *Helicoverpa armigera*. *Biocont. Sci. Technol.* 3: 47–53.

Sandhu, S. S., Unkles S. E., Rajak, R.C. and Kinghorn, J. R. (2001). Generation of benomyl resistant *Beauveria bassiana* strains and their infectivity against *Helicoverpa armigera*. Biocont. *Sci. Technol.,* 11(2): 245–250.

Scheepens, P. C and Hoogerbrugge, A. (1989). Control of *Prunus serotina* in forests with the endetnic fungus *Chondrostereum purpureum*. Proceedings of the VIIth International Symposium on the Biological Control of Weed (Ed. Delfosse ES). Rome, 1988, pp. 545-552.

Schirmbock, M., Lorito, M., Wang. Y. L., Hayes, C. K., Arisan, A. I, Scala, F., Harman, G. E. and Kubicek, C. P. (1994). Parallel formation and synergism of hydrolytic enzymes and peptaibol antibiotics, molecular mechanisms involved in the antagonistic action of *Trichoderma harzianum* against phytopathogenic fungi. pp. 4364–4370.

Sivan, A. and Chet, I. (1993). Integrated control of *Fusarium* crown and root rot of tomato with *Trichoderma harzianum* in combination with methyl bromide or soil solarization. *Crop Prot*.12: 380– 386.

Smith, R. J. Jr., Daniel, J. T., Fox, W. T. and Templeton, G. E. (1973). Distribution in Arkanas of a fungus disease used for biocontrol of northern jointvetch in rice. *Plant Disease Reporter*, 57: 695-697.

Supkoff, D. M., Joley, D. B. and Marois, J. J. (1988). Effect of introduced biological control organisms on the density of *Chondrilla juncea* in California. *J. Appl. Ecol*., 25: 1089– 1095.

Szekeres, A., Leitgeb, B., Kredics, L., Zsuzsanna, A., Hatvani, L., Manczinger, L. and Vagvolgyi C. (2005). Peptaibols and related peptaibiotics of *Trichoderma*. *Acta Microbiol. Immunol. Hung*. 52: 137–168.

Thakur, R. and Sandhu, S. S. (2010). Distribution, occurrence and natural invertebrate hosts of indigenous entomopathogenic fungi of Central India. *Ind. J. Microbiol*., 50(1): 89– 96.

Thakur, R., Rajak, R. C., and Sandhu, S. S. (2005). Biochemical and molecular characteristics of indigenous strains of the entomopathogenic fungus *Beauveria bassiana* of Central India, *Biocont. Sci. Technol.,* 15(7): 733–744.

Tjamos, E. C., Papavizas, G. C., and Cook, R. J. (1992). Biological control of plant diseases. Progress and challenges for the future (eds.). Plenum Press, New York.

Tomley, J. A and Evans, H. C. (2004). Establishment of, and preliminary impact studies on, the rust, *Maravalia cryptostegiae*, of the invasive alien weed, *Cryptostegia grandiflorain* Queensland. *Australia Plant Pathol.,* 53: 475–484.

TrujIllo, E. E. (1985). Biological control of hamakua pa-makani with *Cercosporella* sp. in Hawaii. Proceedings of the VI th International Symposium on the Biological Control of Weeds Vancouver, 1984 (Ed. Delfosse ES). Agriculture Canada, Ottawa, pp. 661-671.

Verma, M., Brar, S. K., Tyagi, R. D., Surampalli, R. Y. and Valéro, J. R. (2007). Antagonistic fungi, Trichoderma spp.: Panoply of biological control. *Biochemical Engineering Journal*, 37(1): 1-20.

Waage, J. K. and Greathead, D. J. (1988). Biological control: Challenges and opportunities. Philosophical Transactions of the Royal Society, London, 318: 111–128.

Walker, H. (1980). Spurred anoda (*Anoda cristata* L. Schlecht) bio-control with a plant pathogen. Proc. *Southern Weed Sci. Soci*., 33: 65.

Walker, H. L. and Sciumbato, G. L. (1979). Evaluation of *Alternaria macrospora* as a potential biocontrol agent for spurred anoda (*Anoda cristata*): host range studies. *Weed Sci.,* 27: 612–614.

Wapshere A. P., Caresche, L. and Hasan, S. (1976). The ecology of *Chondrilla juncea* in the eastern Mediterranean. *J. Appl. Ecol.,* 13: 545–553.

Watson, A. K. (1991). The classical approach with plant pathogens. p. 3–23. *In*: Microbial Control of Weeds (ed. TeBeest DO).Chapman and Hall, New York.

Wraight, S. P., Carruthers, R. I., Jaronski, S. T., Bradley, C. A., Garza, C. J. and Galaini-Wraight, S. (2000). Evaluation of the entomopathogenic fungi *Beauveria bassiana* and *Paecilomyces fumosoroseus* for microbial control of the silver leaf whitefly, *Bemisia argentifolii*. *Biol. Cont.*, 17(3): 203–217.

Zeilinger, S., Galhaup, C., Payer, K., Woo, S. L., Mach, R. L., Fekete, C., Lorito, M. and Kubicek, C. P. (1999). Chitinase gene expression during mycoparasitic interaction of *Trichoderma harzianum* with its host. *Fungal Genet. Biol*., 26: 131–140.

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EFFECTS OF HERDSMEN ACTIVITIES ON CASSAVA PRODUCTION IN YEWA NORTH LOCAL GOVERNMENT AREA, OGUN STATE NIGERIA

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ABSTRACT
Violent clashes between Fulani herdsmen and farmers are common in South-west, Nigeria. This may cause declined agricultural production resulting in food insecurity. This study therefore examined the effects of herdsmen activities on cassava production in Yewa North Local Government Area, Ogun State, Nigeria. Simple random sampling technique was used in selecting 103 registered crop farmers in the study area. Primary data were obtained through the use of a well-structured questionnaire. Data were analyzed using frequency counts, percentages, mean and Student-t test. Results revealed that the mean age, household size, annual income and farming experience of the respondents were 58.54 years, 6 person, ₦ 58592.23k and 26.07 years respectively. Majority (75.7%) of the respondents were male, 83.5% were married, 67.0% were Christian while 33.0% had no formal education. Also, 51.5% were in cooperative society while 72.8% indicated that farming is their primary occupation. The major arable crops grown were cassava (100.0%) and maize (89.3%), high destruction of crops (x = 2.92), destruction of properties (x = 2.89), and kidnapping (x = 2.82) as the major activities of herdsmen in the study area. Furthermore, the mean cassava produced before and after the herdsmen were 5 and 3 tonnes respectively. Student t-test revealed a significant difference in cassava production (t =7.557, $p \leq 0.05$), prices of crop sold (t =8.881, $p \leq 0.05$) before and after the herdsmen activities. The study concluded that the activities of herdsmen had negative effect on the crop farmer in the study area. Therefore, the study recommended that peace building mechanism should be implemented to resolve the conflict between the cassava farmers and herdsmen in the study area.

Key words: *Farmers; Farmers; Conflict; Food security*

INTRODUCTION

Agriculture is a major livelihood activity and pillar to the development of global economy in term of huge contribution to nation's food security, national gross development products (GDP), primary source of raw materials to industry and foreign exchange earnings, especially in sub-Saharan African (SSA) countries like Nigeria (Food and Agriculture Organization-FAO, 2015; Amao *et al*.,2018 and Sasu, 2022). Livestock plays very vital and multiple roles in the livelihood of people, these includes: food supply, family nutrition, source of incomes, livelihoods, coping strategies, draught animal power, manure and sustainable land use for agricultural production (Herrero *et al.*, 2010; Pell *et al.*, 2010; World Bank, 2012). Herders' immigration has been in existence in Southwestern Nigeria over 5 decades and tremendously increased due to greener pastures to feed their herds for meat and leather production (Sodiya, 2005; Fabusoro, 2006). Some factors influence that movement of the herders to southwest, Nigeria due to the greener pastures and friendly environment, however, this movement has resulted to violent clashes between farmers and herders (Abugu*et al*.,2022). Finding has shown that open grazing is most common methods of feeding herds in the developing countries due high cost of feeds (pasture, hay, concentrate and silage etc.) and medication. This destroyed crops and caused conflicts which results to human death, economic activities halted, declination of economic values, migration from the community, women raped, children molested or abused, destruction of valuable properties and food insecurity (Ogboru and Adejonwo-Osho 2018). Finding revealed that more than 35% of the agricultural land use conflicts were between farmers and herdsmen (Fasona and Omojola, 2005). The identified major causes of the agricultural conflict are competition for natural resources and limited assets. The clashes generated violent, unstable, unhealthy and uncomfortable environment and reduce the food

production (Adekunle and Adisa, 2010). The roots of farmer-herder conflicts were reflection of many independent or combinations of underlying historical, political, economic and environmental competition (Karayu, 2017; Ogboru and Adejonwo-Osho 2018). According to Brottem (2021) revealed that the fatalities data in 2018 was twice of 2010, this implies that there was an increase in death, destruction of infrastructural facilities and economic backwardness in the Nigeria. Furthermore, this part of the country is still experiencing farmer-herdsmen conflicts that have been resulted to community unrest, panics, homelessness, theft and joblessness of great proportions among several ethnic and religious communities across the states. Abbass, (2012) as well as Popoola, (2020) reported that farmers-herdsmen conflicts are most significant variable with land related issues accounting to rural development, that bring down the economic activities, increase security hazard, obstruct peace and national food insecurity especially in the southwestern Nigeria. This have disrupted the coexistence of peace and cordiality between farmers and herders in Yewa Local Government Area have led to unbearable setback on their entrepreneurial or economic practice and increase the poverty rate among people in the study area. Therefore, the study examined the effects of herdsmen activities on arable crop production in Yewa North Local Government Area. It specifically sought to:

i. ascertain the socio-economic characteristics of the respondents in the study area;
ii. identify the arable crops grown in the study area;
iii. identify the activities of herdsmen in the study area; and
iv. determine the cassava production before and after the attack in the study area

Hypotheses

The following null hypotheses of the study were tested as follows:

$H_{o1:}$ There is no significant difference in cassava production before and after herdsmen activities.

$H_{02:}$ There is no significant difference in price of cassava production before and after herdsmen activities.

Justification

Several literatures revealed the low productivity of cassava production in the study area was due to emergence of herdsmen activities which resulted food insecurity, increase the poverty level among the cassava farmers, scarcity of cassava (food) and migration from the agrarian environment to non-agrarian environment (Dimelu*et al.,* 2017;Alao*et al.,* 2019; Udosen, 2021). This awkward emergence has led to increase in price of farm produce gotten from the farm after harvesting causing a drastic reduction in food security. A situation whereby there is no much food in circulation and people struggle to get food for their healthy lives. The activities of herdsmen are one of the major challenges toward nation's food security, however this study identified the major activities of herdsmen activities and suggested on the possible solutions to solve the conflict between cassava farmers and herdsmen in order to boost the food security and improve the well-beings of the households. This serves as an impetus to this study to consider herdsmen/farmers violence and its effect on cassava production and finding indicated Nigeria was ranked 84th out of 119 sampled in respect to food security (Global Hunger Index, 2017). Hence, Nigeria is still experiencing food security due to herdsmen/farmer's conflict (Udosen, 2021).

This study is crucial for appropriate responses and invention by stakeholders, Furthermore, this study will be a lime light to further areas of studies such as determine the coping strategieson herdsmen attacks among the cassava farmers in the study areas, determine the possible solutions to herdsmen attacks on cassava production, examine the effect livelihood diversification of cassava farmers on household food security and determine the livelihood outcome of herdsmen attack on cassava production.

METHODOLOGY

The study was conducted in Yewa Local Government Area (LGA) of Ogun state with the headquarter in Ayetoro. It covers a land mass area of 2043.60sq kilometer. It has border communities bounded by Republic of Benin (National Population Commission, 2006). The inhabitants were mostly Yewa-Awori people, but home to diverse people from various works of life and ethnic nationalities. They are predominantly farmers, most crop cultivated are cassava, maize, vegetable and cash. The study population consists of all arable crop farmers, simple random sampling technique was used to select 103 registered crop farmers in the study area. Primary data were collected with the aid of interviewed guide and analyzed using frequency counts, percentages, means and inferential

statistics (Binary and multiple regression). Age, household size, farming experience and income of the respondents were measured at interval level. Sex, marital status, occupation and religion were measured at nominal level. educational status of the respondents was measured at ordinal level. identify the arable crops were measured in nominal level, identify the herdsmen activities were measured in ordinal level, using 3 points likerts type scale as very often (2), often (1) and not often (0) and grand mean was calculated by summing the activities mean diving by number of activities. examine the level of arable productions were measured in interval level and ascertain the effect level of herder's activities were measured at ordinal level using 5 points likerts, type scale. Strongly agree (SA), Agree (A), Undecided (U), Disagree (D), Strongly disagree (SD) with 5, 4, 3,2,1 respectively.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents: The result in Table 1 shows that majority (75.7%) of the arable crop-farmers were male, this implies that agricultural production is highly labourintensive, very tedious and believed that the on-farm activities (clearing, weeding) are mainly for male. The nature of the activities requires much physical exertion of energy and strength. This result is in line with the findings of Adisa (2012) who reported that majority of the crop farmers in Kwara State respectively were male. The mean age of the arable crop farmers were 59 years with few (35.0%) of the respondents fell between the ages of 51-60 years**.** This implies that the arable crop-farmers were within their active of economic and productive age. They could have the strength and traditional knowledge or skills to avoid the herdsmen from entering the farmland. This result is in line with the findings of Olusanya *et al.* (2014) and Ogunleye *et al.* (2021) who reported that majority of the arable crop farmers in Ogun State were within the ages of 40-60 years. Most (83.5%) of the respondents were married with average household size of 6 persons. This revealed that most of the respondents were within the marriage age. Literatures reveals that marriage has positive relationship with crop production, this refers that married household head could have higher chances to promote food security than single (Haliu and Regassa, 2007; Aidoo *et al*., 2013). Household size had a significant relationship with food security status. This implies that the larger household's size, the higher chances of being food secure through production than households with smaller sizes. This result is in line with the finding of Olukoya*et al.*, (2014); Leza and Kuma (2015) that reported that majority of the arable crop farmers in Kwara States were married and the crop farmers have large household size. Furthermore, the respondents in the study area had relatively high number of household members and this may enhance the availability of family labor in farming and boost their income.

In addition, the finding reveals that few (33.0%) of the respondents had no formal education, this implies that majority of the farmers area were illiterate. Moreover, this could affect the attitude and conflict behavior of respondents due to differences in belief and value system. This result is in line with the findings of Raufu*et al.*(2018) reported that majority of crop farmers in Oyo State were illiterate, also Adisa and Akunle (2010) reported that majority of arable crop farmers in the rural area had no formal education. Above half (51.5%) of the respondents were members in co-operative society, this implies that most of the farmers belong to one or different cooperatives societies for assistance or improve their livelihood outcome. This could provide an avenue for the farmers to access credit/loan from the association and also provides support to them. This result corroborates the findings of Raufu*et al.* (2018) who reported that majority of crop farmers in Oyo State were member of one association or the other.

Furthermore, mean years of farming experience of arable crop-farmers was 26 years, less than half (42.7%) had 21-32 years of experience. This implies that the respondents had been into arable crop production for longer period of time, this means they were expertise in producing arable crops and they are expected to be knowledgeable in arable crop production. This result is in line with the findings of Adisa (2012) who reported that majority of the arable crop farmers in Kwara State had average of 20 years of farming experience. Most (67.0%) of the arable crop-farmers were Christians, this infers that the respondents in the study area were dominated with Christianity. This implies that religious institution plays a vital role on belief, knowledge on peace and outcome of war or conflict. Lack of knowledge is one of the greatest threats to peace, economic, social and political development, thus result to national

insecurity. The finding is in line with Jegede (2019) and Richard (2012) that religion is an institution that play dominant role in conflict resolution. Furthermore, the result agreed with the finding of Adisa (2012) that majority of arable crop farmers in Kwara State were Christian and Muslim religion. The finding reveals that above half (51.5%) of the respondents were members in co-operative society and few (31.1%) of the respondents were in different association in the study area. This implies that arable crop farmers were members of cooperative societies and various association for different benefits or purposes, also to improve their livelihood outcomes and to able to meet the daily needs of the household. More so, the respondents could have social affiliation within their societies. This assists the farmers to access credit/loan, accomplish task and get supports from cooperative societies or association. The result corroborates with the findings of Raufu *et al.,* (2018) who reported that majority of arable crop farmers were members in the agricultural producing cooperative societies and in different association in Oyo State. Above the average (58.3%) of the respondents earned between ₦ 45001 and ₦90000 with the monthly mean income of ₦58,592.23k. The monthly income of the respondents could be possible based on the different types of arable crops cultivated and duration of the harvest. Furthermore, majority of the arable crop farmers diversified to other productive activities and economic portfolios like artisans, daily animal farm labourers, daily non-farm labourers, petty traders, okada riders (Aidoo*et al*., 2013). The result support the finding of Oti (2017) that crop farmers in Enugu earned more than ₦ 30,000 farmers diversified their livelihood activities due to farmer-herdsmen conflict. Majority (72.8%) engaged in farming as their primary occupation. This is an indication that disruption of farming activities can encourage diversification to other means of livelihood, hence reducing the amount of people producing food for the populace

Types of Arable Crop(s) Grown: Result in Table 2 show the types of arable crop(s) grown in the study area. Findings revealed that major arable crop grown in the study area were; cassava (100.0), and maize (89.3%). This implies that the aforementioned arable crops were the most prominent arable crop grown by the respondents in the study area. Cassava is the predominant crop in the study area against other arable crops cultivated. Globally ,maize occupies a prominent position in foreign exchange earnings and vital commodity for man, animal and industrial purposes. Each component of the plant is valuable to its cultivator. The products and bye- products are typically processed for human, livestock supplement and industrial consumption. Also, it has high resistance to climate variation, possess greater profit return value to the national economic than other arable crops, less technical knowledge on production, increased level of agro-biodiversity and promote food security. In addition, farmers' relative abundance of maize varieties in the farmers' fields may be to meet their daily needs by improving production, increasing their income, promote the economic value, boost GDP and improve the livelihood of the household in the study area. This result corroborates with several literatures indicated that cassava and maize are mostly grown in Ogun State especially Yewa Local Government Area. (Iyanda *et al*. 2014; Omoregbeeand Banmeke 2014; Obayelu *et al*. 2014; Adeleye *et al.* 2020).

Activities of herdsmen in the study area: The result in table 3 reveals the activities of the herdsmen during attack. The findings indicated that high destruction of crops, destruction of properties and kidnapping as 2.92, 2.89, 2.82, respectively were the major activities of the herdsmen in the study area. This implies that the activities reduce the standard of living, reduction of population of the people and promote food insecurity. The result agreed with the findings of Obaniyi*et al.,* (2020); Bello and Abdullahi, (2021) that the major herdsmen activities in Anka and Maradun Local Government Area of Zamfara State were damage of crops, stealing of farm produce, threat to the safety and security of the people.

Level of cassava production before and after the attack: Table 4 shows the level of arable crop production before and after the herder attack in the study area, the finding shows that the mean cultivable land both before (**x** =2.45ha) and after (**x** =2.03 ha), this indicated that there was decrease in the cultivable land in the study area. This could be due to such as high destruction of crops, destruction of properties and kidnapping and this may discourage the farmers to boost cassava production. This could have negative effects in the farmland and production, resulting to food insecurity, increase poverty level among farmers and negatively affect the livelihood of the farmers in the study area. Generally, the arable crop farmers in the

study area were small scale farmers. This is in line with the findings of Mgbenka*et al.* (2016); Babagana *et al.* (2019) and Ogunleye *et al, (*2021) who reported that most of the farmers in Nigeria were small scale farmers and crop production are greatly affected by the conflicts and could be a threat to food security. Furthermore, the result in Table 4 reveals that cassava produced and cassava sold after herdsmen attack(**x**=3 tonnes and 2 tonnes) respectively decreased compared to produced and cassava sold before herdsmen attack (**x** = 5 tonnes and 4 tonnes) respectively. The finding reveals that reduction of cultivable land for cassava production, destruction of cassava plant on farm by cattle, herdsmen activities and inflation of farm inputs. The herdsmen activities on the cassava farm helps farmers to shift their production from cassava to other arable crops such as maize, Amaranthus, Celeosia, melon etc.This implies that as the cassava production increase, the sale of the produces will increase and vice-versa, but according to this result, reduction of cassava production could be a threat to food security and also contribute negatively to livelihood of the farmers in the study area. Furthermore, the finding revealed that cassava farmers in the study area do not sell one tonne out of their cassava production, this could be used by adding value to it through processing and transforming it to other products (cassava, fufu, boiled cassava, cassava chips or juice) either for sale or household consumption. In addition, the mean of price crop sold before and after the attack were ₦550000.56k and ₦400203.34k respectively. This implies herder attack have negative impact on price of crop, this could be due to some factors which were decrease of cultivable land, decrease in crop production and herdsmen activities. Herdsmen attack result to loss of income, which make it difficult for the farmers to continue or re-invest into crop production, hence reduced amount of food available and aid livelihood diversification. This result agreed with the finding of Ogunleye *et al., (*2021) that herdsmen attack on crops result to loss of revenue, income and crops.

Test of difference in cassava production before and after herdsmen activities: The result in Table 5 reveals that there is significant difference (t =7.557, p≤0.05) in cassava production before and after the herdsmen activities. This implies that the herdsmen activities had negative effect on cassava production leading to low productivity of farm produce, which reduce food security and increase the poverty among the famers and reduce standard of living in the study area. This finding is in line with Olli *et al.* (2018) on their opinion assert that quest for production and preservation of secured economic source of livelihood appear to be the bane of continued conflict between herdsmen and farmers and result to fall in crop production which lead to food insecurity. Also, Popoola (2020) who posited that herdsmen- farmers' conflicts have pose serious challenge on agricultural activities that bring down the economic activities, increase security hazard, obstruct peace and national food insecurity especially in the southwestern Nigeria.

Test of difference in prices of crops sold before and after herdsmen activities: The result in Table 6 reveals that there is significant difference (t =8.881, p≤0.05,) in prices of crop sold before and after herdsmen activities. This shows that the activities of the herdsmen had adverse effect on the price of cassava crop sold. This implies that activities of herdsmen reduces farmers income on cassava production, this could have effect on their household livelihood. They may not able to carter for the household needs as before the herdsmen activities and this may leads to livelihood diversification to avoid be vulnerable.

CONCLUSION AND RECOMMENDATION

The study concluded that the crops grown by the farmers' asides cassava were maize, amaranthus and celosia while the major activities of the herdsmen were destruction of crops, properties and kidnapping which has led to reduction of cultivated cassava land which resulted to low cassava production and decrease the price of cassava. In general, the study revealed that there are significant differences in cassava production and price before and after the herdsmen activities. Therefore, the study recommended that peace building mechanism should be implemented to resolve the conflict between the cassava farmers and herdsmen in the study area.

REFERENCES

Abbas, I. (2012). No Retreat, No Surrender: Conflict for Survival Between the Fulani Pastoralist and Farmers in Northern Nigeria. *European Scientific Journal* 8(1): 331-346.

Abugu, N.A., Oliatan, O.M., Awaisu, A. H.&Bello, Y.A. (2022). Determinant factors of resourcesconflict between farmers and

herdsmen in Benue State, Nigeria. *Global Journal of Social Science.*Vol.21(1): 1-10.

Adisa, S., R. (2012).An empirical phenomenological psychological study of farmer-herdsmen conflicts in North-Central Nigeria. *Journal of Alternative Perspectives in the Social Sciences*, 2(1), 1-27.

Adeleye, N., Osabuohien, E., Adeogun, S., Fashola, S., Tasie, O. & Adeyemi, G. (2020). Access to Land and Food Security: Analysis of 'Priority Crops' Production in Ogun State Nigeria,in, Osabuohien. E (Ed.) The Palgrave Handbook of Agricultural and Rural Development in Africa (pp. 291-311).

Adekunle, O. A &Adisa, R. S. (2010). Farmer-Herdsmen Conflicts: A Factor Analysis of Socio-economic Conflict Variables among Arable Crop Farmers in North Central Nigeria. *Journal of Human Ecology*, 30(1): 1–9.

Aidoo, R., Mensah, J. O., &Tuffour, T. (2013). Determinants of household food security in the Sekyere-Afram

Plains District of Ghana. Proceedings of the 1st Annual International Interdisciplinary Conference held from 24- 26 April in Azores, Portugal.

Alao, D.O, Shaibume, B., Ogunwemimo, T.A., Alao, E.M. & Ogunwemimo, O. (2019).Herdsmen/Native Farmers' violence in Benue State and Food security in Nigeria. *Mediterranean Journal of Social Science,* 10 (6): 38-48

Audu, S. (2014). Freshwater Scarcity: A Threat to Peaceful Co-Existence Between Farmers and Pastoralists in Northern Nigeria. *International Journal of Development and Sustainability* 3(1): 242-251.

Bello, A. (2013). Herdsmen and Farmers' Conflicts in North-Eastern Nigeria: Causes, Repercussions and Resolutions. *Academic Journal of Interdisciplinary Studies* 2(5): 129-139.

Brottem, L. (2021). The growing complexity of farmer-herder conflict in West and Central Africa. Africa Center for strategic studies. Africa secuirty brief Number 39. Washington DC 20319-5066.

David, O.A., (2016). How to resolve herdsmen crisis – Nigerian Working Group. Retrieved from https://www.premiumtimesng.com/news/top-news/255364-resolve-herdsmen-crisis-nigerian-working-group.htm, accessed on 22nd May, 2022.

Dimelu, M.U., Danjuma, S.E., Mbolle, C.J., Achonam, E.I &Mbadiwe, I.E. (2017). Livelihood issue in herdsmen-farmers conflict among farming communities in Kogi State, Nigeria *Africa Journal of Agricultural Research*, 12 (24): 2105-2120

Fasona, M. J. and Omojola, A. S. (2005). "Climate Change, Human Security and Communal Clashes in Nigeria." Paper at International Workshop in Human Security and Climate change, Holmen Fjord Hotel, Oslo Oct. 21- 23, 2005. Pp. 3-13.

Food and Agriculture Organization-FAO., (2015). Regional overview of food insecurity: Africanfood security prospects brighter than ever. Accra: FAO. ISBN 978-92-5-108781-7.

Fabusoro, E. and Sodiya, C.I. (2014). Institutions for collective Action among settled Fulani Agro-Pastoralists in South West, Nigeria. *Journal of Agricultural Education and Extension*. 17(1):53-58.

Hailu, A. and Regassa, N. (2007). Correlates of household food security in densely populated areas of Southern Ethiopia: Does the household structure matter? Department of Rural Development and Family Sciences, Hawassa University, Ethiopia.

Iyanda, J.O., Afolami, C.A., Obayelu, A.E., and Ladebo, O.J. (2014). Social capital and access to creditamong cassava farming households in Ogun State, Nigeria. *Journal of Agricultural Environment Science*. Vol 3:175–196.

Jegede, O.P., (2019). Implication of religious conflicts on peace, national security and development in Nigeria. *Ilorin Journal of Religious Studies*, Vol. 9(1): 53-70

Karayu, D. (2017). Land Tenure System in Pastoralist Societies: Findings of a Study tour to Peru.in: Ndiaga G.N. edition. Sustainable Pastoralism and Rangelands in Africa. Food and Agriculture Organization of the United Nations, 31, 29.

Leza, T., & Kuma, B. (2015). Determinants of rural farm household food security in Boloso Sore District of Wolaita Zone in *Ethiopia. Asian Journal of Agricultural extension, Economics and Sociology*, 5(2), 57-68.

Mc Gregor, A. (2014). Alleged Connection Between Boko Haram and Nigeria's Fulani Herdsmen Could Spark a Nigerian Civil War. *Terrorism Monitor* 12(10): 8-10.

National Population Commission, (2006). National population estimate. Federal Republic of Nigeria official Gazette 94 (24).

NISER, (2019). Strategies for Resolving Conflict between Farmers and Herdsmen in Nigeria. By Hakeem, O. T. Political and Governance Policy Department, Nigerian Institute of Social and Economic Research, Ibadan.

Obayelu, A.E., Olarewaju, T.O. &Oyelami, N.L. (2014). Effect of rural infrastructure on profitability and productivity of cassava-based farms. *Journal of Agricultural Science* Vol. 59:187–200.

OgboruT.and Adejonwo-Osho O. (2018): Towards an Effective Cattle Grazing and Rearing Legal Framework: An Imperative for Environmental Protection.

Ogunyemi, O., (2019). Farmers and Herdsmen crisis: A major threat to food production in Nigeria. (A case study of Yewa North Local Government Areain Ogun State). 1st National Conference of Women in Technical Education and Development programme (WITED), Ilaro Chapter, The Federal Polytechnic Ilaro, August 13-16th, 2019, pp. 259-266.

Oli, N.P., Ibekwe, C.C., Nwankwo, I.U. (2018.) Prevalence of herdsmen and farmers conflict in Nigeria, *International Journal of Innovative Studies in Sociological and Humanities* 3(1), 30-39

Oluwole, A. (2021). Special report: Farmers-Herders Conflict: After many deaths, Ondo residents, Official sseek relief under anti-open grazing law. Premium Newspaper, Nigeria. https://www. premiumtimesng. com/regional/ ssouth-west/50282.html.Accessed on 21st May, 2022.

Omoregbee, F.E.and Banmeke, T.O.A. (2014). I nformation needs of cassava farmers in Delta State of Nigeria. Tanzania. *Journal of Agricultural Science*. Vol. 12:20–25.

Oti, O. G., Onyia, C. C. and Umoinyang, M. E. (2017). Effects of Farmers Herdsmen Conflicts on the Food Security Status of Farming Households in Enugu State, Nigeria. *CARD International Journal of Agricultural Research and Food Production* (IJARFP) Vol. 2 (3): Number 3:97-108. ISSN: 2536-7293 (Print): 2536-7307 (Online).

Popoola M., Aimah, A. N.and Olawale, S.M. (2020). Effect of farmers and Herders' conflict on Entrepreneurial practice in southwestern Nigeria. *International Journal on economics, finance and sustainable Development.* ISSN (electronic): 2620-6269/ ISSN (printed): 2615-4021: 74-83.

Richard, A.O., (201)2. Religion, peace and conflict: An Assessment of the role of African Religioustowards conflicts management in Nigeria (edition), in Religion and Governance in Nigeria. Department of Religious studies, University of Ibadan, pp103-104.

Sasu, D.D., (2022). Contribution of Agriculture to GDP in Nigeria from the 3rd quarter of 2019 tothe 3rd quarter of 2021. Statistics on Agriculture in Nigeria. Retrieved from https:// www. statista.com/ statistics/ 1193506/contribution-of-agriculture-to-gdp-in-Nigeria/, accessed on 10th May, 2021.

Sodiya C.I., (2005). Assessment of agricultural extension services availability and needs in agro-pastoral production system of Ogun State, Nigeria. PhD. Thesis, University of Agriculture, Abeokuta, Ogun State.

Udosen, N.M. (2021). Farmers-Herder's crisis and food security in Nigeria: Causes and implications. *European Journal of Political Science Studies* 5 (1):138-148

Table 1:Socio-economic characteristics of the respondents (n=103)

Socio-economic characteristics	Frequency	%	Mean	SD
Sex				
Male	78	75.7		
Female	25	24.3		
Age (Years)				
37-50	25	24.3		
51-60	36	35.0	58.54	11.08
61-70	22	21.4		
71-80	20	19.4		
Marital Status				
Married	86	83.5		
Separated	7	6.8		
Widowed	10	9.7		
Religion				
Christianity	69	67.0		
Islam	28	27.2		
Traditional	6	5.8		
Educational Status				
No formal education	34	33.0		
Primary education	22	21.4		
Secondary education	29	28.2		
Tertiary education	18	17.5		
Membership				
Association	32	31.1		
Co-operative	53	51.5		
Group	4	3.9		
Religion	10	9.7		
None	4	3.9		
Household size (Person)				
3-6	38	36.9		
6-10	64	62.1	6	2
11-14	1	1.0		
Annual Income(₦)				
20000-45000	33	32.0		
45001-90000	60	58.3	58592.23	23312.63
90001-120000	10	9.7		
Farming experience(years)				
8-20	32	31.1		
21-32	44	42.7	26.07	11.34
33-44	19	18.4		
45-52	8	7.8		
Occupation				
Primary	75	72.8		
Secondary	28	27.2		

Source: Field survey, 2021

Table 2: The types of arable crop(s) grown by the respondent (n=103)

Arable crop Grown	Frequency	%
Maize	92	89.3
Cassava	103	100
Water leaf	13	12.6
Yam	61	59.2
Soybean	2	1.9
Sugarcane	1	1.0
Sugar beet	2	1.9
Amaranthus	91	88.3
Celosia	89	86.4
Pumpkin leaf	3	2.9
Melon	71	68.9

Source: Field survey, 2021

Table 3: Activities of herdsmen on the arable crop farmers (n=103)

Activities of herdsmen	Very Often	Often	Not Often	Mean (x□)	SD
Stealing	46(44.7)	57(55.3)	0(0.0)	2.44	0.49
Destruction of lives	30(29.1)	73(70.9)	0(0.0)	2.29	0.45
Destruction of properties	92(89.3)	11(10.7)	0(0.0)	2.89	0.31
Raping	35(34.0)	68(66.0)	0(0.0)	2.33	0.47
Kidnapping	85(82.5)	18(17.5)	0(0.0)	2.82	0.38
Destruction of crops	95(92.2)	8(7.8)	0(0.0)	2.92	0.26

Source: Field Survey, 2021. Grand mean: 2.60

Table 4: Level of cassava production before and after the attack (n=103)

Variables	(Before attack) Mean	(After attack) Mean
Farmland(ha)	2.45	2.03
cassava produce (tonnes)	5 tonnes	3 tonnes
	4 tonnes	2 tonnes
Cassavasold (tonnes)		
Cassava sold Price	₦550000.56k	(₦)400203.34k

Source: Field survey, 2021.

Table 5: Test of difference in cassava production before and after herdsmen activities

Variable (tonnes)	N	Mean	SD	Mean difference	t-value	df	P-value	Decision
Cassava produced before	103	3.9350	2.89159					
				1.43301	7.557	102	0.000	sig
Cassava produced after	103	2.5019	1.40084					

Table 6: Test of difference in prices of crops sold before and after herdsmen activities

Variable (Price)	N	Mean	SD	Mean difference	t-value	df	P-value	Decision
Cassava sold before	103	316412.6214	107778.90557					
				86000	8.881	102	0.000	sig
Cassava sold after	103	230412.6214	122650.77770					

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CHARACTERIZATION OF THE TWO SPECIES OF *MELOCHIA* L. IN NIGERIA

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ABSTRACT
Melochia corchorifolia L. and *Melochia melissifolia* Benth. have food and medicinal values; however, they are being misidentified. It is therefore necessary to characterize these species comprehensively to establish their taxonomic status. This study employed botanical and cytological parameters to characterize the two Nigerian *Melochia* species following standard methods and it was carried out at the Department of Botany, Obafemi Awolowo University, Ile-Ife, Nigeria between 2020 and 2022. The result showed that *M. corchorifolia* could be distinguished from *M. melissifolia* by its erect and annual habit, numerous, predominantly terminal inflorescences and white petals without pigmentation. *Melochia melissifolia* was procumbent, perennial with a few principally axillary inflorescences, pink flowers with pigmentation on petioles, stem and tip of the fruits. The leaf adaxial stomata type, foliar trichome type, midrib and vascular bundle shapes, presence or absence of starch grain, tylose, brachysclereids, axial parenchyma, and phloem fibre could be used to delimit the two species. They possessed monad, oblate to prolate spheroidal pollen grains with high pollen stainability. In addition, triad pollen was observed in *M. corchorifolia.* Chromosome numbers of 2n=4x=28 and 2n=8x+2=58 were recorded in *M. corchorifolia* and *M. melissifolia* respectively. Both species had high pollen stainability. The germination percentage was high and low in *M. corchorifolia* and *M. melissifolia* respectively. The study revealed many similarities between the two *Melochia* species, indicating their close genetic relationship as well as having a common origin. Nevertheless, the two species could be separated from each other with certain morphological and anatomical characters, chromosome counts and some reproductive parameters. Therefore, the two Nigerian *Melochia* species studied are distinct species from a common ancestor.

Keywords: *Anatomy, Chromosome count, Morphology, Palynology, Reproductive parameters*

INTRODUCTION

The genus *Melochia* L. belongs to the family Malvaceae s.l. based on new evidence from molecular studies (Bayer *et al.,* 1999; Cvet Kovic *et al*., 2021) though it was previously placed in the family, Sterculiaceae (Goldberg, 1967). The genus is from the tribe Hermannieae and it was subdivided into five sections, namely: *Physodium* (K. Presl) Goldberg, *Melochia* L., *Visenia* Schumann, *Mougeotia* Griseb, and *Moluchia* (L. Medicus) Briz (Dorr and Barnett, 1989). However, Section *Moluchia* was stated as *Pyramis* Goldberg by Goldberg (1967). *Melochia* consists of 68 species (Randon, 2009) and the members of the genus are widely distributed in the tropics and sub-tropics with a few recorded in the temperate zones of the world (Martin, 1966). Larger percentage of *Melochia* species described so far is found growing in America, making America seems to be the centre of diversity of *Melochia* species (Goldberg, 1967). *Melochia corchorifolia* is the type species of the genus (Goldberg, 1967). Hutchinson and Dalziel (1952) documented two species in West Tropical Africa while three species were recorded for Africa by Goldberg (1967) out of which he stated that two were endemic to the continent. The members of the genus were reported to be predominantly perennial though annuals have also been reported. They may either be shrub or subshrubs while only a few species were found to be herbs or small trees (Goldberg, 1967). Members of the genus are weeds mostly found on cultivated land, waste land, in open pine land and meadows. They are either found growing in mesophytic or hydrophytic habitats Goldberg (1967). The inflorescence may be terminal or axillary and the flower has a pentacarpelar ovary with five free papillate styles at the apex (Goldberg, 1967; Goncalez and Esteves, 2015; Silveira Junior *et al*., 2015). Stellate trichomes were reported to be common in the genus; other trichomes that have been observed in the genus include glandular, simple and forked trichomes (Goldberg, 1967). Mitra and Maity (2013) reported that trilacunar nodal pattern was diagnostic for the *Melochia* species they studied. Furthermore, the genus is known to be heterostylous which is characteristic of an advance system (Martin, 1966; Goldberg, 1967; Faife-Cabriera *et al.,* 2014; Silveira Junior *et al.,*

2015). Distylous and monomorphic species were said to be self-incompatible and self-compatible respectively (Ramirez and Navarro, 2010). The pollen may be medium or large sized, prolate spheroidal or oblate spheroidal, 3(4) colporate with micro-reticulate to rugulate ornamentation (Silveira Junior *et al.,* 2015). Various basic chromosome numbers ranging from 7, 9, 10, 23 to 27 have been reported in the genus (Dorr and Barnett, 1989).

The leaves of *M. corchofolia* are consumed in the northern part of Nigeria as vegetable and it has high protein content (Umar *et al.,* 2007). The leaves are also cooked as potherbs in some other part of West Africa and it is a popular slimy side-dish in some countries in East Africa and Asia. Furthermore, the leaves, seeds and roots are used in folk medicine in some African and Asian countries for treatment of certain ailments such as dysentery, abdominal swelling, anthelmintic etc. as well as cattle fodder (Batugal *et al*., 2004; Ajaib and Khan, 2010; Pullarah, 2014). Likewise, *M. melissifolia* leaf was reported to serve as food and for treatment of skin infection while the bark fibre is utilised in anti-parasitic products (Burkill, 1985). In Nigeria, two *Melochia* species; *M. corchorifolia* and *M. melissifolia* were recorded by Hutchinson and Dalziel (1952) though Aigbokhan (2014) recorded only *M. corchorifolia* in the southern part of Nigeria. These two species are being used interchangeably and there is paucity of information on these species in Nigeria. Therefore, a comprehensive characterization of these species is necessary in order to ascertain their taxonomic status. The specific objective of this study was to characterize the two *Melochia* species in Nigeria through morphological, anatomical, palynological, cytological, and reproductive biology studies.

MATERIALS AND METHODS

Germplasm collection: Seeds of *Melochia corchorifolia* and *Melochia melissifolia* were collected at Jebba North, Niger State, Nigeria ($09^0$08" N $04^0$50" E) and within the campus, Obafemi Awolowo University, Ile-Ife, Nigeria ($07^0$29" N $04^0$30" E) respectively. The plants were identified and authenticated at the IFE Herbarium, Department of Botany, Obafemi Awolowo University, Ile-Ife, Nigeria. The voucher numbers were then assigned to *M. corchorifolia* and *M. melissifolia* as IFE 18040 and IFE 18041 respectively.

Germination of *Melochia* species studied: Forty seeds from each species were planted. The number of seedlings that emerged after 30 days were recorded and the percentage seed emergence was calculated as shown below. Number of days to seedling emergence as well as life cycle duration was also recorded. The end of life cycle of the plant was marked by the yellowing and drying up of the leaves.

$$Percentage\ seedling\ emergence = Number\ of\ seedlings\ emerged \div Number\ of\ seeds\ planted$$

Morphology of the two *Melochia* species studied: The qualitative morphology characteristics were carefully observed which included the petals, sepals, androecium, gynoecium, seeds, fruits, leaves and stems. The heights of the two plant species at first flowering and senescence were measured with measuring tape.

Anatomical studies: The scrape method of Metcalfe (1960) was used in leaf epidermal studies using razor blade. The epidermal peels of the adaxial and abaxial leaf surface of the two species were preserved in 50% ethanol placed prior to staining. The peels were then stained in 1% aqueous solution of safranin 'O' for 5 minutes, after which it was rinsed in water thrice to remove the excess stain. The stained epidermal peels were mounted on a glass slide in 25% glycerol, the edges of the cover slip were sealed with nail varnish, and the slides were labelled accordingly. Prepared slides were viewed under the light microscope and features such as types of stomata, trichome types, and the features of the epidermal cells of the abaxial and adaxial of the species studied were documented. The transverse section (TS) of the matured leaf as well as the transverse section (TS), Tangential Longitudinal section (TLS), and Radial Longitudinal Section (RLS) of the matured stem of each of the two species were made with a sliding microtome (Reichert, Austria) 20 µm thickness and preserved in 50% ethanol. The different sections for the two species were stained with Safranin 'O' for 5 minutes, rinsed in water thrice and counterstained with Alcian blue for 5 minutes separately. After this, the sections were thoroughly rinsed in water and passed through various grades of ethanol (50%, 70%, 80% and absolute) for dehydration and differentiation according to method used by Akinnubi *et al*. (2016). For wood maceration, the bark (phloem) of the species studied were removed and the

stem wood were cut into tiny pieces using pen knife, boiled in Schutz fluid until soft, rinsed in water, sieved and the preserved in 50% ethanol. The macerates were then stained with Safranin 'O' for 5 minutes, rinsed in water and mounted in 25% glycerol using the technique of Odiye *et al*., (2019). The stained, sections and macerates were mounted in 25% glycerol on cleaned slides and the edges of cover slips were sealed with nail varnish to prevent dehydration. The prepared slides of the leaf epidermis, TS of leaves, wood sections and macerates were observed at x400 magnification using LEICA DN500 binocular light microscope. Tissues, cells and cell inclusions were identified and described according to Metcalfe and Chalk (1979) for foliar anatomical description and International Association of Wood Anatomist (IAWA, 1989) for wood anatomy. Wood characters that were observed were xylem vessel, axial parenchyma, fibre, rays, tylose, secretory duct/canal and crystals. Photomicrographs of the anatomical features were taken using Accu-scope trinocular microscope (ACCU-scope 33001 LED Trinocular microscope with 3.2 MP CMOS digital camera).

Pollen grain studies: The pollen acetolysis was carried out according to Erdtman's method adopted by Azeez *et al.* (2019). Fresh pollen grains from the two *Melochia* species were collected and stored in 70% ethanol in vails separately. The stored samples were crushed with a glass rod and suspended material was sieved into a clean tube using a fine mesh. The alcohol was decanted after the suspension was centrifuged at 1000 rev/ min for 5 minutes. While shaking, 5 cm^3 of glacial acetic acid was added to the residue, centrifuged again, and the supernatant decanted. Six (6) cm^3 of freshly prepared acetolysis mixture (1 sulphuric acid: 9 acetic anhydride) was the added to the residue. The tube was held in a water bath and heated to boiling. The content of the tube was stirred with glass rod, centrifuged and waste acetolysis mixture was decanted. 10 cm^3 of glacial acetic acid was added to the residue, stirred, centrifuged and washed with several changes of distilled water. The acetolysed pollen was stored in 2 cm^2 dilute glycerine. The pollens were mounted in glycerine jelly on clean slides, covered with cover slip and the edges of cover slips were sealed with nail varnish to prevent dehydration.

Pollen grains fertility was estimated from pollens from dehisced anthers, dusted on microscope slides, stained with cotton blue in lactophenol, and scored for stainability at x100 magnification from which percent stainability was calculated. Well formed (round) intact and uniformly stained pollen grains were considered viable while those that were only partially stained or not stained at all, and with collapsed outline were scored as non-viable according to method of Faluyi (1985) used by Azeez (2020). Photomicrographs of the pollen grains were taken at X400 magnification using Accu-scope trinocular microscope.

Mitotic chromosome of the two *Melochia* species studied :The chromosome was studied from root tips collected from seedling immersed in water, harvested and pre-treated in 0.002 M of 8-hydroxyl quinoline for 2-3 hours. After that, the roots were transferred into vials containing fixative (1:3 Acetic acid: Ethanol) for 24 hours before usage. The root tips were hydrolysed in 18% HCl for 10 minutes, squashed on slides and stained with FLP orcein and covered with clean cover slip according to standard technique (Azeez and Faluyi, 2019). Photomicrographs of the chromosomes were taken at X1000 using Accu-scope trinocular microscope.

Statistical analysis: Descriptive statistics (mean, standard deviation and percentage) were employed as appropriate.

RESULTS

Melochia corchorifolia: This was an erect, annual herb and woody at maturity with pubescent leaves and stem. It was found growing in water logged area. The leaves were ovate, simple with alternate arrangement. The leaf base was rounded, leaf apex acute with reticulate vein and serrated margin. It had free white petals; the calyx was fused while the epicalyx was free, green and pubescent with no pigmentation. The anther was yellow with light green filament whereas stigma and style were colourless while ovary was light green. The inflorescence was numerous, axillary and predominantly terminal and the floral aestivation was valvate. The fruit was green and pubescent which turned brown when matured and dried, and then dehisced longitudinally into five compartments (Figure 1).

Melochia melissifolia : This was procumbent, perennial woody herb or subshrub and in the field, it grew wide and formed carpet. It could grow in both hydrophytic and mesophytic environments. The petiole and stem were pubescent and pigmented. The leaves were

ovate, deep green, simple, alternate and pubescent. The leaf base was round and the apex was acute with reticulate and serrated margin. The plant possessed free violent petals, a few axillary inflorescences and the floral aestivation was valvate. The calyx was fused while the epicalyx was free, green and pubescent. The anther was cream with white filament, white style, cream stigma and ovary was green. The fruit was green with touch of pink at its tips, dehisced longitudinally when matured and dry (Figure 1)

Anatomy

Foliar epidermal peel: The leaves of the two *Melochia* species were amphistomatic. The abaxial surfaces of the two had irregular epidermal cell shape with curve or straight anticlinal wall. They possessed anomotetracytic and anisocytic stomata. On the adaxial surfaces of the two species, rectangular, cylindrical and polygonal epidermal cell shapes were observed while anticlinal walls were either curved or straight. Anomotetracytic and anisocytic stomata were observed on the adaxial surface of *M. corchorifolia*, while only anisocytic stomata were seen on adaxial surface of *M. melissifolia* (Figure 2). Only short glandular trichomes were observed on the abaxial and adaxial leaf surfaces of *M. corchorifolia* whereas simple, unicellar and short glandular trichomes were observed on both the abaxial and adaxial leaf surfaces of *M. melissifolia.* In addition, epidermal ornamentation was observed on both abaxial and adaxial surfaces of *M. melissifolia* only (Figure 2).

Leaf transverse section*:* The cuticle was thin, non-striated and gently undulated in both *M. corchorifolia* and *M. melissifolia* though some portions were straight in the latter. The epidermal layers of the leaves in the two species were uniseriate with various shapes of the epidermal cells ranging from oval, circular, cylindrical to rectangular. The trichomes were simple, unicellular and short glandular. The mesophyll was distinguished into palisade and spongy layers; palisade mesophyll was tightly packed with cylindrical shaped parenchyma cells and it occupied two-three layers in *M. corchorifolia* however, it occupied one-two layers in the other species. The spongy mesophyll in the two species was loosely packed with variously shaped parenchyma cells which include oval, circular, cylindrical and polygonal cells (Figure 2). The midrib was jug and arc shaped in *M. corchorifolia* and *M. melissifolia* respectively. The cuticle and epidermal features of the midrib were the same as in the lamina. The cortex of the two species was filled with different shaped parenchyma cells; circular, oval and polygonal. Crystal druses were housed in the parenchyma cells of the cortex in the two species. Vascular bundle was one single arc shape cortical bundle in *M. corchorifolia* whereas it was cortically positioned oval shaped in *M. melissifolia.* The vascular bundle was conjoint, concentric and amphicribral in the two species (Figure 2).

Stem sections

Melochia corchorifolia : Cuticle was thick, gently undulating and striated. The trichome was simple unicellular. Outer bark composed of two to five layers of dead parenchyma cell whose shape ranged from circular, oval, rectangular to polygonal. Inner bark consisted of five to several layers of parenchyma cell whose shape ranged from circular, oval to rectangular. Crystal druses were observed in the parenchyma cell of the inner bark and brachysclereids were also housed in the inner bark. The porosity was diffuse. The pore shape at transverse plane ranged from circular, oval, short rectangular, arc, short cylindrical to polygonal. The pore multiple and pore cluster were many though the solitary vessels were scanty. The pore multiple and pore cluster ranged from two to seven each. Vessel was simple perforated, inclination transverse to oblique, vessel was without tail, with tail at one end or tail at both ends, and pitting was simple alternate. Tylose was present in few vessels. Secretory duct and crystal druses were present in vessel. Axial parenchyma was absent. Fibres were thin walled, large lumen, non-septate, no pitting and non-storied. The Ray was heterogenous (upright and procumbent rays), non-storied, uniseriate, biseriate, multiseriate to compound ray (Figure 3).

***Melochia melissifolia* :** Cuticle was thick, striated, gently undulating in some parts and straight in some other parts. Outer bark consists of several layers of dead parenchyma cells whose shape ranged from short rectangular, short cylindrical, oval to polygonal and they were arranged parallel to the cuticle. Inner bark consists of several layers of variously shaped parenchyma cells whose shape ranged from oval, circular, short rectangular, short cylindrical to polygonal. The parenchyma cell of the outer and inner barks housed starch grain of various shape and sizes. The shape of starch grain was mostly circular. Phloem fibres were present in the inner bark. Crystal druses were housed in the parenchyma cell of the inner bark.

Porosity was diffuse. Pore shape at transverse plane ranged from oval, circular, cylindrical, arc to short rectangular. Pore clusters were few or scanty and it ranged from two to six while the pore multiple was more and ranged from two to nine (Figure 3). Vessel was simple perforated, inclination transverse to the oblique vessels were without tail, with tail at one end or tail at both ends, pitting simple alternate. Axial parenchyma was apotracheal and was scanty. Fibres were thin walled, large lumen, non-septate, no pitting and non-storied. Tylose was absent and secretory duct was observed on the vessel. Ray was heterogeneous, non-storied, uniseriate and multiseriate (Figure 3).

Pollen grain studies: The pollen of the *Melochia* species studied was oblate spheroidal to prolate spheroidal (the ratio of polar axis to equatorial axis (P/E) was approximately 1.00), monad and acolpate with reticulate or micro-reticulate ornamentation on its exine. Monoporate pollens were predominant in *M. melissifolia* while biporate and triporate pollens were occasionally seen. In *M. corchorifolia,* monoporate, biporate and triporate pollens were observed, and triad was observed in addition to monad. The polar axis was 0.0423 mm and 0.0470 mm in *M. corchorifolia* and *M. melissifolia* respectively while the equatorial axis was 0.0425 mm and 0.0469 mm respectively (Figure 4). The pollen stainability was 77.89 % and 71.96 % in *M. corchorifolia* and *M. melissifolia* respectively.

Cytological study: The chromosome numbers of 2n=2X=28 and 2n=4x+2n=58 was documented in *M. corchorifolia* and *M. melissifolia* respectively (Figure 5). The formal was tetraploid while the latter is octoploid with aneuploidy increase.

Germination and phenology: Seedling emergence was observed in the two species five days after planting with 70% and 37.5% germination percentage recorded in *M. corchorifolia* and *M. melissifolia* respectively after 30 days. First flowering was noticed in *M. corchorifolia* and *M. melissifolia* about three months and seven months respectively after planting. *Melochia melissifolia* flowered between late October and late January both at the experimental site and in the field though, irregular flowering was noticed occasionally. Both flowering and fruiting occurred simultaneously. The height of *M. corchorifolia* and *M. melissifolia* at first flowering was 95.17± 4.05 cm and 62.47±3.22 cm respectively. At senescence, the height in *M. corchorifolia* reached 97.5 ± 6.22 and completed its life cycle approximately four months after planting while *M. melissifolia* continued to grow being perennial.

DISCUSSION

Recently, the importance of plants in alternative medicine is becoming popular and misidentification of plants cannot be overlooked. Therefore, the characterization of plants is to establish the identity of plant accessions which subsequently reveals the genetic relationship that exists among the genotypes (Azeez, 2020). Moreover, plant characterization provides opportunity to identify adaptive and productive characters that can be properly utilized to improve plant productivity (Lutatanekwa *et al*., 2020). In this study, many similarities in morphological, anatomical and palynological attributes observed in the two *Melochia* species studied were not unexpected; they belong to the same section, *Melochia.* Oyelakin and Ayodele (2013) stated that when certain species from a genus possess some similar features, it showed that they have a common ancestor. Moreover, the similarity of structures among the members of a genus shows a close genetic association among them based on genetic principle (Goldberg, 1967). Despite all the similarity shared by the two *Melochia* species studied, they still possess certain characters that can be employed to delimit them. Morphologically, the *Melochia* species could be distinguished from each other by their habits, longevity, leaf and petal colours, position of the inflorescences; either terminal or axil as well as the presence or absence of pigmentation on the fruit tip, petioles and stems. Furthermore, the anatomical study revealed that both anomotetracytic and anisocytic stomata were observed on the adaxial surface of *M.* corchorifolia while in *M. corchorifolia,* only anisocytic was noticed on its adaxial surface. Short glandular trichomes characterized both the abaxial and adaxial surfaces of *M. corchorifolia,* whereas simple unicellular short glandular trichomes were seen on the two leaf surfaces of *M. melissifolia.* Though, stellate trichomes were reported in the genus, none was seen in the two *Melochia* species studied. Moreover, Goldberg (1967) reported that the stellate trichomes are common in the sections *Pyramis* and *Physodium* while simple ones are mostly seen in the sections *Melochia* and *Mougeotia.* Epidermal ornamentation was unique to *M. melissifolia*. The midrib and vascular bundle shape were

diagnostic for the two *Melochia* species studied; jug shaped midrib and arc shaped cortical bundle were unique for *M. corchorifolia* whereas arc shaped midrib with cortically positioned oval shaped vascular bundle characterised *M. melissifolia.*

From stem anatomy, the brachysclereids and tylose were present only in annual species hence, diagnostic for it. Furthermore, absence of axial parenchymal cells and starch grain delimited this from its perennial counterpart. Apotracheal axial parenchymal cells, phloem fibres and starch grains which were mostly circular in shape characterized *M. melissifolia.* In addition to uniseriate and multiseriate rays observed in *M. melissifolia,* biseriate and compound rays were seen in *M. corchorifolia.* The pollen features of the two *Melochia* species studied were greatly similar nevertheless, monoporate pollen grains were predominately observed in *M. melissifolia.* Triad was documented only in *M. corchorifolia* which may confer an advantage on the species by increasing its chance of ensuring fertilization.The present observation revealed the chromosome number of *M. corchorifolia* and *M. melissifolia* to be 2n=4x=28 (tetraploid) and 2n=8x=58 (Octoploid) respectively based on basic chromosome number of 7. Other basic chromosome numbers reported in the genus include 9, 10, 23 and 27 (Dorr and Barnett, 1989). This contradicted the previous observation in *M. corchorifolia* where 2n=48 was reported (Bir and Sidhu, 1975) while the 2n=14 was documented in *M. melissifolia var. bracteosa* (Mangenot and Mangenot, 1962). The chromosome count of 2n = 58 observed in *M. melissifolia* could be as a result of aneuploid increase in 2n=28 which resulted in 2n+1= 29. This plant would have been sterile and might not have been able to exchange genes with its 2n=28 relatives. The 2n=29 plant could have been able to create niche for itself and acquired perennial habit and over a period of time, it might have been able to double its chromosome. This chromosome doubling would have restored its fertility and engender a 2n=58 plant giving it a more ecological amplitude. With the above explanation, it is not surprising that *M. melissifolia* is widely spread despite its perennial habit. The two *Melochia* species had high pollen stainability (above 70%) which showed that they have high fertility. However, this did not correspond with the seed viability in the two species; the annual species had high germination percentage (70%) while it was lower in the perennial species (37.5%). The annual completed its life cycle within 4 months and also produced numerous inflorescences which developed into many fruits; it would have produced enough propagules for the next generation and therefore ensure continuity of the species. On the other hand, *M. melissifolia,* a perennial species which had lower seed germination percentage also produced fewer inflorescences with fewer fruits. Though few propagules for the next generation would be available, continuity is ensured by being a perennial species. Rather than producing many propagules that may lead to overcrowding which will also be a threat to their survival when competing for limited resources, the plant will channel its resources to vegetative growth. *Melochia melissifolia* was found growing naturally in both mesophytic and hydrophytic environment while *M. corchorifolia* was found growing in waterlogged area. However, observation in the present study revealed that *M. corchorifolia* could also survive with optimal performance in the mesophytic zone. Moreover, it was also said that *M. corchorifolia* could survive in xerophytic environment due to the mutation it has accumulated overtime and it could still retain its ability to survive in both mesophytic and hydrophytic environments (Goldberg, 1967).

CONCLUSION

The two *Melochia* species reported in Nigeria were characterized based on morphological, anatomical, palynological and cytological attributes along with some reproductive parameters. The study revealed that many similarities were shared by the two species. These include ovate leaf, inflorescence arrangement, anomotetracytic and anisocytic stomata on the abaxial surface, epidermal cell features, anticlinal wall, leaf and stem cuticle features, crystal druses, parenchymal cell shape, pore multiple and pore chain, secretory duct, uniseriate and multiseriate rays and oblate to prolate spheroidal pollen grains. All these similarities were pointing to genetic affinity that exists between the two species. Despite all these similarities, the study identified many features that delimited the two *Melochia* species studied. These attributes are habit, longevity, inflorescence position, stomata on the adaxial surface, tylose, midrib shape, vascular bundle shape, foliar trichomes, brachysclereids, axial parenchymal cells, starch grains, and chromosome counts. It can therefore be

concluded that the two *Melochi*a species studied are distinct species with a common ancestor.

REFERENCES

Aigbokhan, E.I. (2014). Annotated checklist of vascular plants of southern Nigeria- A quick reference guide to the vascular plants of southern Nigeria: a systematic approach. Uniben Press, Benin City. 346p

Ajaib, M. and Khan, Z. (2010). *Melochia corchorifolia* L. of family Sterculiaceae: An addition to the Flora of Pakistan. *Biologia (Pakistan)*, 56(1-2):133-135

Akinnubi, F.M; Akinloye, A.J; Olaleye, O.O. and Adenegan-Alakind, T.A. (2014). Foliar anatomy of some species of Asteraceae in south west Nigeria. *Afr. J. Plant Sci.*, 8(9): 426-440.

Azeez, S.O. and Faluyi, J.O. (2019). Karyotypic studies of four *Physalis* species from Nigeria. *Acta Bot. Hung.* 61(1–2): 5–9. https://doi.org/10.1556/034.61.2019.1-2.2.

Azeez, S.O. (2020). Characterisation and reproductive biology of four *Physalis* L. species from Ile-Ife, Nigeria. *Nig. J. Bot.* 33(2): 153-172.

Azeez, S.O; Faluyi, J.O. and Oziegbe, M. (2019). Cytological, foliar epidermal and pollen grain studies in relation to ploidy levels in four species of *Physalis* L. (Solanaceae) from Nigeria. *Int. J. Biol. Chem. Sci.*, 13(4): 1960-1968. https://dx.doi.org/10.4314/ijbcs.v13i4.4.

Batugal, P.A; Jayashree, K; Lee, S.Y. and Jeffrey, T.O. (eds). (2004). Medicinal plants research in Asia, Volume1: the framework and project workplans. International Plant Genetic Resources Institute-Regional Office for Asia, the Pacific and Oceania (IPGRI-APO), Serdang, Selangor DE, Malaysia.

Bayer, C; Fay, M.F; De Bruyn, A.Y; Savolainen, V; Morton, C.M; Kubitzki, K; Alverson, W.S. and Chase, M.W. (1999). Support for an expanded family concept of Malvaceae within a recircumscribed order Malvales: a combined analysis of plastid atpB and rbcL DNA sequences. *Bot. J. Linn. Soc*., 129: 267-303

Bir, S.S. and Sidhu, M. (1975). In IOPB chromosome number reports XLIX. *Taxon* 24(4): 501-516

Burkill, H.M. (1985). The useful of plants to west tropical Africa, Vol.5, Royal Botanic Gardens, Kew, Richmond, Surrey, UK. Vol.5.

Cvetkovic T; Areces-Berazain, F; Hinsinger, D.D; Thomas, D.C; Wieringa, J.J; Ganesan, S.K. and Strikk, J.S. (2021). Phylogenomics resolves deep subfamilial relatioships in Malvaceae s.l. *Genes, Genom. Genet.*, 11(7) jkab136. https://doi.org/10.1093/g3journal/jkab136

Dorr, L.J. and Barnett, L.C. (1989). A revision of *Melochia* section *Physodium* (Sterculiaceae) from Mexico, *Brittonia*, 41(4): 404-423

Faife-Cabrera, M; Ferrero, V. and Navarro, L. (2014). Unravelling the stylar polymorphism in *Melochia* (Malvaceae): reciprocity and ancillary characters. *Bot. J. Linn. Soc.*, 176:142-158

Goldberg, A. (1967). The genus *Melochia* L. (Sterculiaceae). *Contributes from the United States National Haberium*, 34(5):191-363.

Goncalez, V.M. and Esteves, G.L. (2015). Synopsis of *Melochia* L. (Byttinerioideae-Malvaceae) in southeastern Brazil. *Phytotaxa*, 226(3): 217-232. http://dx.doi.org/10.11646/phytotaxa.226.3.2

Hutchison, J. and Dalziel, J.M. (1952). Flora of West Tropical Africa, Vol 1. 2nd Edition. Crown Agents for Overseas Governments and Administrations, London, UK.

International Association of Wood Anatomists (IAWA). (1989). IAWA list of microscopic features for hardwood identification: With an appendix on non-anatomical information. *IAWA Bulletin*, 10(3): 234-320

Lutatanekwa, D.L; Mtengeti, E.J. and Msalya, G.M. (2020). A review of plant characterization: First step towards sustainable forage production in challenging environments. *Afr. J. Plant Sci.*, 14(9): 350-351.
https://doi.org/10.5897/AJPS2020.2041

Mangenot, S. and Mangenot, G. (1962). In: chromosome number of flowering plants (ED.) Komarov Botanical Inst. Leningrad. P. 705.

Martin, F.W. (1966). Distyly, self-incompatibity, and evolution in *Melochia*. *Evolution*, 21(3):493-499

Metcalfe, C.R. (1960). Anatomy of monocotyledons. I. Gramineae. Clarendon Press, Oxford.

Metcalfe, C.R. and Chalk, L. (1979) Anatomy of Dicotyledons. Systematic anatomy of leaf and stem, with a brief history of the subject. 2nd Edition, Vol. 1, Clarendon Press, Oxford, 40-41.

Mitra, S. and Maity, D. (2013). Nodal and petiolar anatomy of India *Melochia* Griseb. (Sterculiaceae) and their taxonomic significant. *J. Bot. Soc. Bengal*, 67(1): 49-54

Odiye, M.D; Owolabi, S.M; Akinloye, A.J; Folorunso, A.E. and Ayodele, A. (2019). Comparative wood anatomical studies in the genus *Albizia* Durazz in Nigeria and their potential for paper making. *Plant and Environ.*, 1(2): 70-82.

Oyelakin, A.S. and Ayodele, M.S. (2013). Morphotaxonomic evaluation of the relationship between four species of *Crassocephalum* (Moench.) S. Moore (Asteraceae) in southwestern Nigeria. *Sci. Res. Essay*, 8(33): 1629-1636.

Pullaih, T. (2014). Ethnobotany, Phytochemistry and pharmacology of *Melochia corchorifolia* L., *Int. Res. J. Pharm*., 5(7):543.545.

Ramirez, N. and Navarro, L. (2010). Trends in the reproductive biology of Venezuelan *Melochia* (Malvaceae) species. *Plant Syst. Evol.,* 289:147-163. https://doi.org/10.1007/s00606-010-0340-2

Rondon, J.B. (2009). Taxonomic revision of the genus *Melochia* L. (Steculiaceae) in Venezuela. *Acta Bot. Venez.*, 329(1):1-45

Silveira Junior, C.E.A; Lima e Lima, L.C. and Saba, M.D. (2015). Palynological study of heterostylous species of *Melochia* L. (Byttinerioideae- Malvaceae) occurring in Bahia; Brazil. *Rev. Palaebot. Palynol*., 221: 192-203. http://dx.doi.org/10.1016/j.revpalbo.2015.07.005

Umar, K.J; Hassan, L.G; Dangoggo, S.M; Inuwa, M. and Al-Mustapha, M.N. (2007). Nutritional content of *Melochia corchorifolia* (Linn.) leaves. *Int. J. Biol. Chem*., 1(4): 250-255

Figure 1: Morphology of the two *Melochia* species studied. (A) Flower of *M.corchorifolia* (B) Flower of *M. melissifolia* (C & D) Terminal inflorecsence in *M.corchorifolia* (E) Habit of *M. corchorifolia* (F) Habit of *M. melissifolia* (planted) (G) Axillary inflorecsence in *M. melissifolia* (H) Habit of *M. melissifolia* in a maintained lawn (I) Fruits and seeds of the *Melochia* species (black arrow-unripe fruit; white arrow-ripe; red arrow-seeds).

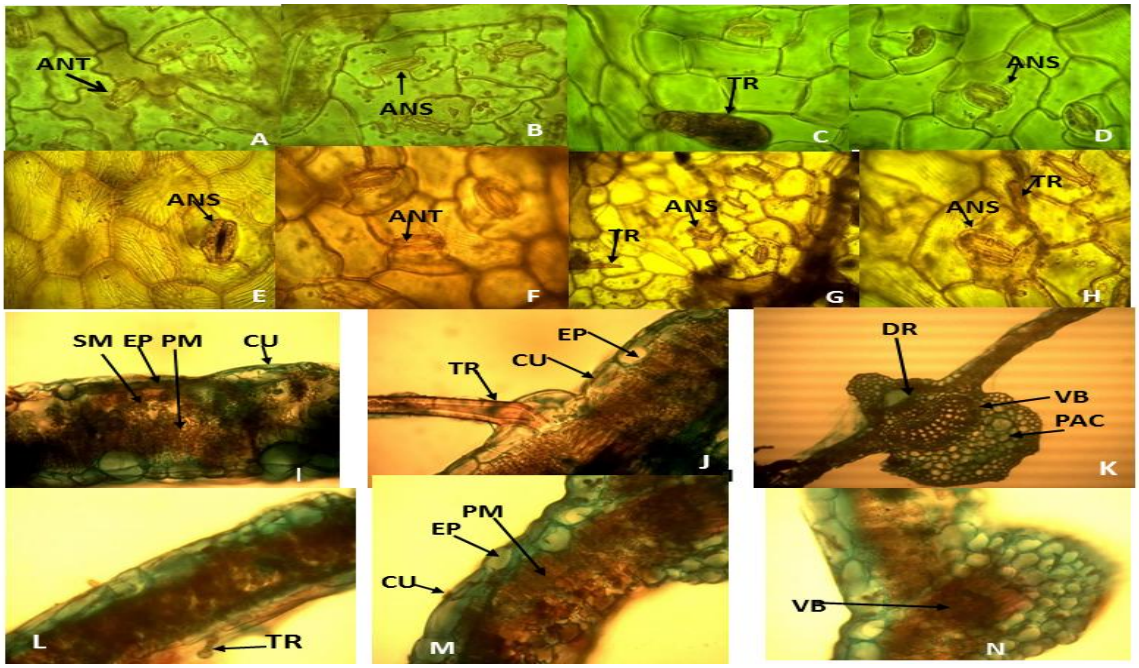

Figure 2: Foliar Epidermal peels and Transverse sections of the Leaves in two *Melochia* species studied. (A & B) Abaxial surface of *M. corchorifolia* (C & D) Adaxial surface of *M. corchorifolia* (E & F) Abaxial surface of *M. melissifolia* (G & H) Adaxial surface of *M. melissifolia* (I) Lamina of *M. corchorifolia* (J) Mesophyll of *M. corchorifolia* (K) Midrib of *M. corchorifolia* (L) Lamina of *M. melissifolia* (M) Mesophyll of *M. melissifolia* (N) Midrib of *M. melissifolia*

Abbreviations:

ANS- Anisocytic; ANT- Anomotetracytic; TR- Trichome; EP- Epidermal layer; SM- Spongy mesophyll tissue; DR- Crystal druses; VB- Vascular bundle; CU- Cuticle; PM- Palisade mesophyll tissue

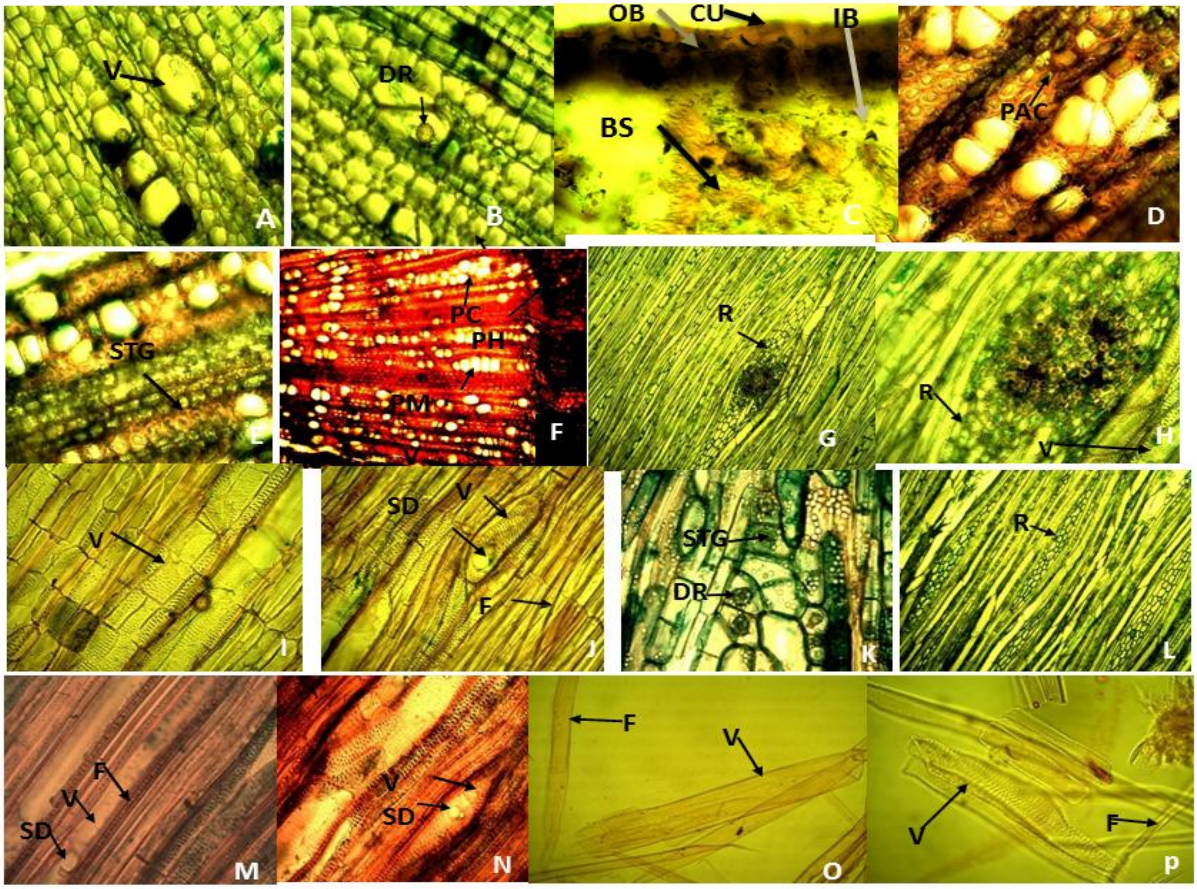

Figure 3: Stem anatomical features in the two *Melochia* species studied. (A & B) Transverse section of *M. corchorifolia* (C) Bark in *M. corchorifolia* (D, E & F) Transverse section of *M. melissifolia* (G & H) Tangential longitudinal section of *M. corchorifolia* (I&J) Radial longitudinal section of *M. corchorifolia* (K & L) Tangential longitudinal section of *M. melissifolia* (M & N) Radial longitudinal section of *M. melissifolia* (O) Maceration of *M. corchorifolia* (P) Maceration of *M. melissifolia*

Abbreviations: PAC- Parenchyma cell; STG- Starch grain; PC- Pore cluster; IB- Inner bark; OB- Outer bark; BS- Brachysclereid; PH- Phloem; PM- Pore multiple; V- Vessel; CU- Cuticle; R- Ray; F- Fibre; DR- Crystal druses; SD- Secretory duct

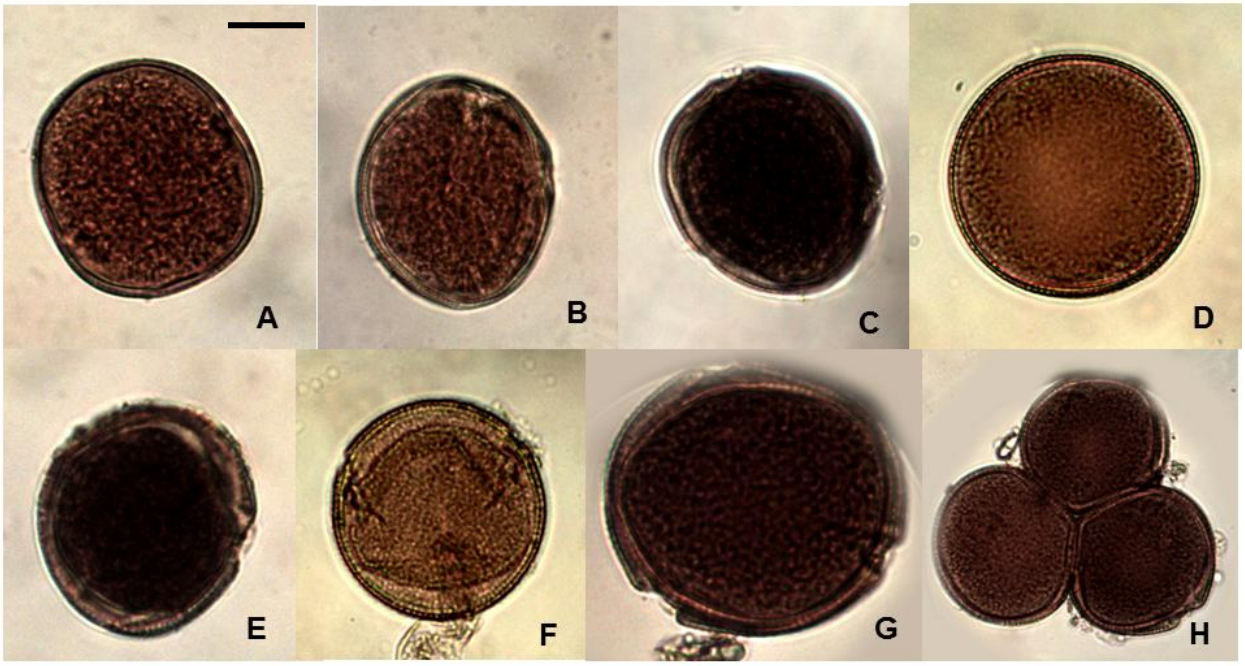

Figure 4: Pollen morphology in the two *Melochia* species studied. (A-C) *M. melissifolia* (D-H) *M. corchorifolia* (A) Aporate showing ornamentation and micro-reticulate exine (B) Monoporate (C) Triporate (D) Aporate (E) Monoporate (F) Biporate pollen ornamentation and reticulate exine (G) Triporate (H) Triad (Scale bar: 1cm = 100 µm)

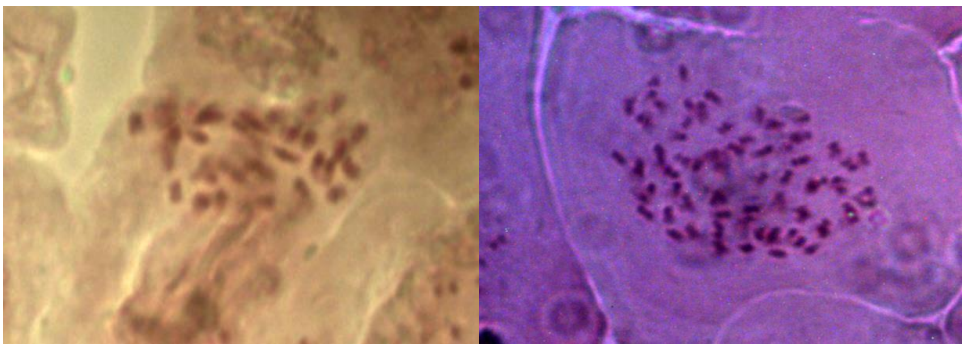

Figure 5: Mitotic chromosome in two *Melochia* species studied (A) *Melochia corchorifolia* (2n=4x=28) (B) *Melochia melissifolia* (2n=8x+2=58)

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VARIATION IN AGRONOMIC CHARACTERISTICS OF FIVE OKRA (*ABELMOSCHUS ESCULENTUS* (L) MOENCH GENOTYPES

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ABSTRACT
This study was conducted to examine the differences existing among five okra genotypes for agronomic characteristics and yield. The genotypes were three established national varieties viz. V35, LD 88/1-8 and 47-4 together with two breeding lines 53-139 and 4-30, from the breeding lines programme of the Department of Agronomy, University of Ibadan, Nigeria. Each genotype was sown in a 3m long single row plot with 45cm between plants within the row separated 1m apart. Flowers on six competitive plants of each genotype were tagged on opening and pods harvested separately at the edible stage six days later. Data collected were subjected to analysis of variance (ANOVA) as for a completely randomised design, the six plants per entry representing six replicates. Flowering period ranged from 20 days in V35 to 28 days in 47-4 and 53-139, 47-4 and 4-30 recorded the highest heights both at flowering and maturity. Average number of harvested fruits per plant ranged from 8 fruits in V35 to 19 fruits in 4-30, fruit yield weight per plant ranged from 15.7g in LD 88/1-8 to 20.7g in 4-30. V35 had the least fresh and dry weight: 319g/m^2 and 34.3g/m^2 while 4-30 had the highest 884g/m^2 and 67.9g/m^2. The breeding line 4-30 recorded high similarity with established variety 47-4 in most of the measured agronomic traits except for different pod colour The estimates of coefficient of variation shows V35 and LD 88/1-8 both established varieties recording highest coefficients confirming contaminations over time while the advanced breeding lines i.e. 4-30 and 53-139 had coefficients indicating greater uniformity within the genotypes. Despite the unknown pedigree of these established varieties, this study result suggested sufficient distinction and justify they can be used to estimate heritability values and used for more okra improvement programmes.

Keywords: *Plant height, Coefficient of variation, Breeding line, Pedigree, Heritability*

INTRODUCTION

Okra (*Abelmoschus esculentus* (L) Moench) belonging to the family Malvaceae is an annual herb used chiefly as a fresh vegetable, it grows up to 2m, the stem is hairy when mature and the leaves are alternately arranged up to 30cm in length, they are generally deeply lobed and pentagonal. All okra has some spines that irritates the skin (Wolford, 2002). According to Schippers, (2002), the flowers are naturally self-fertile however outcrossing does occur with bees of different species acting as pollinators. The total commercial production of okra in the world was estimated at 4.8 million tons, with India and Nigeria being the predominant producers (Gulsen *et al.*, 2007) The smaller the fruits are when picked the tastier when consumed (Wolford, 2000). Okra has a wide range of varieties, which are separated according to period of maturity, branching of stem, leaf shape and colour of the fruit. In terms of plant height, okra may be classified as dwarf, intermediate or tall. The dwarf varieties grow to a height of up to 0.3 to 1.2m while the tall ones grow up to 2 to 2.5m. The plants that are harvested for their pods grow much taller with more branches than the unharvested plants with mature pods. Wolford (2002) reported that if fruits are permitted to mature fully the further production of fruits will decline because maturing, older, tough pods take up more strength that could go to keeping the plant producing new pods daily. Okra is one of the most common vegetable available all year round in Nigeria due to irrigation technology. Okra is used to complement staples which consists of starchy foodstuffs like rice, cassava, maize and yam since it's a good source of vitamins, minerals and proteins (Funsho and Bassir, 1976). In Nigeria, 100g of edible fresh pods of okra was reported to contain 1.6 to 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre, 0.8% ash and 86.1% water (Olajide, 1995). The fruits also contain vitamins A and C with traces of vitamin B, it is a good source of calcium, phosphorus and iron. The mature seed

contains 20% edible oil which is used in manufacture of margarine. In Egypt okra seed flour is used as additives to sweet corn flour (Olajide, 1995). Okra seed cake is rich in protein and can be an additive in animal feed. In Malawi Okra has been used in the treatment of syphilis, a venereal disease while the seed has been used as stimulant to control spasm (Olajide, 1995). Omonhinmin and Osawaru, (2005) mentioned the significant role Okra production plays in the rural economies of most tropical countries, stating that in Africa, where it is cultivated and highly consumed, more attention needs to be directed to the selection of high yielding cultivars for edible fruits and seeds as no serious effort has been directed to improvement in international research programmes in the past. Even in Nigeria, okra has not received much attention in the country in terms of genetic improvement. It is essential to assemble, characterize and evaluate many useful varieties in order to maximize their utilization in any crop improvement programme (Onwueme and Sinha, 1991). However, from the breeding activities on Okra in the Department of Agronomy of the University of Ibadan, a few varieties are available while there is still an ongoing breeding programme. The major objectives of the breeding programmes have been improved edible pod yield with attention given to consumer preference such as smooth, plump edible pods and high mucilage content (Fatokun, *et al*., 1979). Thus this study compares the characters of agronomic interest such as pod yield, days to flowering, flowering period and plant height of two advanced breeding lines from the Department's Okro Improvement programme with three already established genotypes in the country to know the progress with the achieved success and further activities needed.

MATERIALS AND METHODS

The study was carried out behind the Department of Agronomy building at the University of Ibadan. Ibadan lies at 7^0 20^1 3^0 54^1E, 200m above sea level. The study was conducted during the second raining season of the year between September and December, 2020. The soil was classified as Iwo series according to Smyth and Montgomery (1962), Plinthudalf of USDA (Soil Survey Staff, 2003) and chromic luvisol of FAO/UNESCO Soil Taxonomy (1990). Following land clearing and hoe tillage of the experimental area, seeds of five okra genotypes were sown on 3rd September. The genotypes were LD 88/1-8, 47-4 and V35 which are varieties already released for cultivation, along with 53-139 and 4-30 which are advanced breeding lines from the Department of Agronomy, University of Ibadan Okra Breeding Programme. Each genotype was sown in a 3m row plot spaced 1m apart. Seeds treated with Apron plus, a seed dress, were sown three per hole every 45cm within the row. Twenty-five days after sowing, seedlings were thinned to one per stand. A compound fertilizer NPK 15:15:15 was side dressed three weeks after sowing to supply nitrogen at the rate of 30kg N/ha. At flowering, a second dose of 15:15:15 fertilizer was given at the same rate. Plants were sprayed six weeks after sowing with an insecticide, Cypermetrin at a concentration of 2ml in 100ml of water, as a precaution against insect transmitted virus and other insect damage diseases. Plots were weeded manually with hoe as necessary.

Data were collected from six randomly selected competitive and representative plants of each genotype in a row plot. The data collected on individual plants included:

a) Number of days from sowing to initial flowering
b) Number of edible pods per plant
c) Edible pod yield per plant (g)
d) Yield of fresh pod (g)
e) Plant height at flowering (cm)
f) Flowering period (days)
g) Plant height at cessation of flowering (cm)

Flowers were tagged with the date of opening and fresh edible pods harvested six days later. The pods were weighed and dried at 70^0C in a forced-air oven to a constant weight. Percent moisture content was estimated as (fresh weight – dry weight)/fresh weight X 100

Statistical Analysis: The data collected in respect of the nutrient constituents were subjected to Analysis of Variance (ANOVA) as for a completely randomised design (CRD) with the six individual plants per genotype representing six replicates. Treatments means were separated using least significant difference (LSD) when a significant difference was indicated from ANOVA. Using the method outlined by Little and Hills (1972).

RESULTS AND DISCUSSIONS

Soil physic-chemical properties at the experimental site: The soil physic-chemical properties at the surface horizon (0-15cm) of the experimental site are presented in Table 2

together with the critical levels established for the ecological zone. It was observed that the soil is slightly acidic. N, P, Ca, Na are above the critical level while Mg is below the critical level for the zone. The critical or optimum level according to Cate and Nelson (1965) is the soil test value above which response is not expected and below which a large yield response can be obtained with adequate supply of plant nutrient. According to the relative proportions of sand, silt and clay the soil textural class is loamy sand. The experimental site from the native nutrient analysis has most of the soil test value above the critical level thus indicating an inherently fertile soil. However, the results may also reflect previous cropping history during which in the previous two years it has been under okra and millet cultivation respectively and adequate fertilizer applied.

Characteristics of five okra genotypes: Some agronomic characteristics of the okra genotypes are shown in Table 3. The number of days to initial or commencement of flowering ranged between 44 days for 53-139 and 50 days for 47-4. 53-139 can be said to have matured first with an average of 44 days to flowering and can be said to stand a better chance of earlier return than 47-4 with an average of 50 days. This is confirmed with 53-139 recording the longer flowering period of 28 days which was also recorded by 47-4. It has been demonstrated that on a general basis, early flowering is detrimental for overall productivity in okra as the source to sink ratio will be potentially limited for effective photosynthesis (Aboagye *et al*., 1994). In another study by Eshiet and Brisibe, (2015) the days to flowering ranged between 71.75 and 116.45 showing a real significant difference among genotypes however in this report, non-significant differences observed in the flowering periods among these genotypes connotes an unvarying maturity periods between the breeding lines and the established lines. Also, the pod yield relating to flowering period was not significantly different from each other though numerically different among the five genotypes. Flowering period ranged from 20 days in V35 to 28 days for 47-4 and 53-139. The genotypes 47-4 and 4-30 had the tallest plants at both commencement of flowering; 79.3cm and 83.0 cm respectively. V35 had the shortest plants averaging 42.1cm and 76.0cm at initial flowering and maturity respectively. Plant height being an important yield related trait due to the adverse effect on plant stands resulting from lodging during heavy rainfall when the plants are too tall. Thus most farmers prefer dwarf or intermediate plant stands, these values classify the five genotypes as intermediate plant type and will be well desired by consumers. This was also corroborated by Eshiet and Brisibe, (2015), emphasizing plant height at flowering and fruiting are of particular interest for breeding programmes because the presence of plants with tall and thin stems will increase the rate of lodging near harvesting and this could lead to loss of dry matter and subsequent decrease in fruit yield. Average total number of fruits harvested per plant ranged from 8 pods in V35 to 19 pods in 4-30, while fruit yield weight per plant ranged from 15.7g in LD 88/1-8 to 20.7g in 4-30. Number of pods per plant was highest in 4-30 with an average of 19pods and least in LD88/1-8 with 8 pods this translates to the high pod yield of 20.7 in 4-30. The genotypes were seen having far better yield compares to what was obtained by Eshiet and Brisibe, (2015) recording average pod/plant of 3.20 to 5.67. Fresh pods of all the genotypes were deep green except those of 4-30, which were yellowish green. Although the pedigrees of the established varieties were not available, these results suggested that the genotypes are sufficiently distinct to justify their use for estimating heritability values using the procedures in the present study. The established variety, 47-4 and 4-30 an advanced breeding line are similar in most characteristics but differ in pod colour.

Edible pod yield: Table 4 shows the total fresh edible pod yield as well as the dry matter yield of the genotypes. V35 recorded the least fresh (319.0g/m^2) and dry (34.3g/m^2) yields while 4-30 had the highest fresh and dry yields of 884.7 and 67.9g/m^2, respectively. However, its dry matter yield was not significantly better than that of 47-4 an established variety. The dry matter content of breeding line 4-30 was low (7.6%) while dry matter content of 53-139 (9.3%) compares favourably with FAO (1992) recommendation of dry matter content of (10%). The dry yield content corresponds to the mass after complete evaporation of free water. These value ranged from 7.67% for 4-30 to 10.83% for V35. The results show no significant differences (P = 0.05) between dry matter content of the genotypes. There was high moisture contents reflecting low solids content of the samples. Thus more period will be required in the value addition process. These values negates the high dry matter content in okra pods at 86.67-90.31% as previously reported (Gemede *et al*., 2016)

and 87.83 to 92,33% reported by (Combo *et al.*, 2020). The coefficient of variation indicate the extent of variation within genotypes. V35 and LD 88/1-8, both established varieties recorded the highest coefficients of variation indicating possible contamination over time. The remaining genotypes exhibited low or moderate coefficients of variation.

SUMMARY AND CONCLUSIONS

Estimates of coefficients of variation within genotypes indicated relatively greater uniformity of the advanced breeding lines i.e. 4-30 and 53-139 in respect of the agronomic characteristics measured. The established varieties may have been contaminated in the course of their cultivation and maintenance over time. The lines 4-30 and 53-139 were also comparable to the established varieties in the agronomic traits mostly edible pod yield and days to flowering which are playing significant role in the overall yield of the varieties. Thus they may therefore be found suitable for general cultivation after further evaluation.

REFERENCES

Aboagye, L.M., Isoda A., Nyima H., Takasaki Y. and Yoshimura T. (1994). Plant type and dry matter production in peanut (*Arachis hypogea* L.) cultivars: varietal differences in dry matter production. Japanese *Journal of Crop Science* 63: 289-297.

Adeoye, G.O. and Agboola, A.O. (1985). Critical levels for soil pH, available P, K, Zn and Mn and maize ear leaf content of P, Cu and Mn in sedimentary soils of south western Nigeria. *Fertilizer Research* 6: 65-71

Cate, R.B.jnr and Nelson L.A. (1965). A rapid method for correlation of soil test analysis with plant response data. *Technology Bulletin* 1, ISTP series North Carolina State.

Combo, Agnan Marie-Michel, Patrick Aubin Dakia, Koffi Pierre Valery Niaba, Nermegnon Traoré, Grah Avit Maxwell Beugré. (2020). Assessment of Chemical Composition and Nutritional Value of Some Varieties of Okra Available in the Market of Daloa (Côte d'Ivoire) *Asian Journal of Agriculture and Food Sciences (ISSN: 2321 – 1571) Volume 8 – Issue 3*

Eshiet, A. J. and Brisibe, E. A. (2015) Morphological Characterization and Yield Traits Analysis in Some Selected Varieties of Okra (*Abelmoschus Esculentus* L. Moench). *Advances in Crop Science and Technology* 3: 197. doi:10.4172/2329-8863.1000197.

Fatokun, C.A., Chheda, H.R., Aken'ova, M.E. (1979). Potentials for the Genetic improvement of okra (*Abelmoschus esculentus* (L) Moench) In Nigeria. *Nigeria Journal of Genetics.* 3:43-52.

Food and Agriculture Organization of United Nations (1992). Food and Nutrition. Creating a well fed world. Rome, Italy.

Food and Agriculture Organization of United Nations (2000). Soil map of the world revised legend.

Funsho, M. and Bassir O. (1976). Variations in the loss of vitamin C in the leaf vegetables with various methods of food preparation. *Journal of food chemistry* 2, 51-55

Gemede, H F., Haki, G D., Beyene, F., Woldegiorgis, A Z., Rakshit, S K., "Proximate, mineral, and antinutrient compositions of indigenous Okra (*Abelmoschus esculentus*) pod accessions: implications for mineral bioavailability", Food Science & Nutrition, vol. 4, no. 2, pp. 223-233, 2016

Gulsen OS, Karagul S, Abak K (2007). Diversity and relationships among Turkish germplasm by SRAP and phenotypic marker polymorphism. Biologia 62: 41-45.

Lee K.H., Cho C.Y., Yoon S.T. and Park S. K. (2000). The effect of nitrogen fertilizer, plant density and sowing date on the yield of okra. *Korean Journal of Crop Science* 35: 179-183.

Little, T.M. and F.J. Hills (1972). Statistical Methods in Agricultural Research.

Olajide S.Y. (1995). Effects of organic fertilisers on the performance of okra. B.Sc.Project, University of Ibadan, p.6.

Omonhinmin C.A. and Osawaru M.E. (2005). Morphological characterization of two species of Abelmoschus: *Abelmoschus esculentus* and *Abelmoschus caillei*. Genetic Resources Newsletter 144: 51-55

Onwueme I.C. and Sinha T.D. (1991) Field Crop Production in Tropical Africa. CTA, Ede,

Schippers, R.R., (2000). African Indigenous Vegetables. An overview of the cultivated species. Chathaam, U.K: *Natural Resources Institute/ ACP-EU Technical centre for Agricultural and Rural Cooperation* pp.103-118.

Smyth, A.J., and Montgomery R.F. (1962). Soils and land use in central western Nigeria. Government Press Ibadan.

Soil Survey Staff (2003). Key to taxonomy, ninth edition National Resource Conservation Service, Department of Agriculture, United States.

Wolford, R. (2002). http:// www.urbanext.uiuc.edu/.

Table 1: Analysis of variance

Source of variation	df	MS[1]	Expected mean square
Between genotypes	4	MS_b	$\sigma_E^2 + r\sigma_G^2$
Within genotypes (error)	25	MS_w	σ_E^2
Total	29		

[1] Mean square

MS_b = mean square between genotypes

Ms_w = mean square within genotypes

$$H_b = \frac{\sigma_G^2}{\sigma_G^2 + \sigma_E^2} X100$$

Where σ_G^2 = Genetic variance estimated as $\frac{MS_b - MS_w}{r}$

r is number of replicates = 6

σ_E^2 = Error variance, taken to represent environmental variance as it r epresents variation within each genotype

$\sigma_E^2 + \sigma_G^2$ = represent total variation i.e phenotypic variation.

Table 2 : Soil physico-chemical properties of the experimental site at the commencement of the experiment

Soil properties	Unit	Value	Critical level in respect of maize
pH(H20)	====	6.6	5.5-7.5
Organic Carbon	g Kg^{-1}	13.3	------
Total Nitrogen	g Kg^{-1}	2.80	2
Available P	Mg Kg^{-1}	115.09	10 -15
Exchangeable Ca	cmol Kg^{-1}	0.32	4
Exchangeable Mg	cmol Kg^{-1}	0.18	0.5
Exchangeable Na	cmol Kg^{-1}	1.78	>1
Exchangeable K	cmol Kg^{-1}	0.56	0.2
Exchangeable acidity	cmol Kg^{-1}	0.80	
Cation Exchange Capacity (CEC)	cmol Kg^{-1}	3.64	
Base saturation	gkg^{-1}	780.20	
Exchangeable Mn	Mg Kg^{-1}	87.00	5
Exchangeable Fe	Mg Kg^{-1}	56.00	5
Exchangeable Cu	Mg Kg^{-1}	4.80	3
Exchangeable Zn	Mg Kg^{-1}	7.60	5
Sand	%	73.30	
Silt	%	13.80	
Clay	%	12.90	
Textural class	Loamy sand		

Reference Adeoye and Agboola, 1985

Table 3: Characteristics of five okra genotypes

Genotypes	Days to flowering	Flowering period	Height at flowering	Height at maturity[-1]	Fruit colour	No of pods per plant	Pod yield
	no.	days	……...cm.……...			no.	g/plant
V35	45	20	42.1	76	Deep green	8	17.6
	(42-49)	(14-23)	(33.7-45.5)	(69.2-84.1)		(9-10)	(11.9-22.5)
LD 88/1-8	45	23	52.9	122.4	Deep green	14.5	15.7
	(47-50)	(21-24)	(42.5-63.2)	(102.3-131.1)		(12-17)	(13.9-18.7)
47-4	50	28	79.3	1176.1	Deep green	15	19.6
	(48-56)	(23-32)	(65.4-92.2)	134.6-222.0)		(12-19)	(13.9-22.6)
53-139	44	28	45.5	86.4	Deep green	12.5	19.2
	(43-46)	(25-33)	(37.5-51.3)	(72.5-98.3)		(8-15)	(19.8-21.3)
4 -30	48	24	83.0	179.3	Yellowish green	19.3	20.7
	(46-52)	(21-29)	(77.6-90.6)	(165.2-198.0)		(14-20)	(18.4-29.2)

[-1] Maturity corresponds to cessation of flowering
Note: Values in parenthesis are the range values

Table 4: Dry matter content and total fresh and dry edible pod yields of five okra genotypes

			Yield	
Genotypes	Moisture	Dry matter	Fresh	Dry
	%	%	……g/m2……	
V35	89.2	10.83	319.1	34.2
			33.5	33.30
LD 88/1-8	90.6	9.42	510.5	48.2
			23.2	26.3
47-4	90.7	9.35	641.5	59.5
			16.8	15.2
53-139	90.2	9.3	533	49.3
			20.2	18.3
4 -30	92.3	7.67	884.8	67.8
			12.1	16.8
LSD(0.05)	0.80	NS	21.8	2.1

Values in parenthesis are coefficients of variation (%)
NS = non-significant

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DETERMINATION OF PHYTONUTRIENTS IN FIVE LEAFY VEGETABLES

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ABSTRACT:
Phytochemicals are important factors in body defense system activity against reactive oxygen species. Antioxidants are helpful in combating the free radicals in body that cause cellular damage. The present investigation was undertaken to determine the phytonutrients and antioxidant activity of some leafy vegetables viz. *Launea taraxacifolia (Yanrin), Solanium gilo* (Efo igbo), *Solanium nigrum* (Odu), *Sesamum radiatum* (Efo atura), *Ocium gratissimum* (Effirin). The total phenolics were determined spectrophotometrically according to the Folin Ciocalteau procedure and ranged from 39.46 to 165.46 mg/100g Gallic acid equivalent (GAE), Ascorbic acid ranged from 16.5 to 23.4 mg/100g, beta-carotene ranged from 9,000 to 24,900 µg/100g and the free radical scavenging activity was determined using 2, 2,-diphenyl-2-picrylhydrazyl (DPPH) that ranged from 37.01 to 94.46 per cent. The correlation between antioxidant activity and total phenols was highly positive (0.8439, vitamin C and beta-carotene were found to be not linear with R^2 = 0.1146 and 0.0198 respectively. The results indicated that studied vegetables containing high phenolics, beta-carotene and vitamin C may provide a source of dietary anti-oxidants that have preventive and therapeutic roles in a number of human diseases.

Keywords: *Antioxidant, Leafy Vegetables, Total Phenolic Content, Vitamin C and Beta-Carotene*

INTRODUCTION

Research has provided confirmation of a reverse association between plants constituent's rich diet and chronic and deteriorating diseases incidence, showing that high dietary intake of antioxidative compounds would help in maintaining adequate antioxidant status and proper physiological functions of the body tissues (Balijeet *et al*., 2016 and Chekki *et al*., 2014). Vegetables are functional foods (Clifford *et al*., 2015). Leafy vegetables contain a wide variety of biologically active, nutritive compounds known as phytonutrients (Bertuzzi *et al*., 2013 and Ejoh *et al*., 2016). The daily consumption of minimum 400 g of leafy vegetables for the prevention of heart disease, cancer, type II diabetes and obesity have been recommended by WHO and FAO in 2003 (Ghasemzadeh *et al*., 2012 and Jianging *et al*., 2005). In view of the study reported above there is a need for comprehensive determination of antioxidants in vegetables. Present study was aimed to measure the beta-carotene, total phenolic content, vitamin C and antioxidant activity of five different vegetables commonly grown and consumed in Nigeria.

MATERIALS AND METHODS

Plant Materials: Five species of leafy vegetables (Table 1) were used. The vegetables were collected from the germplasm field of the National Horticultural Research Institute, Ibadan, Nigeria. The vegetables were washed, before air dried, the roots and harder part of the stem were removed and chopped the remaining into pieces. Moisture content was determined according to the Association of Official Analytical Chemists (1995). Plant samples were dried at 60^0C for 48 h in an oven, milled into fine powder, and stored in plastic bags and stored for less than 1-month at -20^0 C prior to extraction.

Preparation of Methanolic Extracts: Five grams of crushed paste of each species was refluxed in 50 ml methanol for 2 hrs followed by filtration. The refluxing procedure was repeated and filtrates were pooled. Organic solvents (used in single or mixed forms), especially polar ones, are suitable for extraction of biologically active plant ingredients (Das *et al*., 2012). In this study, methanol was the most highly polar organic solvent for extraction.

Determination of total phenolic content: Total phenolic content of methanolic extracts was measured using the Folin–Ciocalteu reagent method as described earlier (Kumar *et al*., 2015) basis of the standard curve of Gallic acid concentration range from 10 to 50 mg/ml (r2 = 0.998). Total phenolic content calculated from the calibration curve was expressed as mg of gallic acid equivalent (GAE)/g100dry weight.

DPPH scavenging assay: The method of Wang *et al* 2011 was used for the determination of scavenging activity of DPPH radical in the

extract solution. A portion of 0.135 mM DPPH prepared in methanol containing 0.5 mL of the extracts. The reaction mixture was vortexed thoroughly and left in dark at room temperature for 30 min. The absorbance was measured spectrophotometrically at 517 nm. The scavenging ability of the plant on DPPH was calculated using the equation: DPPH scavenging activity (%) = [(Abs control – Abs sample)]/(Abs control)] ×100, where Abs control is the absorbance of DPPH + methanol; Abs sample is the absorbance of DPPH radical + sample extract or standard. The results were expressed in % % inhibition = DPPH scavenging activity (%).

Determination of beta-carotene in Samples: 0.5g of chopped and homogenous samples was esterify with 5 mL of 10% trichloroacetic acid in methanolic solvent, which allowed to stay overnight to remove the green pigment and thoroughly washed with distilled water and remaining extract was added with 5ml cold Acetone and 5ml ethanol, until the total loss of pigmentation. 3ml of distilled water was added which was later partitioned with 10ml petroleum ether. The ether phase was passed through Neutral Alumina (activity III) packed column. The column was eluted with petroleum ether and the first band was pooled into 25ml volumetric flask. The extract was read at 420nm to determine beta –carotene content calculated are as follows;

$$C\ (\mu g/g) = \frac{A \times \text{Volume (ml)} \times 10^4}{A1\% \times 1cm \times \text{sample weight (g)}}$$

Where A = Absorbance, A1 % = absorption coefficient of beta –carotene in PE (2592) (Rodriguez-Amaya and Kimura, 2004)

Determination of Ascorbic acid content: Vitamin C was determined in fresh vegetable samples by dichlorophenol Indophenol dye reduction method according to Ejoh *et al*., 2016.

Statistical Analysis: Data analysis was carried out with Systat statistical program version 16 (SPSS Inc., USA). Analysis of variance was used to evaluate phytochemical characteristics and the antioxidant activity of vegetables. Means were separated with Tukey's tests at $p<0.05$. Simple linear correlation analysis was run between the parameters determined.

RESULTS AND DISCUSSION

Antioxidant activity: The presence of different antioxidant components in plant tissues especially fruits and vegetables make it relatively difficult to measure each antioxidant component separately. In the present study, total antioxidant activity was calculated using DPPH. The antioxidant activity ranged between 37.01% for scent leave to 94.46% for Seseme (Table 1). These results corroborated with the earlier reports (Mbbenyanne *et al*., 2017; Wang *et al*., 2011). Nino-Nedina *et al.* (2014) reported that garden egg leaves contains water soluble components that possess antioxidant activity. The free radical scavenging activity of the antioxidants present in plants or their extracts are routinely evaluated (at room temperatures) using synthetic radicals like that of DPPH· in the presence of polar organic solvents. DPPH· is a stable free radical, which is capable of accepting an electron or a hydrogen radical to become a stable diamagnetic molecule. Generally, the scavenging of DPPH· radicals is used to evaluate chain-breaking activity in the propagation phase of lipid (and protein) oxidation. The mechanism of action involves the reaction of specific compounds or plant extracts with DPPH· in methanol.

Total phenolic content: Phenolics are aromatic secondary plant metabolites associated with color, sensory qualities, nutritional and antioxidant properties of food (Das *et al*., 2012). There is a variation in the total phenolic content of the vegetables investigated; the values of the total phenolic content varied from 39.46 mg/100g GAE for scent leave to 165.46 mg/100g GAE for Sesame leave. The higher phenolic content of some vegetables is due to their individual phenolic components. The results of the phenolic content analysis of 5 vegetables are given in Table 1. Similar results for total phenolic content have been reported by Sreeramulu and Raghunath for some root tuber and vegetables consumed in India.

Vitamin C content: Vitamin C is a water soluble vitamin required in high amount, as its loss is frequent from body. It participates in reversible oxidation-reduction system and acts as an antioxidant. The vitamin C content of the vegetables under investigation varied from 16.5 mg/100g for garden egg leave to as high as 23.4mg/100g for Sesame leave (Table 1). Ascorbic acid also called as vitamin C, it is found particularly in citrus fruits and green vegetables. It is essential in maintaining healthy connective tissue, and is also thought to act as an antioxidant. Severe deficiency causes scurvy diseases a lack of vitamin C in your body happens because of a lack of sufficient amounts of vitamin C in your diet (Ejoh et al., 2016).

Ascorbic acid is one of the important water soluble vitamins. It is essential for collagen, carnitine and neurotransmitters biosynthesis. Most plants and animals synthesize ascorbic acid for their own requirement. However, apes and humans cannot synthesize ascorbic acid due to lack of an enzyme gulonolactone oxidase (Ghasemzadeh, 2012). The current US recommended daily allowance (RDA) for ascorbic acid ranges between 100–120 mg/per day for adults.

Beta-carotene content: Beta-carotene is an organic, strongly coloured red-orange pigment abundant in plants and fruits. It is a member of the carotenes, which are terpenoids, biochemically synthesized isoprene. It protects the body from damaging molecules called free radicals. The beta-carotene content in the studied leafy vegetables ranged from 9,000 ug/100g wild lettuce to 24,900 ug/100g black nightshade. In the body, beta-carotene converts into vitamin A. It has been reported that vitamin A is good for vision, eye health, for a strong immune system, and for health skin and mucous membranes. Dietary carotenoids are thought to provide health benefits in decreasing the risk of disease, particularly certain cancers and eye disease (Wang *et al*., 2011)

Correlations between phenolic content and antioxidant capacity: A positive correlation is observed between total phenolic content and antioxidant activity of the vegetables measured by all the DPPH assay (Figure 1). Highest correlation between total phenolic content and antioxidant activity (R2 = 0.8439). Therefore, phenolic compounds contribute significantly to the antioxidant capacity of the investigated vegetables. These results arein agreement with the findings of many research groups who have reported such positive correlations between antioxidant activity and total phenolic content. A poor correlation was observed both of beta-carotene and vitamin C with DPPH antioxidant scavenging activity. The coefficient of variation of 0.0198 and 0.1146 for beta-carotene and vitamin C respectively in relation to DPPH antioxidant activity.

CONCLUSION

All five GLVs studied herein possess high antioxidant potential, and it is suggested that they be incorporated into the normal diet of the general population. The authors' results should enhance interest in evaluating various GLVs to be used in the development of new nutraceutical and pharmacological products. The consumption of these GLVs may play a vibrant role in preventing human diseases that involve free radicals, such as aging, cancer, and cardiovascular diseases. However, isolation and characterization of individual components, their *in vivo* antioxidant activities, and the various antioxidant mechanisms need further study. Because great variability was found in the quantity of antioxidant compounds present in different green leafy vegetables, it would be meaningful to study the influence of factors, such as stage of maturity and harvesting time on the content of antioxidant compounds.

REFERENCE

Baljeet, S., Yadav, B.S., Yadav, R., Yadav, R.B. and Garg, M. (2016) Antioxidant activity of various extracts of selected gourd vegetables. *J Food Sci Technol*: 53(4):1823–1833.

Bertuzzi, G., Tirillini, B., Angelini, and Venanzoni, R. (2013) Antioxidative of action of Citrus limonum Essential oil on skin. Eurp. J. Med. Plants.3:1-9.

Chekki, R.Z., Snoussi, A., Hamrouni, I. and Bouzouita, N. (2014) Chemical composition, antibacterial and antioxidant activities of Tunisian garlic (Allium sativum) essential oil and ethanol extract. *Mediterranean Journal of Chemistry:* 3(4), 947-956.

Clifford, T., Howatson, G.,West, D.J. and Stevenson, E.J. (2015) Potential Benefits of Red Beetroot Supplementation in Health and Disease. Nutrients: 7, 2801-2822.

Das, L., Bhaumik, E., Raychaudhuri, U. and Chakraborty, R. (2012) Role of nutraceuticals in human health. *Journal Food Science Technology*: 49(2):173–183.

Ejoh, S.I., Samuel, F.O. (2016) Identification of traditional green leafy vegetables, benefits to consumers and level of utilisation in a rural farming community in southwest Nigeria: qualitative findings. *West Afr J Food Nutrition*: 13(1):10–23.

Ghasemzadeh, A., Azarifar, M., Soroodi, O. and Jaafar, H. Z. E. (2012). Flavonoid compounds and their antioxidant activity in extract of some tropical plants. *Journal of Medicinal Plants Research*, 6, 2639-2643.

GÚlcin˙I (2012). Antioxidant activity of food constituents: An overview. Arch Toxicology 86:345-91.

Jiangning, G, Xinchu,W., ,Hou,W., Qinghua, L., Kaishun, B.(2005) Antioxidants from a Chinese medicinal herb – *Psoraleacorylifolia* L. Food Chem.:91:287-92.

Kumar, H., Kaur, C. and Madhav, J.V. (2015) A Comprehensive Evaluation of Total Phenolics, Flavonoids Content and invitro Antioxidant Capacity of Selected Fruits and Vegetables. *Research Journal of Agricultural Sciences*: 6(6): 1186-1189.

Mbhenyane, X. (2017). Indigenous foods and their contribution to nutrient requirements. S Afr J Clin Nutr.; 30(4):5–7.

Mohan, R., Birari, R., Karmase, A., Jagtap, S. and Bhutani, K. K. (2012). Antioxidant activity of a new phenolic glycoside from Lagenaria siceraria Stand. Fruits Food Chemistry, 132, 244–251.

Nino-Medina, G., Muy-Rangel, D., Gardea-Bejar, A.,Gnzalez- Aguilar, G., Heredia, B., Baez-Sanudo, M., ASiller-Cepeda, J. and Velezdela –Rocha, R. (2014) Nutritional and Nutraceutical Components of Commercial Eggplant Types Grown in Sinaloa, Mexico. Not Botanicae Horti Agrobotanici: 42(2):538-544.

Sreeramulu D, Raghunath M. (2010). Antioxidant activity and phenolic content of roots, tubers and vegetables commonly consumed in India. Food Res Inter; 43:1017-20.

Stadlmayr, B., Charrondiere U.R., Enujiugha, V.N. (2012). West African food composition table. Rome: Food and Agriculture Organization of the United Nation.

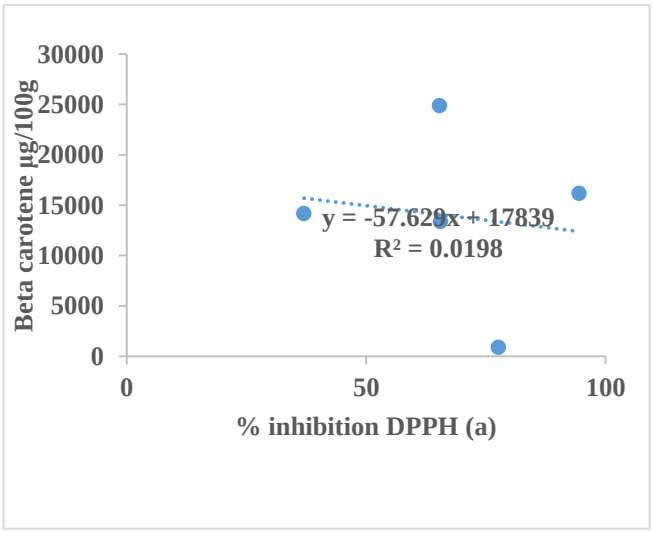
Suganya, D., Fathima, M. and Kanimozh, K. (2016) Antibacterial and phytochemical analysis on Brassica oleracea var. botrytis Linn. International Journal of Applied and Pure Science and Agriculture: 21, 2394-823X.

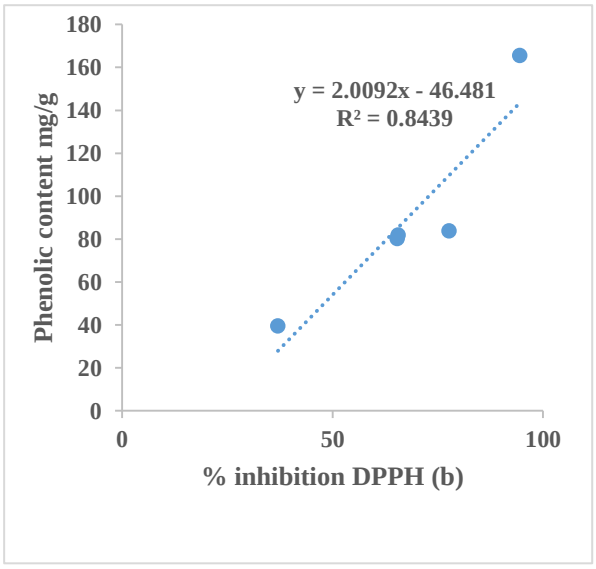
Wang, S., Melnyk, J.P., Tsao, R., and Marcone, M.F. (2011). How natural dietary antioxidants in fruits, vegetables and legumes promote vascular health. Food Res Inter.; 44:14-22.

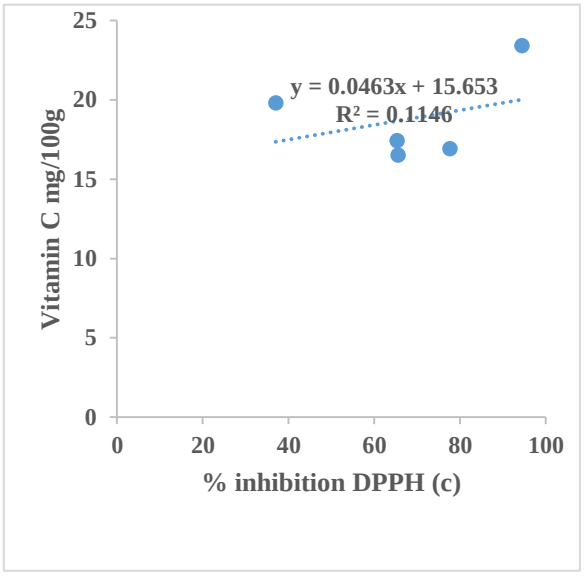
Table 1: Antioxidant activity DPPH, total phenols, Beta-carotene and vitamin C content of the vegetables.

Sample scientific names	Common / native names	Vitamin C mg/100g	Beta-Carotene µg/100g	Vit A(mcg RAE µg/100g	Phenolic content mg/g	DPPH % inhibition
Ocimum gratissium	Scent leaves/Effirin	19.8 ± 1.2^{b}	14,200 ± 25.7^{c}	1,183 ± 9.6^{c}	39.46 ± 2.1^{c}	37.01 ± 1.3^{d}
Solanum gilo	Garden egg leaves/Efo igbo	16.5 ± 1.4^{cd}	13,400 ± 31.6^{c}	1,117 ± 8.9^{c}	81.83 ± 2.9^{b}	65.56 ± 1.8^{c}
Solanum nigrum	Black nightshade/ Efo Odu	17.4 ± 0.9^{c}	24,900 ± 21.8^{a}	2,075 ± 9.5^{a}	80.19 ± 2.4^{b}	65.34 ± 1.4^{c}
Launaea taraxacifoila	Wild lettuce//Yanrin	16.9 ± 1.5^{cd}	9,000 ± 23.7^{d}	750 ± 5.3d	83.80 ± 2.1^{b}	77.64 ± 1.5^{b}
Sesamum radiatum	Benniseed/ ewe atura	23.4 ± 1.1^{a}	16,200 ± 31.1^{b}	1,350 ± 9.8^{b}	165.46 ± 3.4^{a}	94.46 ± 1.9^{a}

Values with same superscript are at par and non-significantly different from each other. Values with different superscript differ significantly ($p<0.05$).Values are means of triplicate batch analysis ± SE Retinol activity equivalent (RAE): conversion of 12 µg β-carotene to 1 µg RAE was used (FAO/INFOODS, 2012).







1: correlation between % inhibition DPPH scavenging activity (a) beta-carotene, (b) with phenolic content, (c) with vitamin C.

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EFFICACY OF INSECTICIDES ON FRUIT YIELD AND FRUIT DAMAGE OF EGGPLANTS (*SOLANUM MELONGENA* L.) IN OGBOMOSO, OYO STATE, NIGERIA

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ABSTRACT
Field trials were conducted during 2016 and 2017 raining seasons at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, to determine the effects of leaf extracts of Pawpaw, Tobacco and Cashew on insect pests of three selected eggplant varieties. Synthetic insecticide (Lambdachyalothin) and untreated plants were included in the experiment for comparison and each treatment was replicated three times. The experiments were laid out in Randomized Complete Block Design. Data were collected on insect pests, fruit damage and fruit yield. Four major insect pests of eggplant – *Zonocerus variegatus, Spodoptera litoralis, Leucinodes ornabalis* and *Epilachna* species were observed. Among the tested varieties, *S. depressum* had the least significant ($P< 0.05$) infestation. All the tested leaf plant extracts were effective in the control of the observed insect pests when compared with the level of insect pest attack on untreated plants. However, cashew extract had the highest insecticidal efficacy (55%) compared with other tested plant extracts while insecticidal potential of pawpaw extract was comparable to tobacco extracts. Meanwhile, none of the tested plant leaf extracts was effective as Lambdachyhalothrin in the control of the observed insect pests. Among the tested varieties, *Solanum depressum* had highest fruit yield (3.45 - 3.88 t/ha) and least fruit damage.

Keynote:*Solanum species, zonocenis variegate, epilachna species, leucinodes ornabadi, lambdachyhalothrin*

INTRODUCTION

Eggplant (*Solanum melongena* L.) is a short-lived perennial herb that belongs to the family *Solanaceae*. In the tropical part of Africa, it is grown as an annual plant and is one of the most common fruit vegetables probably the third after tomato and onion, and before okra (Grubben and Denton, 2004). Eggplant is well adapted to both wet and dry season cultivation. In West Africa, the fruits (eggfruits) are eaten in its raw state, cooked or fried with spices in stews, or dried and pound as condiments (Fayemi, 1999; AVRDC, 2008). Eggplants are a good source of Calcium, Phosphorus and Iron salts which enhances bone and blood cell formation in the body, as well as a reasonable source of vitamin A (Carotene), Vitamin B-complex and vitamin C which are all essential for good health (Fayemi, 1999; Schippers, 2000; Romain, 2001). In spite of the economic and nutritional value of the crop, production is hampered by some field insect pests. These include; *Spodoptera litoralis*, *Zonocerus variegatus*, *Epilachna* species, *Leucinodes ornabolis.* They have been reported as major insect pests of eggplant (Rashid *et al*, 2008 Raju *et al*, 2007, Onekutu, 2011). They are cosmopolitan field pests causing more than 80 % damage to the eggplant right from the nursery stage to harvest (Ali *et al.* 1994; Chakraborti and Sarkar, 2011). Damage caused by these pests can either be direct and indirect which in turn results in broad based problems. The common approach to control is the use of synthetic insecticides. Literatures have it that most of these synthetic insecticides cause environmental pollution, insect pest resistant and resurgence, unavailability at critical point and carcinogenesis (Singh and Saratchandra, 2005; Isman, 2008). The aforementioned problems call for the alternative to the use of synthetic insecticides. Several alternatives have been proposed and the only environmental friendly and cost-effective approach is botanical insecticides (Isman, 2006). Meanwhile, botanical insecticides have been described as the use of natural chemical extracted from plants to control menace of insect pests attack (Isman, 2008). Botanical insecticides are biodegradable and are effective in pest management programs (Isman, 2017). They interfere with growth, feeding and reproduction of insects (Copping and Menn 2000). However, pesticides of plant origin are gaining serious attention among the

farmers that are conscious of the safety of their environment and this play a vital role in organic farming. Therefore, this experiment was conducted to evaluate the insecticidal potential of selected plant extracts against major insect pests of egg plant

MATERIALS METHODS

Study site: The experiment was conducted at the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, between November 2016 and May, 2017. The eggplants varieties seeds used for this study were procured from the Institute of Agriculture Research and Training, Ibadan (IAR&T) in the year, 2016.During the experimental period minimum and maximum temperature ranged from 5.7 and 24.4 ^{0}C and 32.2 – 34.8 ^{0}C, Rainfall distribution ranged between 19.2 and 63.5 mm while relative humidity ranged between 88 and 92%.

Experimental Design and Management: The experimental land was ploughed and harrowed once. Each plot was arranged and demarcated in a Randomized Completed Block Design (RCBD) with three replicates. The plot size was 2 x 2 m with a planting space of 0.5 x 0.5 m between and within the plant rows respectively. Two to four seeds per hole of the eggplant varieties (*S. depressum, S. escullantum, S. sapientum*) were planted separately which was later thinned to one plant per stand after two weeks after transplanting planting. Manual weeding was done fortnightly till maturity.

Preparation of Plant extracts: Freshly collected leaves of *Anacadium occidentalis*, Nicotiana tabacum and *Carica papaya* were washed to remove sand, dust and surface contaminants. The plant leaves samples were air dried for three days to reduce the moisture content. One thousand grammes 1000g of each plant sample was crushed separately with electric blender and later soaked in a 10- litre bucket containing 2000 ml of water for 12 hours. Filtration was done with muslin cloth and filtrates collected were stored in a 10- litre keg. 10 g of taxapol, 20 g of salt, 20 g of black soap, and 20 g of nitrisol were added to the filtrate collected and this served as stock solution for the experiment. Unsprayed plots and synthetic insecticide (Lambdacyalothrin) was also included for comparism. Each of the synthetic and botanicals were diluted with 1000 ml of water.

Treatment Application: From the extract, 100 ml was diluted with 900 ml of water. Foliar application was done with hand-held sprayer (2-litre capacity). The spraying was done early hours of the morning to avoid photo degradation of the extracts. Four weekly applications were made at 7-day interval. Lambdachyalothrin was applied at manufacturer's recommended rate.

Data Collection and Analysis: Data were collected on insect population densities and this was done early in the morning when they were relatively inactive by visual observation from the two middle plant rows. The agronomic data collected were based on plant heights, percentage defoliated leaves, and number of fruits damaged. The yield was calculated in kg/ha. Data were collected were subjected to analysis of variance (ANOVA) and means were separated with Ducan multiple range text at 5 % probability.

RUSULTS

Result presented in Table 1 shows the effect of different plant extracts and Synthetic insecticide (Lambdacyahalothrin) on *Epilachyna* spp on eggplant. At 1 week after treatment (WAT) no significant different was observed between the treated plants and untreated plants. Meanwhile, all the tested plant extracts had the same significant control of *Epilachna* spp irrespective of the varieties at 2 WAT. At 3 WAT, none of the applied plant extract was effective as Lambdachyalothrin but the plant extracts exhibited the same insecticidal action. Meanwhile, all the tested plant extracts compete effectively with Lambdacyhalothrin in the control of *Epilchna* spp at 4 WAT but att 5WAT, *N. tabacum* and *A. occidentalis* extracts applied on *S. depresum* and *S. escullantum* had the same significant *Epilachna* spp infestation with Lambdacyhalothrin. The result presented on Table 2 indicates effect of insecticides on *Z. variegatus* population. The applied plant extracts and Lambdachyalothrin had same significant effect on *Z. variegatus*at 1 WAT meanwhile at 2 WAT, untreated plants had highest *Z. variegatus* infestation. However, cashew leaf extracts treated plantshad least significant infestation when compared with pawpaw and Tobacco leaf extractsirrespective of the varieties.However, at 3 WAT, all the tested plant extracts exhibit the same insecticidal potentials in the control of *Z. variegatus*. The table 3 shows the effect of insecticides on *S. litoralis*. The plant extracts

were not effective as Lambdachyalothrin against *S. litoralis* infestation but untreated plants had highest *S. litoralis* infestation except variety *S. depresum* at 1 WAT but at 2 WAT, pawpaw extracts effectively controlled *S. litoralis* on *S. depresum* when compared with other varieties but the untreated plants were heavily attacked by *S. litoralis*. At 3 WAT, Tobacco and Cashew leaves extract applied on *S. escullantum* and *S. sapientum* had significant low *S. litoralis* infestation when compared with pawpaw leaves extract applied on *S. escullantum* and *S. sapientum.* Table 4 showed the effect of insecticides on *L. ornabalis.* At 3 WAT, application of pawpaw leaf extracts on *S. escullantum* significantly failed to control *L. ornabalis* infestations. No significant different was detected between tobacco and cashew leaf extracts against *L. ornabalis* on *S. Escullantum* and *S. Serpentium* plants. Meanwhile, *S. Depressum* treated with Lambdachyalothrin had least *L. ornabalis* infestations compared with other varieties at 3 WAT. treated *S. depressum* plants with pawpaw leaf extracts did not exhibit insecticidal effects on *L. ornabalis* infestation while tobacco leaf extracts had the same insecticidal control of *L. ornabalis* on *S. escullantum* and *S. sapientum* plants at 4 WAT, similar trend was observed on *S. escullantum* and *S. sapientum* plants treated with cashew leaf extracts at 4WAT. Application of tobacco and cashew leaf extracts on *S. escullantum* and *S. sapientum* had the same insecticidal control of *L. ornabalis* while pawpaw leaf extracts failed to control *L. ornabalis* infestation on *S. escullantum* plants at 5 WAT. As presented in table 5, *S. depressum* treated with Lambdacyalothrin had the least fruit damage (6.67%) compare with other two varieties. *S. escullantum* and *S. serpientium* treated pawpaw leave extracts had higher fruit damage(50.7 and 52.3% respectively) compared with *S. depressum* which had least significant fruit damage (12.0%). Among the varieties treated with tobacco leave extracts *S. serpientium* had the highest fruit damage (48.3%) while the least fruit damage was observed on *S. depressum* (1.7 %). *S. depressum* treated with cashew leave extract had least fruit damage (9.33%) followed by *S. escullantum* which had (34.7%). Among the plant extracts, cashew leave extracts treated plants had least fruit damage followed by tobacco leave extracts meanwhile, the least fruit damage was observed on Lambdachyalothrin treated plant compared with the other treatments. The table 6 shows the effects of insecticides on fruit yield of eggplant. The highest fruit yield was observed on *S. depressum* treated with Lambdachyalothrin (4.33t/ha) compared with other varieties treated the same insecticide. *S. escullantum* and *S. serpientium* are treated with pawpaw leaves extract had significant lower fruit yield than *S. depressum* which had (3.45 t/ha). Tobacco and cashew leaves extract had the same significant effect on the fruit yield. Meanwhile, *S. depresum* treated with tobacco and cashew leaves extract which had the higher yield than the *S. escullantum* and *S. serpientium*. The applied plant extract on *S. escullantum* and *S. serpientium* which had the same significant effect with Lambdachyalothrin.

DISCUSSION

Throughout the course of study, four major insect pests were observed which caused major economic damage to the eggplant. Those insects caused various degree of damage to the leaves, flowers and fruits. This goes in line with earlier report by Rice and Pedigo (2014) who reported that various insect pests attacked different phenology of crops. *Z. variegatus* and *Epilachna* species were discovered to have attacked the leaves but the level of their infestations decreased as the age of the plants increased this is an indication that the aforementioned insect pests are leave eating insects. This observation agreed with Indra and Kamini, (2012) who reported that adult flea beetles feed on the cotyledons and leaves of young plants and this resulted into a short-hole effect. Although, very few of the adult flea beetles were found at flowering and fruiting stages of the target crop. However, *S. litoralis* and *L. ornabolis* were not observed at vegetative stage in all the tested varieties but the largest population densities were discovered at flowering and fruiting stages of the target crop. Yield has been reported as the ultimate aim of farmers but insect pests infestations have been described as the major factors that hindered the hope of our local farmer in getting appreciable yield (Adebayo, 2003; Alao, 2015). Yield obtained on *S. depressum* is considerably higher than that of other tested varieties. This can be attributed to the low level of insect infestation observed on *S. depressum*. This is an indication goes in line with Alao (2015) who reported that yield loss corresponds to the level of insect infestation. The synthetic insecticide which

produced the highest yield constitutes the environmental hazard such as environmental pollution, insect resistance and resurgence and most of these insecticides are carcinogenic (Isman, 2008; Olaifa, 2004; Ileke, *et al*; 2012). Despite inadequacy of plant extracts in the protection of crops against insect infestations when compared with synthetic insecticides, the environment is better protected since botanical insecticides have been reported as ecological and environmentally friendly (Alao, 2009; Olaniran, *et al* 2012). Also, botanical insecticides have been reported to have gained advantage over synthetic insecticides through quick decomposition and protect the food through contamination and safety of live is granted (Khater, 2012).

REFERENCES

Adebayo, T.A; Adedeji, O.S; Olayeni, T.B; Emiola, I.A. and Adeleke, G.O. (2003). Toxic effects of extracts of *Petiveria alliacea* on laboratory rats. *Journal* of *Research and Production*, 8: 44-58.

Akhtar, Y; Yeoung, V.R. and Isman, M.B. (2008). Comparative bioactivity of selected extracts from Meliaceac and some commercial botanical insectides against two noctuid caterpillar, *Trichoplusia and Pseudaletiaunipuncta. Phytochemistry Reviews*. 7: 77-88

Ali, M. I. S; Ahmed, S. and Rahman, T. (1994). Host plant resistance in brinjal against the brinjal shoot and fruit borer, Leucin odes orbonalisGuenee, pp 52 – 53 in annual presearch report, 1993 – 94 Ent DIV BAR Joycebpur, Gazipur, Bagladesh

Alao, F.O. (2009). Insecticidal principle of allellochems derived from *Tephrosiavogell i*and *petiverianalliacea*post flowering insect pests of cowpea. M. Tech Dissertation submitted to Ladoke Akintola University of Technology, Ogbomoso, Nigeria. 55pp

Chakraborti, S. and Sarkar, P.K. (2011). Management of leucinodes orbonalis (Quenee) on *Solanum macrocarpon* on eggplalnts during the rainy season in India. *Journal* of *Plant Protection. Res. 51(4): 352-328.*

Copping, L.G. and Menn, J.J. (2000). Biopesticides: a review of their action, applications and efficacy. *Pest Management Science*, 56:651–676

Ileke, K.D. and Bulus, D.S. (2012). Response of Lesser grain borer, *Rhizoperthadominica* (Fabr.) (Coleoptera: Bostrychidae) to powders and extracts of *Azadirachta indica* and *Piper guineense* seeds in stored wheat grains. *Jordan J. Biol Sci*., 5(5): 315 – 320.

Indra, P.S. and Kamini, V. (2003). Control of flea beetle, Phyllotretanemorum L. (Coleoptera: Chrysomelidae) using locally available natural resources. Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal

Isman, M.B. (2006). Botanical insecticides, deterrents and repellants in modern Agriculture and increasingly regulated World. *Annual Review of Entomology*. pp 51:45-66.

Isman, M.B. (2008). Perspective Botanical Insecticides for richer for poorer , pest Management science 64, 8- 11

Khater, H.F. (2012). Prospects of botanical biopesticides in insect pest management. *Journal of Applied Pharmaceutical Science*, 02 (05): 244 – 259.

Larry P. P. and Martin, E. Rice Entomology and Pest Management 2014

Diaz, F.J; Mcleod P.J. and Johnson, D.T. (2004). Seasonal occurrence and distribution of eggplant flea beetle, Epitrixfuscacrochtcoleoptra: chysomelidea) on egg plant in Arkansas. *Kanses Entomol* ,77: 80-88.

Olaniran, A .O; Alao, F. O; Yusuf, S. Y. and Adebayo T.A. (2016). Effect of selected plant extract formulation on Insect pests and Nutritional Quality of Eggplant fruits. *International Journal of Applied Agricultural* and *Apicultural Research*, 12(2):59-70.

Olaifa, J.A. and Adebayo, T.A. (2003). Procedure for evaluation of toxicity and dosage and plant-based pesticides. *Journal of Annals of Agriculture Sciences.* 3(2): 31-37.

Onekutu, A. (2011). Bioecology and management of Leucin odes Orbonalis Guenee on solanum of giloRaddi unpublished PhD These in University of Ibadan.

Roman, H. R. (2001). Crop production in Tropical Africa DGIC, Brussels, BELGUM PP 444 – 449.

Schippers, R. R. (2000). Africa Indigenous vegetables Chathan, U. K. 214 PP

AVRDC (2008) – The World Vegetable Center, Shanhua, Taiwan. AVRDC Publication No. 09-729. 64p.

Cork, A. S; Alam, F.M.A. Rouf, N. and Taleker, N.S. (2005). Female sex pheromone of eggplant fruit and shoot borer res 93: 107 – 113

Fayemi, P.O. (1999). Nigeria vegetables, Heinemann Educational Books Plc.

Romain, H.R. (2001). Crop protection in Tropical Africa DGIC, Brussels, Belgium, pp 444-449.

Schippers, R.R. (2000). Africa Indigenous Vegetables Chatham, U.K. pp 214-218.

Ghimire, A. and Khatiwada, B.P. (2001). Use of pesticides in Commercial vegetable cultivation in Tandi, Eastern Chitwan, Nepal. Survey report submitted to Department of Entomology Institute of Agricultural and Animal Science (IAAS), Rampur, Chitwan, Nepal. pp 10.

Jaeger, P.M.L. and Hepper, F.N. (1986). A review of the genus solanum in Africa, In: SolanaceaeBiology and Systemic (eds) W.G.D Arcy (New York: Columbia University Press). pp 41- 55.

Seam Search. (2011). Heterosis Breeding in Eggplant (Solanum melongena L) : Gains and Provocations.

Table 1: Efficacy of Insecticides on Epilachna species Population

		Weeks after application				
Treatments	Varieties	1	2	3	4	5
Labdacyalothrin	V1	1.01^{a}	1.29^{b}	0.71^{b}	0.71^{c}	0.71^{c}
	V2	0.91^{a}	1.39^{ab}	0.71^{b}	0.71^{c}	0.71^{c}
	V3	1.39^{a}	1.29^{b}	0.71^{b}	0.71^{c}	0.71^{c}
Control	V1	1.65^{a}	2.12^{ab}	1.94^{a}	2.01^{ab}	1.74^{ab}
(untreated)	V2	2.04^{a}	2.04^{ab}	1.76^{ab}	1.57^{ac}	1.39^{ac}
	V3	2.12^{a}	2.35^{a}	2.09^{a}	2.19^{a}	2.02^{a}
Pawpaw Leaves	V1	1.48^{a}	1.48^{ab}	1.39^{ab}	0.91^{c}	1.17^{bc}
	V2	1.77^{a}	1.66^{ab}	1.39^{ab}	1.01^{c}	0.88^{c}
	V3	1.48^{a}	1.65^{ab}	1.58^{ab}	1.27^{bc}	1.17^{bc}
Tobacco Leaves	V1	1.37^{a}	1.48^{ab}	1.39^{ab}	0.71^{c}	0.71^{c}
	V2	1.48^{a}	1.86^{ab}	1.29^{ab}	1.17^{c}	0.91^{c}
	V3	1.48^{a}	1.48^{ab}	1.39^{ab}	1.01^{c}	1.01^{bc}
Cashew Leaves	V1	0.91^{a}	1.39^{ab}	1.65^{ab}	0.71^{c}	0.71^{c}
	V2	1.57^{a}	1.39^{ab}	1.39^{ab}	1.01^{c}	0.88^{c}
	V3	1.76^{a}	1.39^{ab}	1.47^{ab}	1.01^{c}	1.05^{bc}

Means with the same alphabet(s) are not significantly different at $p<0.05$
V1 *Solanum depressum*, V2 *Solanum escullantum* and V3 *Solanum serpentium*

Table 2: Efficacy of Insecticide on *Zonocerus variegatus* Population

		Weeks after application				
Treatments	Varieties	1	2	3	4	5
Lambdacyalothrin	V1	1.01^{a}	1.95^{abc}	0.71^{c}	0.71^{c}	1.01^{a}
	V2	1.27^{a}	1.95^{bcd}	0.91^{bc}	0.71^{c}	0.91^{a}
	V3	1.29^{a}	2.08^{abcd}	1.01^{bc}	0.71^{c}	01.01^{a}
Control (Untreated)	V1	1.56^{abcd}	2.08^{ac}	1.93^{ab}	2.01^{ab}	1.39^{a}
	V2	1.66^{a}	2.61^{ab}	2.74^{a}	2.54^{a}	1.39^{ac}
	V3	1.68^{a}	2.73^{a}	2.71^{a}	2.54^{a}	1.27^{a}
Pawpaw Leaves	V1	1.01^{a}	1.72^{cd}	1.39^{bc}	1.27^{bc}	0.71^{a}
	V2	1.48^{a}	2.03^{abcd}	1.57^{bc}	1.39^{bc}	1.39^{a}
	V3	1.68^{a}	2.04^{abcd}	1.76^{bc}	1.39^{bc}	1.39^{a}
Tobacco Leaves	V1	1.39^{a}	2.02^{abcd}	1.01^{bc}	1.27^{bc}	1.01^{a}
	V2	1.64^{a}	2.41^{abc}	1.48^{bc}	1.48^{bc}	1.01^{a}
	V3	1.56^{a}	2.08^{abcd}	1.47^{bc}	1.18^{bc}	1.17^{a}
Cashew Leaves	V1	1.01^{a}	1.47^{d}	1.48^{bc}	0.71^{c}	0.91^{a}
	V2	1.29^{a}	1.94^{bcd}	1.48^{bc}	1.01^{bc}	1.01^{a}
	V3	1.39^{a}	1.86^{bcd}	1.56^{bc}	1.27^{bc}	1.27^{a}

Means with the same alphabet(s) are not significantly different at $p<0.05$
V1 *Solanum depressum* , V2 Solanum*escullantum* and V3 *Solanum serpentium*

Table 3: Efficacy of Insecticide on *Spodoptera litoralis* Population

	Weeks after application			
Treatments	Varieties	1	2	3
Lambdacyalothrin	V1	0.71^{c}	0.71^{e}	0.71^{d}
	V2	1.29^{bc}	0.91^{de}	0.71^{d}
	V3	1.10^{bc}	1.01^{de}	0.71^{d}
Control (Untreated)	V1	0.71^{c}	0.71^{e}	0.71^{d}
	V2	2.03^{a}	2.48^{a}	2.66^{a}
	V3	2.03^{a}	2.34^{ab}	2.61^{ab}
Pawpaw Leaves	V1	0.71^{c}	0.71^{e}	0.71^{d}
	V2	1.48^{ab}	1.64^{ac}	1.90^{bc}
	V3	1.56^{ab}	2.12^{ac}	1.90^{bc}
Tobacco Leaves	V1	0.71^{c}	10.71^{e}	10.71^{d}
	V2	1.39^{abc}	1.54^{ec}	1.56^{c}
	V3	1.58^{ab}	1.64^{ac}	1.43^{cd}
Cashew Leaves	V1	0.71^{c}	1.71^{e}	1.71^{d}
	V2	1.76^{ab}	1.27^{ec}	1.39^{cd}
	V3	1.68^{ab}	1.58^{ec}	1.39^{cd}

Means with the same alphabet(s) are not significantly different
V1 *Solanum depressum,* V2 Solanum *escullantum* and V3 Solanum *serpentium*

Table 4: Effect of Insecticide on L. ornabolis Population in Eggplant Field

	Weeks after application			
Treatments	Varieties	3	4	5
Lamdacyhalohtrin	V1	0.71^{b}	0.71e	1.01^{b}
	V2	1.01^{ab}	0.71e	1.25^{ab}
	V3	1.26^{ab}	0.71e	1.29^{ab}
Control (Untreated)	V1	0.71^{b}	1.71^{b}	1.09^{b}
	V2	1.25^{ab}	1.91^{a}	1.56^{a}
	V3	2.09^{a}	2.23^{a}	1.61^{a}
Pawpaw Leaves	V1	0.71^{b}	0.71^{e}	1.01^{b}
	V2	1.86^{a}	1.95^{a}	1.53^{a}
	V3	1.65^{ab}	1.61^{ab}	1.45^{ab}
Tobacco Leaves	V1	0.71^{c}	1.71^{b}	1.71^{a}
	V2	1.76^{ab}	1.27^{cd}	1.39^{ab}
	V3	1.68^{ab}	1.58^{cd}	1.39^{ab}
Cashew Leaves	V1	0.71^{b}	0.71^{e}	1.01^{b}
	V2	1.48^{ab}	1.47^{ab}	1.39^{ab}
	V3	1.09^{ab}	1.48^{ab}	1.36^{ab}

Means with the same alphabet(s) are not significantly different at $p<0.05$
V1 *Solanum depressum* V2 *Solanum escullantum* V3 *Solanum serpentium*

Table 5: Percentage fruit damage of the three varieties of eggplant after Treatment

Treatments	Varieties	Fruit damage (%)
Lambdacyalothrin	V1	6.67[e]
	V2	16.7[d]
	V3	16[de]
Control (Untreated)	V1	19.7[d]
	V2	70.7[a]
	V3	03[a]
Pawpaw Leaves	V1	12[e]
	V2	50.7[b]
	V3	52.3[b]
Tobacco Leaves	V1	11.7[de]
	V2	41.3[bc]
	V3	48.3[b]
Cashew Leaves	V1	9.33[de]
	V2	34.7[c]
	V3	42.3[bc]

Means with the same alphabet(s) are not significantly different
V1 *Solanum depressum,* V2 Solanum *escullantum* and V3 *Solanum serpentium*

Table 6: Effects of insecticides on garden egg fruit yield

Treatments	Varieties	Fruit yield(t/ha)
Lambdacyalothrin	V1	4.33[a]
	V2	0.53[de]
	V3	0.69[de]
Control (untreated)	V1	1.73c
	V2	0.14[e]
	V3	0.17[de]
Pawpaw Leaves	V1	3.45b
	V2	0.24[e]
	V3	0.25[de]
Tobacco Leaves	V1	3.67[a]b
	V2	0.43[de]
	V3	0.5[de]
Cashew Leaves	V1	3.88b
	V2	0.45[de]
	V3	0.36[de]

Means with the same alphabet(s) are not significantly different at $p<0.05$
V1 *Solanum depressum,* V2 *Solanum escullantum and* V3 Solanum *serpentium*

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PRELIMINARY OBSERVATIONS ON THE RESPONSE OF SOYBEAN GENOTYPES TO FROGEYE DISEASE UNDER NATURAL CONDITIONS IN EBONYI STATE, NIGERIA

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ABSTRACT
Frogeye leaf spot (FLS) of soybean (*Glycine max* L.) is an important disease that causes significant seed yield loss in warm, humid regions of the world. The study was conducted with the objective to assess the response of soybean to source of FLS at the Teaching and Research Farm, Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria during 2021 late cropping season. Eight soybean genotypes were screened against FLS under natural condition. The experiment was laid out in a randomized complete block design and replicated three times. The data collected were disease incidence, severity and agronomic performance which were subjected to analysis of variance and the means were separated using Tukey at P<0.05. The results revealed that genotype TGX-1904-6F had the highest disease incidence (46.67%), followed by TGX-1989-19F (18.33 %) while TGX-1987-62F (5.00 %) had the least. Similarly, the result of the disease severity ranged from 1.00-3.77. TGX-1904-6F (3.77) had the highest, followed by SCSL-01 (2.47) while TGX-1987-10F (1.00) had the least. The result of resistant levels indicates that one soybean genotype (TGX-1987-10F) was highly resistant, five were resistant (TGX-1951-3F, TGX-1448-2E, TGX-1987-62F, TGX-1989-19F and TGX-1835-10F), one genotype was moderately resistant (SCSL-01) and one moderately susceptible (TGX-1904-6F). Five fungi organisms belonging to four genera were isolated from eight soybean seeds which includes *Aspergillus niger*, *Aspergillus flavus*, *Fusarium oxysporum*, *Penicillium* species and *Curvularia* species. *Aspergillus flavus* (38.30 %) had the highest percentage of occurrence while *Curvularia* species (2.13 %) had the least. The study recommended that the resistant genotypes could be further planted in other agro ecological zone to determine resistant genotypes against frogeye leaf spot disease in soybean.

Keywords: *Soybean, Resistance, Frogeye, Leaf, Spot*

INTRODUCTION

Soybean (*Glycine max*, L.) is an important legume plant that is cultivated all over the world, not only as a major source of oil and protein in livestock feeds but also for human consumption, soil fertility improvement and for producing industrial products such as soy inks, non-toxic adhesives, candles and paints (Hartman *et al.*, 2011). It has a high protein content (about 40 %) of good nutritional quality, and a high oil content (about 20 %) which, together with numerous beneficial nutrients and bioactive factors, make soybean the crop of choice for improving the diets of millions of people in developing countries (Ali, 2010). As a major source of oil and protein, soybean accounts for about 56 and 67 % of the total global oilseed production and world supply of protein to be consumed, respectively (USDA, 2014). Global soybean production rose nearly 10-fold, from 27 million tonnes in 1961 to 276 million tonnes in 2013 (FAOSTAT, 2013). Soybean production in Africa occupies 1.3% of the total world, area under soybean production representing 0.6% of the total production. In 2011, soybean was planted on 1.1 million ha of land in sub-Saharan Africa, which is approximately 1% of the total arable land. South Africa is the highest soybean producer in Africa, contributing about 35% of the total production, followed by Nigeria (27%) and Uganda (8.5 %) (FAOSTAT, 2013). The major factors that are expected to drive soybean production include land availability, the investment by private equities, international developmental organizations and banks into corporate farms, growth of the poultry market and the development of household consumption (Technoserve, 2011). Frogeye leaf spot of soybeans is a very severe disease in the warm and humid tropical and subtropical regions of the world. Frogeye leaf spot is primarily a disease of foliage even though stems, pods and seeds may also be infected. Frogeye leaf spot

(FLS) causes yield loss range from 23.7 to 32.5 % (Mittal, 2001). These decreases in yield are a result of reduced photosynthetic area, premature defoliation and reduced seed size. Since it is a fungal disease, its control through chemical practice is not effective, nor is it environment friendly. Various fungicides control the disease with dissimilar cost-benefit ratio (Das, 2015). Deployment of genetic resistance is the best approach for management of FLS disease. The resistance of genotypes may vary from region to region depending upon the strain of fungus prevalent in the area. Hence, the need to identify the fungi organisms associated with soybean and determine the resistant levels among the eight soybean genotypes to frogeye leaf spot disease.

MATERIALS AND METHODS

Experimental site: The experiments were conducted at the Teaching and Research Farm, Plant Pathology Laboratory, Federal College of Agriculture, Ishiagu, Ivo L.G.A. of Ebonyi, State with Latitude $5^0 56''$N and Longitude $7^0 41''$E South-eastern, Nigeria. It is in South-Eastern part of Nigeria, with annual mean temperature of 27 ^{0}C minimum and 33 ^{0}C maximum and average relative humidity of 88 %, with annual rainfall of 1350 mm to 2000 mm (Nwite *et al.*, 2008). The experiments were conducted during the late growing season July to September, 2021.

Source of the Soybean seeds: Soybean seeds were sourced from National Cereal Research Institute (NCRI), Badeggi, Minna, Niger State, Nigeria

Experimental design and field operation: Eight Soybean genotypes were evaluated for infection by frogeye leaf spot disease during 2021 cropping season. The land was manually prepared, clear with cutlass and stumping was done manually. Dimensions for each plot was 2 x 1 m with alley row of 1 m. The total land area was 96 m^2. The experimental design used was Randomized Complete Block Design (RCBD) with three replications. Seeds of each of the eight soybean genotypes were planted on three different rows with plant spacing of 15 x 50 cm. The seedlings were thinned to two per spot with thirteen spots per row. Five plants at the centre of the row for each genotypes were tagged and used for data collection throughout the experiment. Weeding was done manually as the need arose, starting from three weeks after sowing (Idowu *et al.,* 2013).

Disease Assessment

Frogeye Leaf Spot (FLS) assessment: Disease incidence and severity assessments of Frogeye Leaf Spot (FLS) was taken at 10 weeks after planting.

Disease incidence (DI) using the following formula

$$\text{Incidence} = \frac{NDP}{TNPP} x100$$

Where NDP = Number of Diseased plant, TNPP = Total number of plant per plot (Diseased and Healthy Plant) and 100 = percentage.

Disease severity for Frogeye Leaf Spot (FLS) was assessed through the spots development and rating of symptom expression with the aid of a visual scale (Table 1). Five plants per plot were selected and on each plant, the spread of spots on the area of one leaf at the second node to the achene were observed. Disease severity (DS) was calculated using the formula adopted from Gwary *et al*., (2009).

$$\text{Disease severity} = \frac{\Sigma n \times 100}{N \text{ x } S}$$

Where, Σ = Summation

n = number of infected leaves

N = Number of leaves assessed, S = Maximum numerical value/grade

Preparation of potato dextrose agar (PDA)

The Potato Dextrose Agar (PDA) was prepared by weighing 39 g of PDA, this was poured into Sterile Distilled Water (SDW) in a conical flask and made up to 1.0 litre. The flask was swirled gently to allow dispersion of the PDA powder in the added water. The PDA medium contained in the conical flask was plugged with cotton wool and covered with aluminium foil paper which was later sterilized in an autoclave at 121°C for 15minutes. The sterilized medium was subsequently allowed to cool to 45°C and streptomycin at the rate of 20ml/L (PDA) were added and poured aseptically into 9cm diameter Petri dishes, covered and allowed to solidify.

Isolation of the fungus: Soybean seed were surface sterilize in (1% NaOCl for 3 mins), rinsed in three changes of sterile distilled water and five seeds were placed on each 9 cm diameter Petri-dish containing Potato Dextrose Agar culture media amended with streptomycin (PDAs) before incubating for 7 days at room temperature (24 -30 ^{o}C) and observed daily. The pure culture obtained were sub-cultured unto fresh PDA media and were examined under the

microscope and the fungus were identified using appropriate taxonomic and morphological evidence or criteria guided by Barnett and Hunter (2006).

Determination of fungal frequency of occurrence: The most prevalent fungi in the study sample were identified by the frequency of occurrence of each of the isolated fungus from the seeds obtained from a particular treatment. This was determined by recoding the number of times each fungus was encountered. It was calculated using the formula below;

$$\text{Frequency (\%)} = \frac{\text{Number of isolates}}{\text{Total number of fungi occurrence}} \text{ X } 100$$

Statistical analysis: The data collected were subjected to analysis of variance (ANOVA) using Minitab software version 17 and the mean separated using Tukey at $p < 0.05$.

RESULTS

Percentage of occurrence of fungi organisms associated with soybean seeds sourced from NCRI, Badeggi, Minna Niger state, Nigeria: The results of the study on figure 1. revealed the percentage of occurrence of the isolated fungi organisms associated with soybean seeds sourced from NCRI, Badeggi, Minna Niger state, Nigeria. Five fungal organisms belonging to four genera were isolated which includes *A. niger*, *A. flavus*, *Fusarium oxysporum*, *Penicillium* species and *Curvularia* species. The results showed that *Aspergillus flavus* (38.30 %) had the highest percentage of occurrence, followed by *Fusarium oxysporum* (31.92 %) while *Curvularia* species (2.13 %) had the least. *Aspergillus species and Fusarium oxysporum* were found to be prevalent in the eight soybean genotypes investigated.

Distribution of the fungi organisms isolated from soybean seed sourced from NCRI, Niger State, Nigeria : Table 2 revealed the distribution of the fungi organisms isolated from soybean seed sourced from NCRI, Badeggi, Minna Niger state, Nigeria. The percentage distribution of the isolated fungi from the eight soybean genotypes revealed that TGX-1987-10F and TGX-1448-2E genotypes had 17.02 % apiece, followed by TGX-1989-19F with 14.89 % while SCSL-01 and TGX-1987-62F had the least with 6.38 % apiece.

Resistant levels of eight soybean genotypes screened for resistance to frogeye leaf spot disease during 2021 cropping seasons in Ishiagu, Ebonyi State: The results in table 3 revealed the incidence, severity and resistant levels among the eight soybean genotypes investigated during 2021 cropping season in Ishiagu. The result of the incidence showed that genotype TGX-1904-6F had the highest disease incidence (46.67%), followed by TGX-1989-19F (18.33 %) while TGX-1987-62F (5.00 %) had the least. Similarly, the result of the disease severity ranged from 1.00-3.77. More so, genotype TGX-1904-6F (3.77) had the highest, followed by SCSL-01 (2.47) while TGX-1987-10F (1.00) had the least. However, the result of resistant levels indicates that one soybean genotype (TGX-1987-10F) was highly resistant, five were resistant (TGX-1951-3F, TGX-1448-2E, TGX-1987-62F, TGX-1989-19F and TGX-1835-10F), one genotype was moderately resistant (SCSL-01) and one moderately susceptible (TGX-1904-6F).

Agronomic performance of eight soybean genotypes screened for resistance to frogeye leaf spot disease during 2021 cropping seasons in Ishiagu, Ebonyi State: Table 4 showed the agronomic performance of eight soybean genotypes screened for resistance to leaf spot disease during 2021 cropping seasons in Ishiagu, Ebonyi state. The results revealed that there was significant difference in the agronomic performance of the eight soybean tested. Genotype TGX-1987-10F (48.25 cm) had the highest plant height, followed by TGX-1835-10F (40.80 cm) while TGX-1989-19F (32.02 cm) had the least. The value for leaf number ranged from 8.78 – 11.44 on soybean genotypes GX-1989-19F and TGX-1987-10F respectively. Similarly, results for days to 50% flowering revealed that genotype TGX-1987-10F and TGX-1448-2E had 51.00 apiece while genotype SCSL-01 (46.00) had the least. The results for the 100 grain weight revealed that genotype TGX-1951-3F (17.49 g), followed by genotype SCSL-01 (15.70 g) while TGX-1989-19F (12.37 g).

DISCUSSION

This study provides an assessment of the resistant levels and diversity of soybean seed-borne fungi among eight soybean genotypes sourced from National Cereal Research Institute, Badeggi, Minna, Niger State, Nigeria. The results showed a varying degree of infection

of the different soybean genotypes by the fungi with fairly high frequencies observed from one genotype to others. This might be attributed to favourable weather conditions for their survival in the storage room. All the fungal isolates observed in this study were listed among the eight species isolated from ten soybean cultivars in India (Khayum *et al.*, 2006) and the thirty-nine species isolated from one cultivar of soybean in Pakistan (Nasreen, 2003). Five fungi organisms belonging to four genera were isolated which includes *A. niger, A. flavus, Fusarium oxysporum*, *Penicillium* species and *Curvularia* species were recovered from eight soybean genotypes from NCRI. Ahmed *et al.* (2016) reported that five fungal species were isolated from the fifteen soybean cultivars which includes *Aspergillus* sp., *Curvularia* sp., *Fusarium* sp., *Penicillium* sp. and *Phomopsis* sp. The present results also showed some interesting points. For instance, none of the tested soybean genotypes was susceptible (S) to frogeye leaf spot disease. Such genotypes maintained their resistant level. Such genotypes might be helpful for breeding programmes due to stability of both characters (resistance and seed yield). It should also be noted that overall growth parameters improved with increasing degree of resistance to frogeye leaf spot disease including yield turnover. Khati *et al.* (2007) screened 78 soybean germplasms, among them 16 genotypes were resistant, twenty-three genotypes showed moderately resistant reaction having spots on few plants only, thirty genotypes were found moderately susceptible and nine genotypes susceptible to disease. Similar type of observation was reported by Chanda, (2012). These highly resistant, resistant and moderately resistant genotypes could be used as good donor for developing resistant varieties against Frogeye leaf spot disease in soybean. The results indicate that severity of frogeye leaf spots also varied among the eight soybean genotypes. Disease severity was absent in TGX-1987-10F genotype than the other genotypes, probably due to its inherent resistance to attack by the pathogens than the other genotypes. This result agrees with Izge *et al.* (2007) who in a study determine the level of variability of crop to *Cercospora* leaf spot and concluded that variability existed among varieties in all characters, probably due to their inherent level of resistance to attack by the pathogens. The presence of total immune or highly resistant genotype among tested soybean disagrees with earlier reports by Das *et al.* (2017) during their evaluation of 26 soybean varieties, non was found totally immune, fifteen were observed to be resistant, eight were moderately resistant, two were moderately susceptible, only one was found susceptible and none of the varieties was found highly susceptible. Iwo *et al.* (1998) documented the evaluation of leaf spot disease and gall midge among newly developed sesame inbred lines and the bulk germplasm materials showed that most of sesame lines were moderately resistant to leaf spot disease.

CONCLUSION

The study has demonstrated that soybean genotypes from NCRI, Nigeria were well adapted to the derived savanna of Ebonyi State. While disease incidence, severity and some important plant traits, seedborne fungi identify from this study; may serve as a reference for future studies regarding soybean and its reaction to frogeye leafspot.

RECOMMENDATIONS

The study recommended that those genotypes that are resistant could be helpful for breeding programmes due to stability of both characters (resistance and seed yield). Also, those resistant soybean genotypes could further be planted out in other agro-ecological zones for further studies on the management of frogeye leaf spot of soybean in Nigeria.

REFERENCES

Ahmed O., Balogun, O. S., Fawole, O. B., Fabiyi, O. A., Hussein, A. T. and Kassoum, K. O. (2016). Seed-Borne Fungi of Soybeans (*Glycine max* [L.] Merr) in the Guinea Savannah Agro ecology of Nigeria. *Journal of Agricultural Sciences*. 61(1): 57-68

Ali N, (2010). Soybean processing and utilization. In: Singh G, ed. The Soybean. Botany, Production and Uses. Wallingford, UK: CAB International. Pp. 345–374.

Barnett, H. L. and Hunter, B. B. (2006). Illustrated Genera of Imperfect Fungi. 4th Edition, American Phytopathological Society Press, St. Paul, 218 pp.

Das, R. (2015). Evaluation of fungicides against *Alternaria* blight disease of rapeseed-mustard in West Bengal. *Journal of Crop and Weed*, 11 (special issue). Pp. 220-223.

Das, R., Ray, D. D and Bhattacharyya, P. K. (2017). Screening of Soybean Varieties for

Resistance to Frogeye Leaf Spot (FLS) Disease Caused by *Cercospora sojina* Hara in West Bengal, India. *International Journal of Basic and Applied Biology*, 4(2):140-142

FAOSTAT, (2013). Food and Agricultural Organization of United Nations (FAO) database.http://faostat3.fao.org/faostat-gateway/go/to/download/Q/QC/E.

Hartman, G. L, West D. E, and Herman T. K. (2011). Crops that feed the world 2. Soybean – worldwide production, use, and constraints caused by pathogens and pests. *Food Security* 3:5–17.

Iwo, G. A, Misari S. M, and Idowu, A. A. (1998). Current status of sesame improvement in Nigeria. In: L. D. Busari, A. A. Idowu and S. M. Misari (eds). Proc. 1st National Workshop on Beniseed. 3-5 March 1998, NCRI, Badeggi. Pp. 47-68.

Izge, A. U, Muhammad Z. H and Goni, H. (2007). Level of variability in groundnut (*Arachis hypogaea* L.) to *Cercospora* leaf spot disease implication for selection. *Journal of Sustainable Development in Agriculture and Environment*. 2(2):64-72.

Kafrriti, E. M, and Deckers J. (2001). Sesame (*Sesamum indicum*) in Rece mackers, R.H. (Editor) Crop Production in Tropical Africa. Directorate General for International Cooperation, Brussels, Belgium. Pp. 797-804.

Khati, P., Hooda, K. S. and Shukla, S. K. (2007). "Screening of soybean genotypes against frogeye leaf spot", *Indian Phytopathology,* 60 (1):121-127.

Khayum, Ahammed, S., Anandam, R. J., Prasad, Babu, G., Munikrishnaiah, M. and Gopal, K. (2006): Studies on seed mycoflora of soybean and its effect on seed and seedling quality characteristics. *Legume Research*, 29(3):186-190.

Li, L. L, Wang, X. S. Y, Fang, X. P and Hung, Z. H. (2013). Evaluation of 2229 accessions of sesame originating from 6 ecological regions in China and 116 accessions from 14 other countries. *Oil Crops of China.* 2(5):54-62.

Mittal, R. K. (2001). Yield losses by frog-eye leaf spot and anthracnose diseases in soybean under different sowing dates in the hills. *Indian Phytopathology*. 54:32–34.

Nasreen, N. (2003). Detecting seed-borne fungi of soybean by different incubation methods. *Pakistan Journal of Plant Pathology* 2(2):114-118.

Nwite, J. C, Igwe, C. A and Wakatsuki, T. (2008). Evaluation of Sawah rice management systems in an inland valley in South-Eastern Nigeria 1: Soil chemical properties and rice yield. *Paddy water Environment*, 6: 299-307.

Sangeetha, C. G. and Siddaramaiah, A. L. (2007). Epidemiological studies of white rust, Downy mildew and *Alternaria* blight of Indian mustard (*Brassica juncea* (Linn.) Czern and Coss. *African Journal of Agricultural Research* 2 (7): 305-308

Technoserve, (2011). Southern Africa Soy Roadmap – Zambia Value Chain Analysis. Washington, DC, USA:

USDA, (2014). Foreign Agricultural Services. Oilseeds: World Markets and Trade. FAS/USDA Office of Global Analysis. http://apps.fas.usda.gov/psdonline/circulars/oilseeds.

Table 1: Severity scale of frogeye leaf spot disease of soybean

Grade/Numerical value	Plant tissue damage (%)	Rating
1	0	Highly Resistant (HR)
2	1 – 30.9	Resistant (R)
3	31 – 60.9	Moderately Resistant (MR)
4	61 – 80.9	Moderately Susceptible (MS)
5	81 – 100	Susceptible (S)

*Modification of Das *et al.* (2017) disease severity assessment scale for frogeye leaf spot of soybean.

Table 2: Distribution of the fungi organisms isolated from soybean seed collected from NCRI, Niger State, Nigeria

Soybean genotypes	***Aspergillus flavus* (n)**	***Aspergillus niger* (n)**	***Curvularia* species (n)**	***Fusarium oxysporum* (n)**	***Penicillium species* (n)**	**Distribution (%)**
TGX-1951-3F	0	2	0	3	0	10.64
TGX-1987-10F	5	1	0	2	0	17.02
SCSL-01	0	1	1	1	0	6.38
TGX-1448-2E	3	1	0	3	1	17.02
TGX-1987-62F	1	1	0	1	0	6.38
TGX-1989-19F	3	1	0	2	1	14.89
TGX-1904-6F	2	2	0	2	0	12.77
TGX-1835-10F	4	1	0	1	1	14.89

n = number of isolates

Table 3: Resistant levels of eight soybean genotypes screened for resistance to frogeye leaf spot disease during 2021 cropping seasons in Ishiagu, Ebonyi State

S/N	Soybean genotypes	Incidence (%)	Severity	Status
1	TGX-1951-3F	8.33^{b}	2.13^{ab}	R
2	TGX-1987-10F	11.67^{b}	1.00^{b}	HR
3	SCSL-01	16.67^{b}	2.47^{ab}	MR
4	TGX-1448-2E	18.33^{b}	1.67^{b}	R
5	TGX-1987-62F	5.00^{b}	2.37^{ab}	R
6	TGX-1989-19F	18.33^{b}	1.53^{b}	R
7	TGX-1904-6F	46.67^{a}	3.77^{a}	MS
8	TGX-1835-10F	16.67^{b}	1.83^{ab}	R
	Means	17.71	2.096	
	SE	2.87	0.202	
	CV (%)	79.42	47.31	

Means in the same column followed by different alphabets are significantly different ($P < 0.05$) using Tukey. SE means Standard Error while CV means Coefficient of Variation. HR=Highly Resistant, R=Resistant, MR=Moderately Resistant, MS=Moderately Susceptible

Table 4: Agronomic performance of eight soybean genotypes screened for resistance to frogeye leaf spot disease during 2021 cropping seasons in Ishiagu, Ebonyi State

S/N	Soybean genotypes	Plant height (cm)	Leaf number	Days to 50% flowering	100 grain weight (g)
1	TGX-1951-3F	32.97^{a}	8.79^{a}	47.00^{bc}	17.49^{a}
2	TGX-1987-10F	48.25^{a}	10.67^{a}	51.00^{a}	13.19^{b}
3	SCSL-01	33.18^{a}	9.00^{a}	46.00^{c}	15.70^{ab}
4	TGX-1448-2E	32.92^{a}	10.40^{a}	51.00^{a}	14.16^{ab}
5	TGX-1987-62F	32.13^{a}	10.11^{a}	50.33^{ab}	13.00^{b}
6	TGX-1989-19F	32.02^{a}	8.78^{a}	50.00^{ab}	12.37^{b}
7	TGX-1904-6F	36.91^{a}	9.78^{a}	50.33^{ab}	15.13^{ab}
8	TGX-1835-10F	40.80^{a}	11.44^{a}	50.67^{a}	13.87^{ab}
	Means	36.15	9.870	49.542	14.363
	SE	2.05	0.266	0.430	0.407
	CV (%)	27.75	13.20	4.25	13.87

Means in the same column followed by different alphabets are significantly different ($P < 0.05$) using Tukey. SE means Standard Error while CV means Coefficient of Variation.

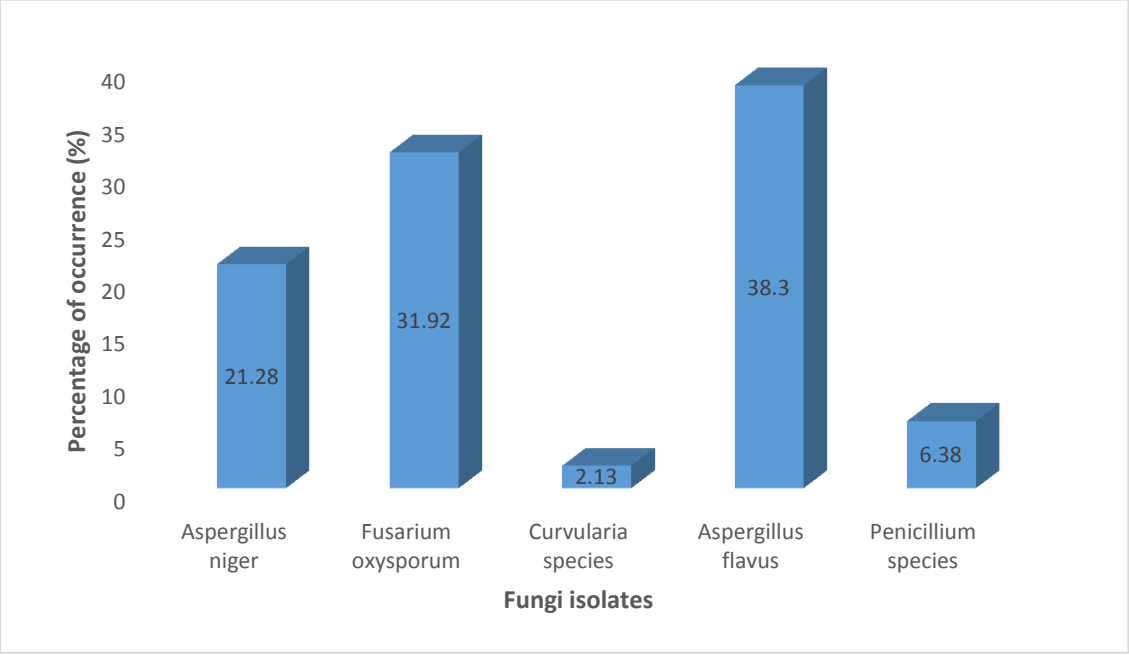

Figure 1: Percentage of occurrence of fungi organisms associated with soybean seeds sourced from NCRI, Badeggi, Minna Niger state, Nigeria

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EFFECTS OF RAINFALL VARIABILITY ON MOISTURE AVAILABILITY FOR CULTIVATION OF SORGHUM, KENAF AND OKRA IN TROPICAL WET-AND DRY-CLIMATIC WESTERN ZONES OF NIGERIA

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ABSTRACT

Field experiments to determine the effects of moisture availability on the growth and yield of sorghum, kenaf, and okra in sole and mixtures, were conducted during the 2011 and 2012 cropping seasons at the Federal University of Agriculture, Abeokuta, Nigeria. Treatments consisted of eleven planting patterns (sole crops, 2-tier mixtures, and 3-tier mixtures) formed from the mixtures of two sorghum cultivars (Sr and Sw) with kenaf (K) and okra (O) arranged as randomized complete block design with three replications on a sandy loam soil. Daily agroclimatic data of rainfall, air temperature, relative humidity, bright sunshine hours, day length and wind speed were collected and processed into decadal means and then related to the various growth components (establishment, vegetative, reproductive and maturity stages) of the crops. Agronomical data collected were panicle length and grain yield, bast fibre and seed yield, number of fruits, fruit weight, and fruit yield of sorghum, kenaf, and okra, respectively The results of this study showed that the rainfall amount received during the 2011 growing period (1018.2 mm) was greater than that during the 2012 growing period (728 mm), but approximately 71% and 73% were available for crop use, respectively. In addition, only 68.8% and 70.8% of the total rainfall recorded during the 2011 and 2012 growing periods, respectively, was available for consumptive water use. The water use efficiencies of the crops in the mixtures were higher than those of their respective sole crops. The yield components of sorghum, kenaf, and okra in both soles and mixtures were significantly ($p < 0.05$) higher in 2011 growing period. Based on the values of the water requirement satisfaction index (> 90%), both seasons were suitable for the cultivation of sorghum/kenaf/okra. The study concluded that the cultivation of crops in mixtures was suitable for ecological areas with a total annual rainfall of at least 1000 mm.

Keywords: *Water requirement satisfaction index, water use efficiencies, sorghum, kenaf, okra*

INTRODUCTION

Climate change and variability have led to inadequate food for human consumption and fibre for use in pulp and paper mills. The heavy dependence of agricultural activities on climatic factors such as rainfall, in tropical wet and dry climate, has led to a significant impact of climatic factors on optimal crop growth and yield, making the region susceptible to climate variability and change. Arable crop production can be affected by water availability throughout the season because of uncertainties in spatial and temporal rainfall distribution. Agroclimatic risk encountered during the cropping season is a major factor in arable crop production. Plant growth and developmental processes are directly and indirectly controlled by rainfall (Hoogenboom 2000). Therefore, in crop-climate studies, it is particularly important to consider the amount of rainfall because of its significant influence on crop developmental rates, which depend on the stage of development and crop types (Nortes *et al.*, 2009). For example, moisture stress during the flowering, pollination, and grain-filling stages is harmful to agricultural crops (Decker *et al*., 1986). Although agricultural losses arising from increasing variability and changes in climatic parameters are completely unavoidable, they can be minimized considerably. In this situation, however, one of the proper strategies that can be adopted to boost agricultural production and service, increasing food and fibre demands, is intercropping. Attempts to address the threat of food insecurity have led researchers to focus on intercropping arable crops under different crop

combinations. However, there is a paucity of agro-climatic information on the effects of available water in mixtures on crop production. An attempt to fill this gap forms the basis of the present study. Hence, this study aimed to examine the effects of climate variability on moisture availability for crop growth and the yield of sorghum, kenaf, and okra in soles and mixtures.

MATERIALS AND METHODS

Experimental Site: The experiments were conducted during the 2011 and 2012 cropping years at the Federal University of Agriculture, Abeokuta, Nigeria situated at an altitude of 141 m above sea level, 7^0 15`N latitude and $3^0$ 25`N longitude. The soil at the experimental site was sandy loam.

Treatments and Experimental design: A gross plot size of 45 × 25 m was cleared, stumped, and ridged manually using cutlass and hoe. Each plot was 7 m wide and 3 m long, with a walk path of 1 m, resulting in thirty-three plots. Two sorghum cultivars, Janare (Sr) and Farin-Dawa (Sw), were mixed with one kenaf (K), Cuba 108, and okra (O), NHAe 47-4 cultivars to form eleven treatments (Sr, Sw, K, O, SrK, SwK, SrO, SwO, KO, SrKO, and SwKO). The treatments were replicated thrice in a randomized complete block design. The plant spacing and population of sorghum, kenaf, and okra crops in the sole and mixture (2-tier and 3-tier) stands are shown in Table 1. All crops in the 2-tier mixtures (SwK, SrK, SwO, SrO, SK, and KO) and 3-tier mixtures (SwKO and SrKO) were planted in alternate rows according to the sequence of their arrangement in each mixture. The experimental crops were sown after the full establishment of rain on June 9, 2011, and June 29, 2012, corresponding to day 161 (16 dekad) and 181st day (18 dekad) of the year, respectively. Four sorghum, four kenaf, and two okra seeds were dibbled in soil at a depth of 2.5 cm. To maintain the required plant population, excess seedlings were thinned at 20 DAS (days after sowing) to two plants per stand for kenaf and sorghum, and to nee plant per stand for okra.

Data Collection

Agro-climatic data: During each experimental year, daily observations of rainfall (P, mm), relative humidity (RH, %), maximum and minimum air temperatures (T, ^{0}C), bright sunshine hours (hrs), day length (hrs) and wind speed (ms^{-1}) were collected from the agro-meteorological weather station at the Department of Water Resources Management and Agricultural Meteorology. The daily agroclimatic data collected were processed into moisture indicators (effective rainfall, consumptive water use, and water requirement satisfaction index) using Instat+ statistical and FAO Cropwat software. The moisture availability index (MAI) was determined following the criteria of Hargreaves (1972) for determining the MAI, effective rainfall (ER) is divided by the potential evapotranspiration (ET_o) and expressed mathematically as.

$$MAI = \frac{ER}{ET_o}$$

The classification of deficiencies and excesses set by Hargreaves (1972) was recategorized and adopted in this study as follows:

MAI = 0.00 - 1.00	Deficient
MAI = 1.01 - 1.33	Adequate
MAI = 1.34 and above	Surplus

Agronomic data: The phenological growth parameters considered in this study for sorghum, kenaf, and okra are listed in Table 2. The growth parameters were days to reach panicle initiation (sorghum), days to reach 50% flowering (sorghum, kenaf, and okra), days to reach first okra pod harvest and days to reach physiological maturity (sorghum and kenaf). The days when 50% of the samples flowered and fruited were considered as the days to flowering and fruiting, respectively. The yield parameters determined were grain yield (ton/ha) and panicle length (cm) of sorghum, fibre yield (ton/ha), seed yield (ton/ha) of kenaf, number of fruits/plants, fruit weight (g), and fruit yield (ton/ha) of okra. At maturity, the selected sorghum samples in the cropping system were harvested and tied into small bundles for sun drying for approximately one week. The dried bundles were manually threshed to collect the grain yield data. In addition, the panicles of the sampled sorghum plants were measured. Fibre yield was determined by hand-harvesting kenaf plants, which were cut at a point immediately below the first capsule and 10 cm near the stalk root. The yield was determined by placing the whole stalk kenaf in a slow-moving stream for one week. The fibre was then stripped off from the stem, washed, sun-dried, and weighed. The capsules were sun-dried, threshed, and weighed to determine the seed yield. Immature okra pods were picked every three (3) days for up to 80 days after planting. Fresh okra pods were counted, weighed, and recorded as pod number and pod weight.

Analysis of Data: Data collected on yield parameters were subjected to an analysis of variance using a randomized complete block design (SAS, 1999). The treatment means were compared using the least significant difference method (Steel *et al*. 1997).

RESULTS

The amount and distribution of rainfall during the two cropping seasons differed considerably (Figure 1). In 2011 growing season, the total rainfall (1018.2 mm) was higher than the amount of rainfall in 2012 growing season (902 mm). The highest total monthly rainfall occurred in July (349 mm) and June (225.4 mm) for the 2011 and 2012 growing seasons, respectively, whereas 29 and 27% of the total rainfall during the 2011 and 2012 growing seasons, respectively, was not available for crop use. Figures. 2 and 3 show the relationship between the total seasonal effective rainfall and crop consumptive water use of various cropping planting patterns during the 2011 and 2012 growing seasons, respectively. In 2011, the total seasonal effective rainfall (700.3 mm) was 25% higher than in 2012 (525.6 mm). However, the total seasonal effective rainfall satisfied the crop consumptive water use required by all treatments except for the mixtures of SrK, SwK, SrKO, and SwKO in the 2011 and 2012 growing seasons. Figures 4 and 5 depict the distribution of decadal effective rainfall (Peff), consumptive water use (ETcrop) and the water requirement satisfaction index (WSRI) at different phenological stages of sorghum (Sr/Sw), kenaf (K) and okra (O) in the sole and mixed planting patterns respectively, during the 2011 growing season. The results showed that the effective rainfall (P_{eff}) was consistently higher than that of the ET_{crop} for Sr/Sw, K and O planting patterns at 16 dekad, 19 dekad, 20 dekad, 27 dekad, 28 dekad, 29 dekad and 30 dekad and in addition, at 17 dekad and 26 dekad for Sr/Sw and O, and K and O planting patterns respectively. Furthermore, P_{eff} was more than ET_{crop} for Sr/Sw treatment at 24 dekad. However, evidence of marked moisture deficits was detected at 21, 22, 23 and 31 dekad in all sole planting patterns (Figure 4). This coincided with the vegetative and physiological stages of sorghum and kenaf, and the vegetative and late harvesting stages of okra. Similarly, P_{eff} was greater than the ET_{crop} for the two- and three-tier planting patterns at 19 dekad, 20 dekad and 29 dekad, and at 28 dekad and 30 dekad for SrO and SwO treatments, respectively (Figure 5). Evidence of marked moisture deficit occurred from 16 dekad to 18 dekad, and 21 dekad to 27 dekad for the two- and three-tier planting patterns, respectively. In addition, at 28 dekad, 30 dekad, and 32 dekad, moisture deficits were observed in the SrK/SwK and SrKO/SwKO. The moisture deficit coincided with the establishment and reproductive stages; late vegetative and physiological maturity of sorghum and kenaf; and establishment, early vegetative, and reproductive stages of okra. The decadal crop water requirement satisfaction index (CWRSI) at different phenological stages of sorghum, kenaf, and okra during the 2011 growing season was reduced by two periods of 19 dekad and 20 dekad. Apart from these periods, the CWSRI remained constant throughout the remaining periods. The final CWRSI value at the end of the growing season was 94%. Figures 6 and 7 depict the distribution of decadal effective rainfall (Peff), consumptive water use (ETcrop) and the water requirement satisfaction index (WSRI) at different phenological stages of sorghum (Sr/Sw), kenaf (K) and okra (O) in the sole and mixed planting patterns respectively, during the 2012 growing season. P_{eff} was consistently higher than ET_{crop} of Sr/Sw, K and O planting patterns at 18 dekad, 19 dekad, 20 dekad, 21 dekad, 22 dekad, 28 dekad, 29 dekad and 31 dekad. However, evidence of marked moisture deficit was observed at 23, 24, 25, 26, 27 and 30 dekad (Figure 6). This coincided with the mid-vegetative and reproductive stages of sorghum and kenaf and the late reproductive and harvesting stages of okra. In the mixed planting patterns, P_{eff} was also more than the ET_{crop} of SrK/SwK, SrO/SwO, KO and SrKO/SwKO from 18 to 21, and at 28 dekad, while in addition, at 29 dekad for SrK/SwK, SrO/SwO and KO. Similarly, at 30 dekad, P_{eff} was more than ET_{crop} of SrO/SwO (Figure 7). Furthermore, moisture deficit was noticed from 30 to 32 dekad for SrK/SwK and SrKO/SwKO while at 29 dekad, only three-tier planting patterns had ET_{crop} greater than P_{eff}, thus resulting to moisture deficit. Meanwhile, a moisture deficit was detected from 22 dekad to 27 dekad for all the mixed planting patterns. The period of moisture deficit coincided with mid-vegetative and late physiological maturity of sorghum; mid-vegetative, reproductive, and late physiological stages of kenaf; and mid-reproductive and harvesting stages of okra. The decadal crop water requirement satisfaction index (CWRSI) at different phenological stages

of sorghum, kenaf and okra during the 2012 growing season was reduced by one period at 26 dekad for sorghum crop, while kenaf and okra crops did not show any reduction (Figure 6 and 7). The CWRSI value at the end of the sorghum growing season was 97%, whereas those of kenaf and okra were 100%. The limits of moisture availability in kenaf production showed that moisture was surplus from crop establishment until the mid-vegetative stage and from the early to late physiological stages. There was evidence of moisture deficit from the mid-vegetative to mid-flowering stages of the crop. In okra production, the limits of water availability showed that moisture was surplus throughout crop establishment to the vegetative stage. However, moisture availability during the critical period of the crop (from fruiting to early harvest) is deficient.

Yield parameters of the experimental crops: The yields of sorghum in the sole and mixed planting patterns (Table 3) revealed that the longest panicle length was recorded in SrK (52 cm), followed by Sr, Sw, SrKO, SwO, and SrO. The shortest panicle length (45.4 cm) was observed in SwKO, followed by SwK. During the 2012 growing season, the longest panicle length was recorded for Sw (41.6 cm), followed by Sr, SrO, SwO, SwK, SrK, SwKO, and SrKO. The results further showed that the grain yield during the 2011 growing season was at its maximum in all treatments except for the SrO treatment. Significantly highest grain yield was recorded in Sw (1.54 t ha^{-1}) followed by SwO, Sr, SwK and SrO, while SrKO (0.35 t ha^{-1}) recorded lowest grain yield. During the 2012 growing season, the lowest grain yield was recorded for SwKO (0.40 t ha-1), whereas a significantly higher grain yield was observed for Sr (1.08 t ha^{-1}), followed by Sw and SrO. To confirm the adequacy of water availability at various phenological stages of the crops, the moisture adequacy index (MAI) during the 2011 season (Figure 8) showed that the available moisture during the moisture-sensitive period was adequate for sorghum except at the late stage of phyisological maturity (30-32 dekad) (Figure 8). In addition, available moisture was deficient in the establishment and late vegetative stages of sorghum. There is evidence that available moisture is deficient at crop establishment and late physiological maturity stages and from the late vegetative to early physiological maturity stages of kenaf. The available moisture was adequate for kenaf production during the early vegetative and physiological maturity stages (Figure 8). For okra production, the limit of water availability indicated that moisture was deficient at the crop establishment and crop moisture critical period (reproductive stage), while available mositure was in excess at both the moisture non-sensitive period (vegetative stage) and late harvesting stage (Figure 8). During the 2012 growing season (Figure 9), MAI showed that the available moisture was deficient during the moisture-sensitive period of sorghum production (physiological maturity). In addition, the available moisture was deficient from the middle to the end of the vegetative stage. The available moisture was in surplus at crop establishment until the early vegetative and fruiting stages.

The yield of kenaf, either sole or intercropped with sorghum and okra, is presented in Table 4. The results show that during 2011 growing season, significant highest fibre yield was recorded in sole K treatment (2.75 t ha^{-1}) followed by KO (1.27 t ha^{-1}), SrK (1.23 t ha^{-1}), SwK (1.18 t ha^{-1}), SrKO (0.99 t ha^{-1}) and SwKO (0.80 t ha^{-1}). Similarly, during 2012 growing season, significantly highest fibre yield was observed in K treatment (2.07 t ha^{-1}) followed by KO (1.22 t ha^{-1}) and SrK (1.17 t ha^{-1}), whereas significantly lowest fibre yield was recorded in SwKO (0.70 t ha^{-1}) followed by SrKO (0.91 t ha^{-1}) and SwK (1.11 t ha^{-1}). A similar trend was observed for the kenaf seed yield (Table 4).

Table 5 shows that during the 2011 growing season, the highest fruit number was observed in the O treatment (15), followed by KO (10), SrO (8.67), SwO (8.33), SwKO (7.67), and SrKO (7.33). Also, significantly highest fruit number was observed in O (14.67), followed by SrO (9.0), KO (8.83), SwO (8.33), SwKO (6.67), and SrKO (6.33) during 2012 growing season. The table further revealed that significant highest fruit weight was recorded in sole okra (51.62 g) followed by two-tier planting patterns of SrO (41 g), KO (38.12 g), SwO (31.8), and three-tier planting patterns of SrKO (31.6 g) and SwKO (26.57 g). During the 2012 growing season, the highest fruit weight was observed in O (46.63 g), followed by KO (34.75 g), SrO (29.07 g), SwO (28.73 g), SwKO (22 g), and SrKO (21.3 g). The table further shows that fruit yield reached its maximum and minimum during the 2011 and 2012 growing seasons, respectively. Significant highest yield was noticed in sole planting of okra (4.47 t ha^{-1}), followed mixed planting patterns of KO (3.4 t ha^{-1}), SwO (3.16 t

ha^{-1}), SrO (2.96 t ha^{-1}), SwKO (2.07 t ha^{-1}), and SrKO (1.80 t ha^{-1}). Likewise, during 2012 growing season, O (3.61 t ha^{-1}) recorded significantly highest yield, followed by KO (2.5 t ha^{-1}), and SwO (2.42 t ha^{-1}). However, significantly lowest yield was noticed in SrKO (1.61 t ha^{-1}), followed by SwKO (1.7 t ha^{-1}), and SrO (2.3 t ha^{-1}).

DISCUSSION

Annual effective rainfall and consumptive water use were higher in 2011 (700.3 mm) than in 2012 (525.6 mm). The relationship showed that annual effective rainfall was optimum for the growth of all treatments except sorghum red+kenaf (SrK), sorghum white+kenaf (SwK), sorghum red+kenaf+okra (SrKO), and sorghum white+kenaf+okra (SwKO) mixtures. Further analysis of the relationship based on crop growth stages clearly showed that moisture deficits of varying values occurred at different phenological stages of all crops in sole stands and mixtures. However, the moisture deficit was more pronounced in the two- and three-tier mixtures than in their respective sole crops. Further investigation of the crop-water relationship showed that the effective rainfall was adequate on few occasions. In the 2011 cropping year, moisture was deficient for approximately 5 days (coinciding with the late establishment and early vegetative stages of sorghum and kenaf, and okra, respectively), and 12 days (coinciding with the late physiological period of sorghum and kenaf). In the 2012 cropping year, moisture was deficient for approximately 20 days (coinciding with the mid-vegetative stage of sorghum and kenaf, and mid-reproductive and early harvesting stages of okra), which may be responsible for the poor vegetative growth of the crops in both sole stands and mixtures, as compared to the 2011 cropping year. Thus, prolonged moisture deficit affects the plant leaf area, thereby weakening the photosynthetic capacity of plants. In addition, it further inhibited the vegetative growth of crops coinciding with the stage, as was found in this study. These findings agree with those of Kassim *et al*. (2019) and Makinde *et al*. (2011). The findings of Olaniran (1983) and Bello (1997) corroborate the results of this study. Therefore, it is not surprising that a higher grain yield of sorghum was recorded in 2011, as moisture stress did not occur during the critical moisture growth stage(s) of the experimental crops. Bello (1997) reported that moisture stress in sorghum crops, especially during inflorescence development, can reduce the rate of panicle development or even cause the cessation of panicle development at any stage between panicle initiation and flowering. The higher crop water-use efficiencies recorded in the crop mixtures (SrK, SwK, KO, SrKO, and SwKO) over their respective sole stands (Sr, Sw, and K) revealed that intercrops used water more efficiently than the sole crops. Among the studies conducted under tropical conditions Natarajan and Willey (1980), Hulugalle and Lal (1986) and Ong *et al.* (1996) investigated water use by various intercrops in sole and mixtures and found that water use was similar to their sole counterparts, but intercrops utilised water more efficiently. The higher crop water use efficiency recorded in the mixtures over their sole crops could be associated with the higher yield values of the component crop(s) in the mixtures. However, the water use efficiencies of the crops in sole stands and mixtures during the 2012 season were higher than those in 2011, except for K, O, SrO, and SwO. This could be attributed to the lower use of water by the crops in the 2012 cropping year because of the shorter growth period of the crops in both the sole and mixtures. Contrary to earlier studies, the water use efficiency of the sole okra (O) was higher than that of the respective mixtures (SrO, SwO, KO, SrKO, and SwKO) in the present study. This could be attributed to the cumulative okra yield during the harvest period. The reduction in crop yield in the mixtures was attributed to severe interspecies competition and shade. These results agree with those reported by Olasantan (2001), Adeniyan (2007), and Kassim *et al*. (2019). The number of component crops in the mixed planting patterns affected the grain yield of sorghum, the bast fibre yield of kenaf, and the fruit yield of okra. This was probably because of the severe competition between the component crops for moisture. The fact that yields of 2-tier and 3-tier planting patterns differed could be attributed to early senescence and low stature of okra crops, thus reducing the competition between the two crops. This finding is corroborated the works of Singh and Jadhav (2003), Anil (2007), and Makinde (2011).

CONCLUSION

This study revealed that the availability of water for crop growth and development was affected by variations in rainfall in the study area. Based on the total seasonal effective rainfall and the consumptive use of water by the crops in the mixtures, the production potential of the three-

tier planting patterns is discouraged. Partitioning the growing season into growth stages to study the relationship between available moisture and crops provides a better understanding of the extent to which available moisture affects the growth and yield of sorghum, kenaf and okra in sole and mixed stands. Despite varying rainfall conditions during different growth periods of the experimental crops, the water available during the critical periods of crop moisture was adequate to meet their water consumption. The mean value of the water requirement satisfaction index (>90%) indicated that the seasons were suitable for producing sorghum, kenaf, and okra in mixed planting patterns, if only rainfall was agroclimatic factor considered. Hence, cultivation of sorghum/kenaf/okra intercrop is feasible in an agroecological zone with a minimum annual rainfall of 1000 mm.

REFERENCES

Adeniyan, O.N., Akande, S.R., Balogun, M.O. and Saka, J.O. (2007). Evaluation of crop yield of African yam bean, maize, and kenaf under intercropping systems. *American-Eurasian J. Agric. and Environ. Sci., 2*(1): 99 - 102.

Anil, K. (2007). Effects of legumes on growth, yield, and quality of pop sorghum in inter and mixed cropping system (Unpublished master's thesis). University of Agricultural Sciences, Dharwad.

Bello, N.J. (1997). An investigation of the agroclimatic potential of the forest-savanna transition zone of Nigeria for the cultivation of sorghum. *Experimental Agriculture, 33*:157 - 171.

CROPWAT. (2009). CROPWAT for windows, An FAO software, version 8.0. http://www.fao.org/nr/water/infores_databases_cropwat.html

Decker. W.L., Jones, V.K. and Achutuni, R. (1986). The impact of CO_2-induced climate change on US agriculture. In M.R. White (ed.), Characterization of information requirements for studies of CO_2 effects: Water resources Agriculture Fisheries Forests and Human Health. US Department of Energy, DOE/ER-0236, Washington, D.C.

Hargreaves, G.H. (1975). Water requirements manual for irrigated crops and rainfed agriculture. United States Agency for International Development, Utah State University.

Hoogenboom, G. (2000). Contribution of agrometeorology to the simulation of crop production and its applications. *Agric. and Forest Meteorology*. *l103*: 137 - 157.

Hulugalle, N.R. and Lal, R. (1986). Soil water balance in intercropped maize and cowpea grown in a typical hydromorphic soil Western Nigeria. *Agron.* J. 77, 86-90

Kassim, H.G., Bello, N.J. and Olasantan, F.O. (2019). Investigating agroclimatic feasibility of kenaf/maize intercrop in forest-savannah transition zone of southwest Nigeria. *Journal of Environmental and Tourism Education (JETE),* 1(2) and 2(1), 85 - 99.

Makinde, A.A., Bello, N.J., Olasantan, F.O., Adebisi, M.A. and Adeniyi, H.A. (2011). Seasonality and crop combination effects on growth and yield of two sorghum (*Sorghum bicolor*) cultivars in sorghum/maize/okra intercrop in a forest-savanna transition zone of Nigeria. *Agricultural Journal 6(3):92–99.* DOI: 10.3923/aj.2011.92.99.

Natarajan, M. and Willey, R.W. (1980). Sorghum-pigeonpea intercropping and the effects of plant population density two. Resource use. *The Journal of Agricultural Science, 95* (1): 59 - 65.

Nortes, P.A., Gonzalez-Real, M.M., Egea, G. and Baille, A. (2009). Seasonal effects of deficit irrigation on leaf photosynthetic traits of fruiting and non-fruiting shoots in almond trees. *Tree Physiology*, *29*: 375 - 388.

Olasantan, F.O. (2001). Optimum plant populations for okra (*Abelmoschus esculentus*) in a mixture with cassava *(Manihot esculenta)* and its relevance to rainy season-based cropping systems in south-western Nigeria. *Journal of Agricultural Science, 136*: 207 - 214.

Ong, C.K., Black, C.R., Marshall, F.M. and Corlett, J.E. (1996). Principles of resource capture and utilisation of light and water. In: Ong, C.K., Huxley, P.A. _Eds.., Tree crop Interactions a Physiological Approach. CAB International.

Singh, P.K. and Jadhav, A.S. (2003). Intercropping of sorghum with pigeonpea, groundnut and soybean under varying planting geometry. *Indian Journal of Dryland Agricultural Research and Development, 18*(2): 126 - 129.

Steel, R.G.D., Torrie, J.H. and Dickey, D.A. (1997). Principles and procedures of statistics: a biometrical approach (3rd ed.), McGraw Hill, New York.

Stern, R., Knock, J., Rijks, D. and Dale, I. (2009). Instat+ (Interactive Statistics Package). Statistics Services Center. University of Reading, U.K. pp 153.

Table 1: Plant spacing and population

Pattern	Spacing			Plant/plot		
	Sorghum	Kenaf	Okra	Sorghum	Kenaf	Okra
Sole	0.9 x 0.6	0.75 x 0.6	0.9 x 0.3	78	92	78
2-tier						
SrK/SwK	0.9 x 0.6	0.9 x 0.6	-	39	46	-
SrO/SwO	0.9 x 0.6	-	0.9 x 0.3	39	-	39
KO	-	0.9 x 0.6	0.9 x 0.3	-	46	39
3-tier						
SrKO/SwKO	1.5 x 0.6	1.5 x 0.75	1.5 x 0.3	19	23	19

Table 2: Critical phenological stages of sorghum, kenaf and okra crops considered during the experimental period

Phenological stages	Experimental crops		
	Sorghum	Kenaf	Okra
First stage	Establishment (period from germination and emergence)	Establishment (period from germination and emergence)	Establishment (period from germination and emergence)
Second stage	Vegetative (period of leaf area development, stem growth and tillering until the beginning of panicle initiation)	Vegetative (period of leaf area development, stem growth and plant height growth until the beginning of flowering)	Vegetative (period of leaf area development, stem growth and plant height growth until the beginning of flowering)
Third stage	Flowering (period of panicle emergence until anthesis)	Flowering (period of anthesis until fruiting)	Flowering (period of fruiting)
Fourth stage	Physiological maturity (period after anthesis until the end of grain enlargement)	Physiological maturity	Harvesting period

Table 3: Effect of two sorghum cultivars mixed with kenaf and okra on some yield attributes of sorghum

Planting patterns	Panicle length (cm)		Grain yield (t ha^{-1})	
	2011	2012	2011	2012
Sole				
Red Sorghum	51.9	50.7	1.50	1.44
White Sorghum	51.3	51.7	1.54	1.42
2-tier mixed				
Red Sorghum+Kenaf	52	47.7	0.81	0.63
White Sorghum+Kenaf	46.2	46.4	0.98	0.69
Red Sorghum+Okra	49.8	49.6	0.87	0.92
White Sorghum+Okra	50	49.4	1.03	0.86
3-tier mixed				
Red Sorghum+Keanf+Okra	50.7	45.6	0.55	0.43
White Sorghum+Kenaf+Okra	45.4	46.2	0.68	0.40
LSD (0.05)	5.24	4.09	0.09	0.06

Table 4: Effect of two sorghum cultivars mixed with kenaf and okra on bast fibre and seed yield of kenaf

Planting patterns	Bast fibre yield (t ha^{-1})		Seed yield (t ha^{-1})	
	2011	2012	2011	2012
Sole				
Kenaf	2.75	2.07	1.22	1.15
2-tier mixed				
Kenaf+Okra	1.27	1.22	0.45	0.81
Red Sorghum+Kenaf	1.23	1.17	0.39	0.95
White Sorghum+Kenaf	1.18	1.11	0.41	0.84
3-tier mixed				
Red Sorghum+Keanf+Okra	0.99	0.91	0.31	0.39
White Sorghum+Kenaf+Okra	0.80	0.70	0.26	0.34
LSD (0.05)	0.12	0.06	0.06	0.10

Table 5: Effect of two sorghum cultivars mixed with kenaf and okra on yield attributes of okra

Planting patterns	Number of fruits/plant		Fruit weight (g/plant)		Fruit yield (t ha^{-1})	
	2011	2012	2011	2012	2011	2012
Sole						
Okra	15	14.67	51.62	46.63	4.47	3.61
2-tier mixed						
Kenaf+Okra	10	8.83	38.12	34.75	3.40	2.50
Red Sorghum+Okra	8.67	9.0	41.0	29.07	2.96	2.30
White Sorghum+Okra	8.33	8.33	31.8	28.73	3.16	2.42
3-tier mixed						
Red Sorghum+Kenaf+Okra	7.33	6.33	31.6	21.3	1.80	1.61
White Sorghum+Kenaf+Okra	7.67	6.67	26.57	22.0	2.07	1.70
LSD (0.05)	2.91	2.69	3.69	6.03	0.59	0.55

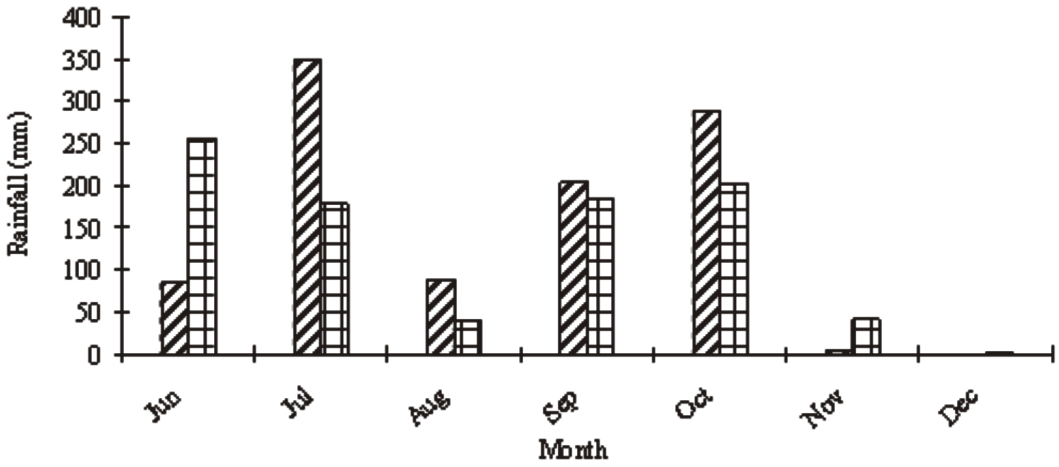

Fig. 1: Total monthly rainfall during 2011 and 2012 growing seasons at Abeokuta, Nigeria

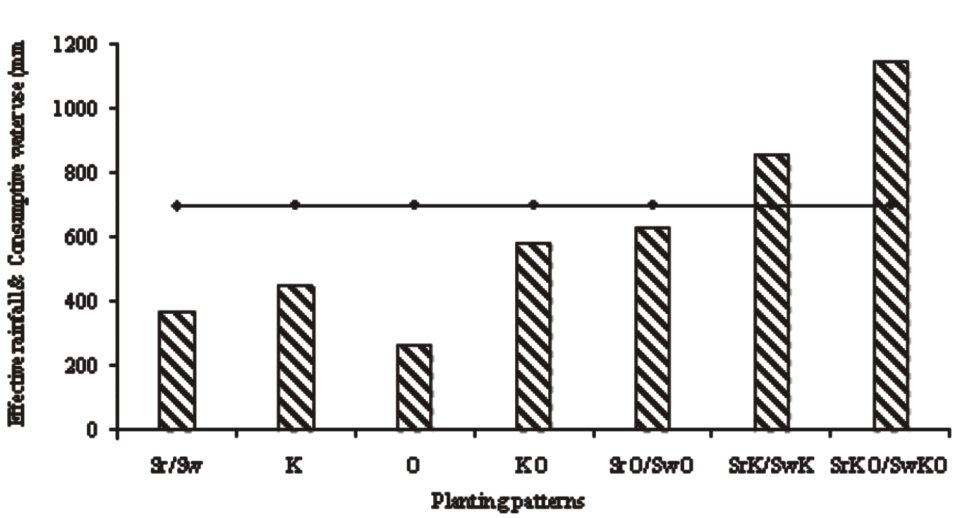

Fig. 2: Total seasonal values of effective rainfall (Peff) and crop consumptive water use (ETcrop) for the various planting patterns in 2011 at Abeokuta, Nigeria

Sorghum red (Sr), Kenaf (K), Okra (O), kenaf+okra (KO), White Sorghum+Kenaf (SwK), Red Sorghum +Kenaf (SrK), Red Sorghum+Okra (SrO), White Sorghum+Okra (SwO), Red Sorghum+Kenaf+Okra (SrKO) and White Sorghum+Kenaf+Okra (SwKO)

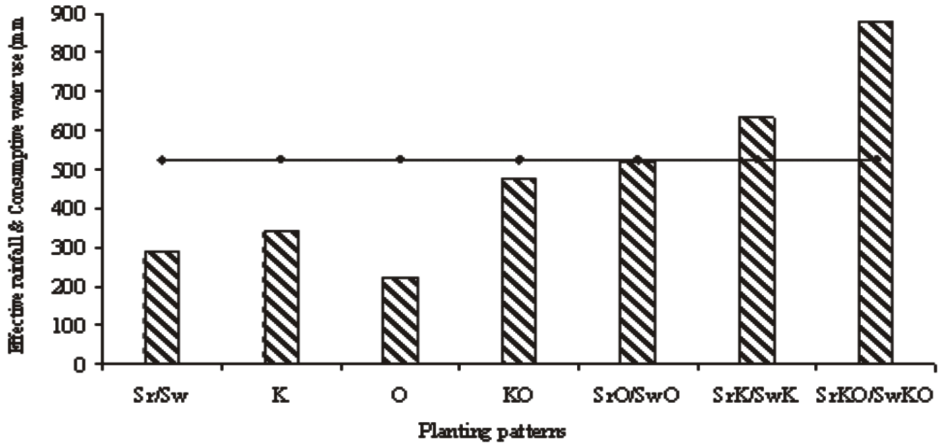

Fig. 3: Total seasonal values of effective rainfall (Peff) and crop consumptive water use (ETcrop) for the various planting patterns in 2012 at Abeokuta, Nigeria

Sorghum red (Sr), Kenaf (K), Okra (O), kenaf+okra (KO), White Sorghum+Kenaf (SwK), Red Sorghum +Kenaf (SrK), Red Sorghum+Okra (SrO), White Sorghum+Okra (SwO), Red Sorghum+Kenaf+Okra (SrKO) and White Sorghum+Kenaf+Okra (SwKO)

ETcrop Peff

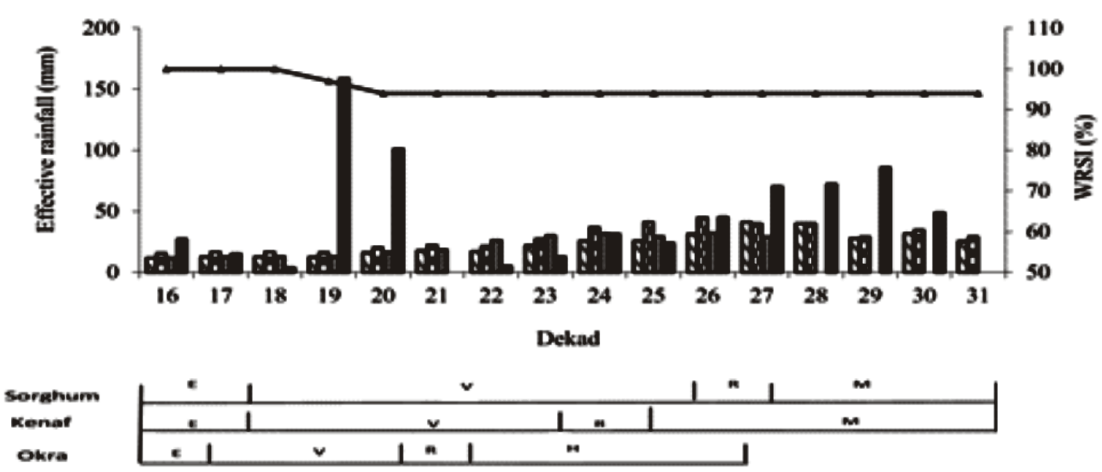

Fig. 4: Relationship between effective rainfall (Peff), consumptive water use (ET_{crop}) and water requirement satisfaction index (WRSI) of sorghum, kenaf and okra in sole planting patterns during 2011 growing season at Abeokuta, Nigeria

Establishment (E), Vegetative growth (V), Reproductive growth (R), Physiological maturity (M), Harvesting period (H), Sorghum red (Sr), Sorghum white (Sw), Kenaf (K) and Okra (O)

Etcrop Sr/Sw Etcrop K Etcrop O Peff WRSI

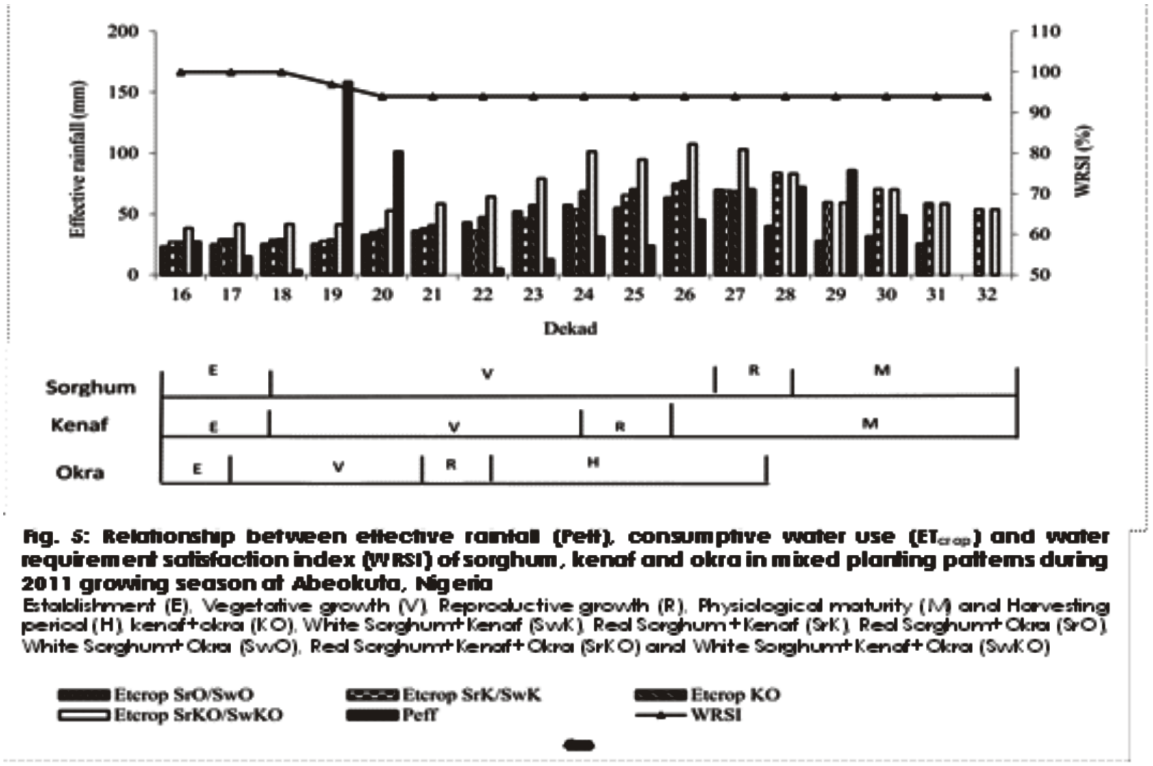

Fig. 5: Relationship between effective rainfall (Peff), consumptive water use (ET_{crop}) and water requirement satisfaction index (WRSI) of sorghum, kenaf and okra in mixed planting patterns during 2011 growing season at Abeokuta, Nigeria

Establishment (E), Vegetative growth (V), Reproductive growth (R), Physiological maturity (M) and Harvesting period (H), kenaf+okra (KO), White Sorghum+Kenaf (SwK), Real Sorghum+Kenaf (SrK), Real Sorghum+Okra (SrO), White Sorghum+Okra (SwO), Real Sorghum+Kenaf+Okra (SrKO) and White Sorghum+Kenaf+Okra (SwKO)

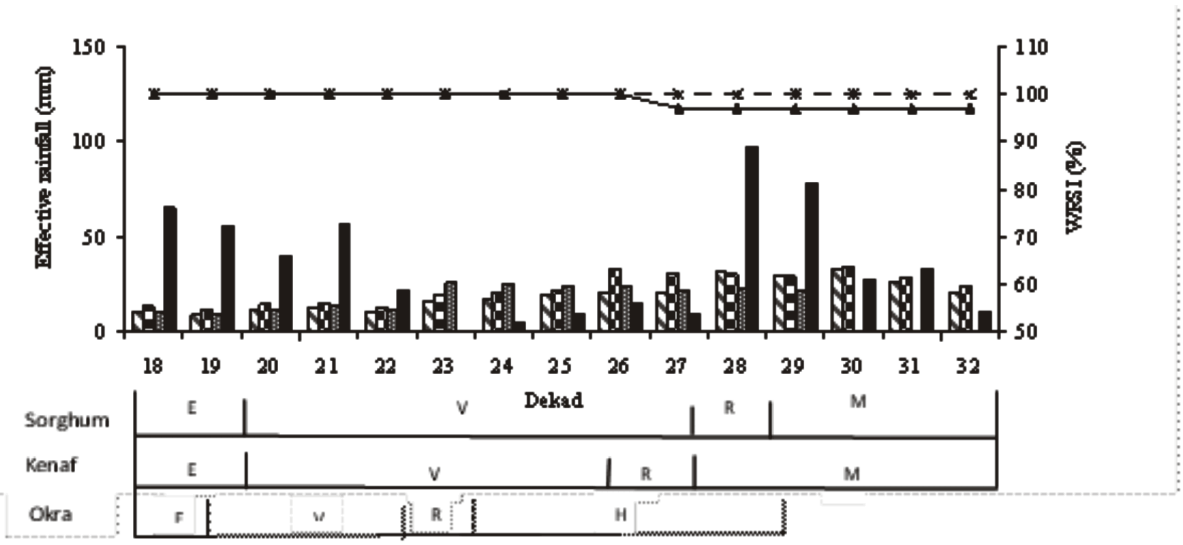

Fig. 6: Relationship between effective rainfall (Peff), consumptive water use (ET_{crop}) and water requirement satisfaction index (WRSI) of sorghum, kenaf and okra in sole planting patterns during 2012 growing season at Abeokuta, Nigeria

Establishment (E), Vegetative growth (V), Reproductive growth (R), Physiological maturity (M), Harvesting period (H), Sorghum red (Sr), Sorghum white (Sw), Kenaf (K) and Okra (O)

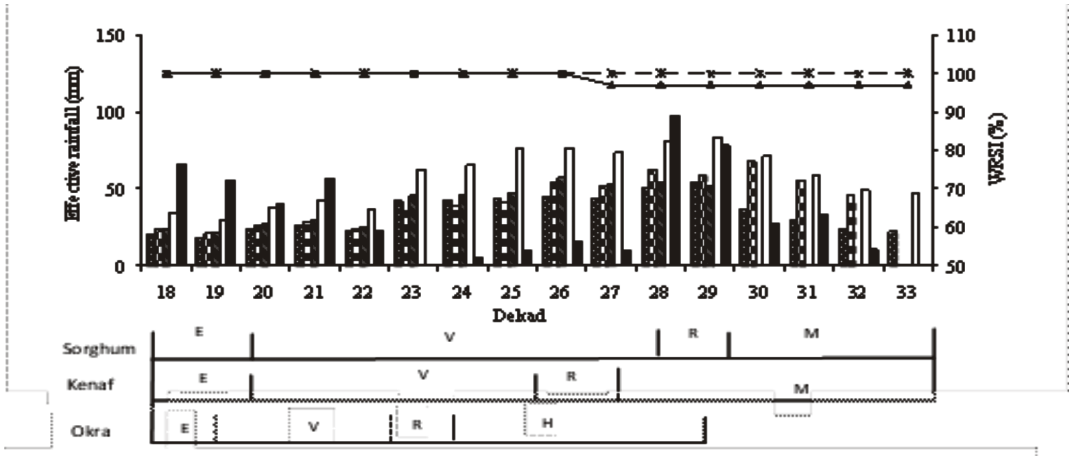

Fig. 7: Relationship between effective rainfall (Peff), consumptive water use (ET_{crop}) and water requirement satisfaction index (WRSI) of sorghum, kenaf and okra in mixed planting patterns during 2011 growing season at Abeokuta, Nigeria

Establishment (E), Vegetative growth (V), Reproductive growth (R), Physiological maturity (M) and Harvesting period (H), kenaf+okra (KO), White Sorghum+Kenaf (SwK), Red Sorghum +Kenaf (SrK), Red Sorghum+Okra (SrO), White Sorghum+Okra (SwO), Red Sorghum+Kenaf+Okra (SrKO) and White Sorghum+Kenaf+Okra (SwKO)

ETcrop SrO/SwO ETcrop SrK/SwK ETcrop KO
ETcrop SrKO/SwKO Peff WRSI(Sr/Sw)

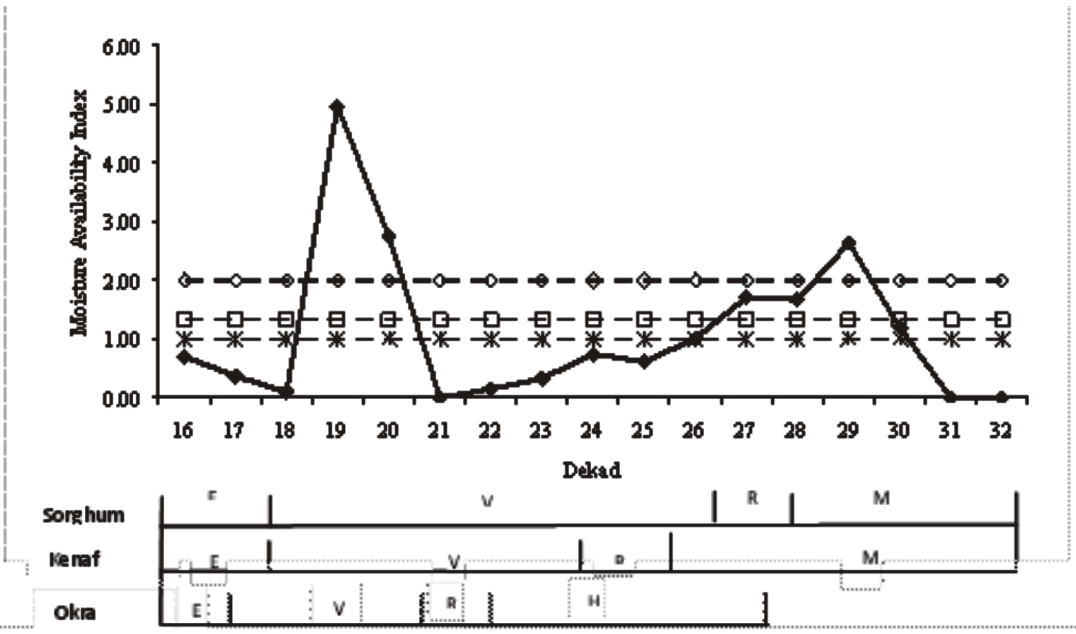

Fig. 8: Decadal moisture availability index at different phenological stages of sorghum, kenaf and okra during 2011 growing season at Abeokuta, Nigeria

Establishment (E), Vegetative growth (V), Reproductive growth (R), Physiological maturity (M) and Harvesting period (H)

MAI Deficit Adequate Surplus

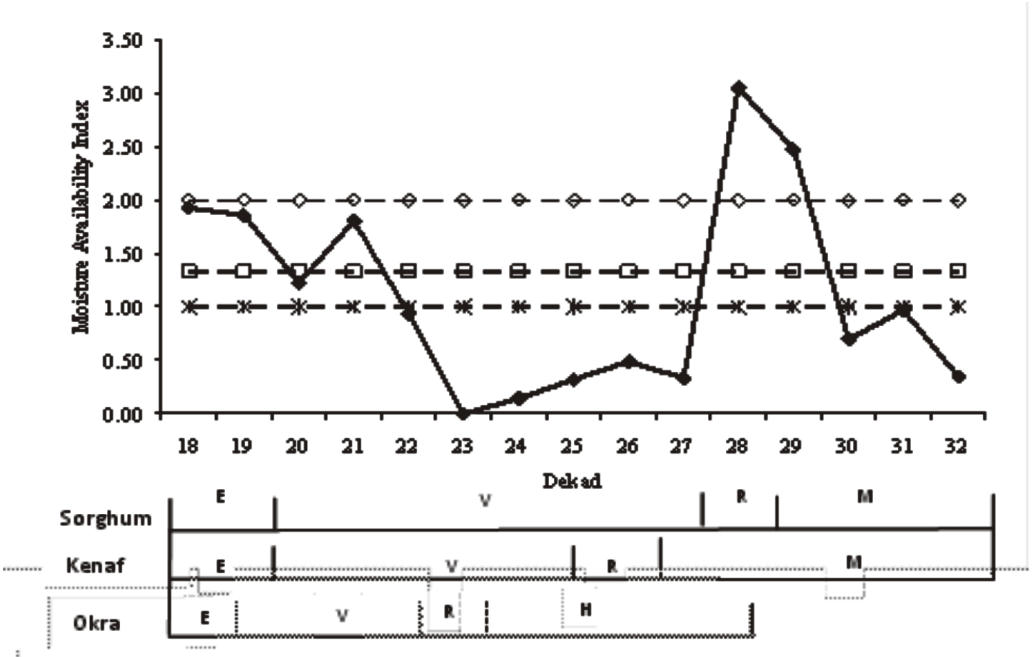

Fig. 9: Decadal moisture availability index at different phenological stages of sorghum , keanf and okra during 2012 growing season at Abeokuta, Nigeria

Establishment (E), Vegetative growth (V), Reproductive growth (R), Physiological maturity (M) and Harvesting period (H)

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PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF KOLA (*Cola nitida)* SEEDLINGS AT DIFFERENT COLOURS TO APPLICATION OF PLANT GROWTH SUBSTANCES

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ABSTRACT

Kola belongs to the family sterculiaceae. This study evaluated the effect of plant growth substances on the physiological and biochemical components of *Cola nitida* seedlings. This study was carried out in Cocoa Research Institute of Nigeria, CRIN, Ibadan. A total of 200 fresh nuts of different colours of *C. nitida* were used. Nuts were pre-germinated, thinned and sown one per polyethene bag arranged in Randomized Complete Block Design, replicated thrice. Treated plants were sprayed every two weeks with 50 mg/L, 100 mg/L and 200 mg/L of indo-3-acetic acid, gibberellic acid, kinetin and 20% coconut water while the control was watered with tap water. Samples were analyzed after drying at 60^0c for two days for 2hrs. White *C, nitida* seedlings recorded the highest value in sodium (7.45mg/100g dry matter), calcium (7.33mg/100g dry matter), manganese (2.36 mg/100g dry matter) and zinc (5.34 mg/100g dry matter) when treated with 50mg/L GA_3. Similar results were observed for pink and red colours of *C. nitida* seedlings with 50 mg/L GA_3 recorded the highest value in sodium and calcium respectively. 100 mg/L GA_3 recorded the highest in anthraquinone and theobromine for white *C. nitida* seedlings. 200 mg/L GA_3 recorded the highest in anthraquinone, theobromine, kolatin and poytphenol for pink *C, nitida* seedlings. 20% coconut water had highest in trypsin inhibitor for pink and red *C. nitida* seedlings. Conclusively, application of plant growth substances enhances mineral and phytochemical content of *C. nitida* seedlings of different colours compared to the control.

Keywords: *C, nitida seedlings, plant growth substances, minerals and phytochemical composition*

INTRODUCTION

Plants are a primary source of medicines, fibre, food, shelters and other items in everyday use by humans. The roots, stems, leaves, flowers, fruit and seeds provide food for humans (Hemingway, 2004). Seeds have nutritive and calorific values which make them necessary in diets (Odoemelam, 2005). Among these plants are the nuts of *Cola nitida* and *Cola nitida* which can also be eaten for their special taste and flavour. *Cola* is a tropical African genus that belongs to Sterculiaceae. The genus comprises of about 140 species (Onomo *et. al.*, 2006). Fifty species of this genus have been described in West Africa (Adebola, 2003).The most commonly used species are *Cola nitida* [(Vent) Schott and Endlicher], *Cola acuminata* [(pal de. Beuav) Schott and Endl]. Kola nuts contain major active ingredient know as caffeine (soluble substance). Industrially, it is useful for the preparation of kola type beverages namely Coca Cola, Pepsi- Cola, wine and kola chocolate. Also, it is reported by Mokwunye (2009) that kola powder best suited for beverage production could be produced by drying kola nuts at 80^0c for 9 hrs. Kola nuts invigorate dental gums and prevent gout and diseases (Opeke, 1992). The kola testa is used in feeding Africa giant land snail raised in a kola plantation (Hamzat, *et. al.,* 2002). Kola nuts are good source of material for dyes in textile and thread industry. The kola pod husk has also been utilized for the production of liquid soap. The most recent and remarkable advancement in kola by-product utilization is the use of kola pod husk in the replacement of up to 60% of the maize used in poultry feed formulations (Yahaya *et. al*., 2001;Hamzat, 2001; Hamzat and Babatunde, 2001; Hamzat*et. al*., 2000; 2002a; 2002b;Hamzat and Longe, 2002; Hamzat *et. al*., 2002; Olubamiwa *et. al*., 2002). Kola nut also contain essential minerals like K, Ca, Mg, Na, Fe Zn, Mn, and P (Ugioro *et al.*, 2015). Some of these minerals act as sources of macro and micro nutrients needed for growth and development and metabolic activities by man.

This study therefore was carried out to evaluate the effect of plant growth substances on physiological and biochemical content of *C. nitida* seedlings.

MATERIALS AND METHODS

The study area: This study was carried out at Cocoa Research Institute of Nigeria (CRIN) Headquarters, Idi-Ayunre, Ibadan.CRIN Headquarters is situated in the derived savannah zone of Nigeria (latitude$7^0$25'N, 3^0 25'E., altitude 122m above sea level. The rainfall is between 1250-1500mm per annum and average temperature of 30^0C. The soil is sandy oxicpaleustaff (Alfisol). (Soil survey staff, 1999).

Collection of samples: *Cola nitida*nuts that was used for studying morpho- physical factors was obtained from Cocoa Research Institute of Nigeria (CRIN),Oyo State.

Raising nuts for seedlings: A total of two hundred (200) fresh nuts of different colours of *C. nitida* were obtained from mature fresh pods (Cocoa Research Institute of Nigeria Headquarters).

Nuts extraction was by splitting matured pods with a sharp knife, the nuts were soak and washed in water to remove the testa on them, air dried at room temperature, bagged in a poly sac, labeled and stored properly to prevent insect attack. Five seed boxes of (90x60x30cm) size each was filled with a mixture of composted sawdust and topsoil (ratio 50:50). The mature nuts of *Cola nitida* was sown on the substrate. The bulk soil taken from the site (0-15cm depth) was sieved to remove stones and plant debris and 2.5kg of the sieved soil was placed into a polythene bag (25cmx13cm). The nuts were first pre-germinated in the nursery before transferring into the polythene pot.

Nursery Establishment: Kola nuts were sown one per polythene bag arranged in a completely randomized block design (RCBD) replicated three times. The treated plants were spray every 2 weeks with 50ppm, 100ppm and 200ppm of IAA, Kinetin, GA_3 and 20% coconut water while the control was watered with tap water. Weeding was done at three months after planting and repeated at 6, 9, 12, 15 and 18 months. At 96 weeks after planting, the seedlings were carefully removed from the polythene bags, oven dried at 60^0c for 2 days. Mineral, phytochemical and anti- nutrient were analyzed using standard procedures.

Quantitative analysis of phytochemicals

Determination of alkaloids: This was done by the alkaline precipitation gravimetric method described by Harborne (1973). A know weight of the sample was dispersed in 10% acetic acid solution in ethanol to form a ratio of 1:10 (10%). The mixture was allowed to stand for 4h at 28^0C. It was later filtered via whatman No 42 grade of filter paper. The filtrate was concentrated to one quarter of its original volume by evaporation and treated with drop wise addition of conc. aqueous NH_4OH until the alkaloid was precipitated. The alkaloid precipitated was received in a weigh filter paper washed with 1% ammonium solution and dried in the oven at 80^0C. Alkaloid content was calculated and express as a percentage of the weight of sample analyzed.

Flavonoids: This was done according to the method of Harborne (1973). Five gram of the sample was boiled in 50ml of 2M HCl solution for 30mins under reflux. It was allowed to cool and then filtered through whatman No 42 filter paper. A know volume of the extract was treated with equal volume of ethyl acetate starting with drop. The flavonoid precipitated was recovered by filtration using weighed filter paper. The resulting weight differences gave the weight of flavonoid in the sample.

Tannin: Tannin content was determined by the Folis- Dennis colorimetric method described by Kirk and Sawyer (1998). Five gram of the sample was dispersed in 500ml of distilled water and shaken. The mixture was allowed to stand for 30mins at 28^0C before it was filtered through whatman No 42 grade of filter paper. 2ml of the extract was dispersed into a 500ml volumetric flask. Similarly, 2ml standard tannin solution (tannic acid) and 2ml of distilled water was put in separate volumetric flask to serve as the standard. Reagent was added to each of the flasks and the 2.5ml of saturated $NaCO_3$ solution added. The content of each flask was made up to 50ml with distill water and allow to incubate at 28^0C for 90 min. Their respective absorbance was measured on a Spectrophotometer at 260nm using the reagent blank to calibrate the instrument to zero

Saponin: Quantitative determination of saponin was done according to Obadoni and Ochuko (2001). Twenty gram of each powdered sample was added to 100ml of 20% aqueous ethanol and kept in a shaker for 30min. The sample was heated over a water bath for 4h at 55^0C. The mixture was filtered and the residue re-extracted with another 200ml of 20% aqueous

ethanol. The combined extract was reduced to approximately 40ml over bath at 90^0C. The concentrate was transferred into 250ml separatory funnel, extracted twice with 20ml diethyl ether. Ether layer was discarded while aqueous layer was retained and 60ml n- butanol extract was wash twice with 10ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath and after evaporation; the sample was dried in an oven at 40^0C to a constant weight. The saponin content was calculated as percentage of the initial weight of sample taken.

Caffeine determination: Caffeine content was determined according to Irgolic *et al.* (1982) methods. Two samples of grated kola nuts were put into a round bottom flask and 300ml of distilled water was added to each. The mouth of the flask was covered with condenser and then connected to closed jar of water. Each of the flasks was placed on electric heater. As soon as the content begins to boil the close tap or jar of water was open to drain the water and was allowed to stand for one hour. As the content was boiling, the refluxing system was turned on and the reflux was sieved out. The residue was discarded and the filtrate was retained and placed in ice block for 15mins; thereafter, 100ml of the filtrate was placed in a 250 ml separatory funnel and 120ml chloroform was added gradually. The corked separatory funnel was shaken until the chloroform water interface was established and after 50 mins clear solution was formed into which caffeine dissolved in chloroform. It was later put into 50ml beaker and chloroform evaporated over a water bath. The weight of the resultant yellowish white caffeine crystals was taken on mettler P-165 electric balance

Mineral element composition of the pulverized seed was estimated by the method described by Pearson (1976) after acid digestion of the ashed sample of a known weight. Sodium and potassium were analyzed using a flame photometer; calcium and magnesium was determined using Vernasate (EDTA) complexometric titration method while phosphorus was determined using UV Visible Spectrophotometer. Phytate was determine by Thompson and Erdman (1982); Total oxalate was determined by Ukpabi and Ejidoh (1989) while calcium oxalate and Trypsin inhibitors were determined by Kakade *et al.* (1974). The phenolic content was analyzed using Folin-Ciocalteu reagent following a modified procedure of Singleton and Rossi (1965). One ml of the appropriately diluted sample was mixed with 5 mL of Folin-Ciocalteu reagent (1:10, v/v, diluted with distilled water). The reaction was neutralized by adding 4 ml of 75g l^{-1} sodium carbonate. Samples was held for 2 h at 25 ± 2^0C and the absorbance of the resulting blue colour was measured at 760 nm against a reagent blank on a Cecil CE 7400 UV-visible Spectrophotometer (Cecil Instruments, Cambridge, England).

Statistical analysis: The average data obtain for the physiological and and soil chemical composition of kola seedlings were analyzed using ANOVA with an F-test. The treatment means were compared using a Duncan Multiple Range Test at the 5% probability level.

RESULTS AND DISCUSSION

Table 1 showed the effect of hormone treatment on mineral content of white *C. nitida* seedlings.White *C. nitida* seedlings treated with 50mg/L GA_3 has the highest mean value in sodium (7.45mg/100g dry matter), calcium (7.33 mg/100g dry matter), manganese (2.36 mg/100g dry matter) and zinc (5.34 mg/100g dry matter) at 24MAP. Similarly, the highest mean value for potassium (117.35 mg/100g dry matter), phosphorus (53.80 mg/100g dry matter), iron (5.09 mg/100g dry matter) and magnesium (5.50 mg/100g dry matter) were induced by 100mg/L GA_3 and the least detected in control of all the mineral element content analyzed. Potassium recorded the highest of all the mineral content analyzed in *C. nitida* seedlings when treated with various plant growth substances of different concentrations and the control, followed by phosphorus and the least was detected in manganese. All the elements assayed were significantly different from each other compared to the control. Table 2 shows that 100mg/L GA_3 have the highest in sodium (7.22mg/100g dry matter) and calcium (7.46mg/100g dry matter) respectively. Similarly, 200mg/L GA_3 have the highest mean value in potassium (114.29mg/100g dry matter), phosphorus (57.31mg/100g dry matter), magnesium (5.92mg/100g dry matter), manganese (2.22mg/100g dry matter) and zinc (5.85mg/100g dry matter) respectively and the least was detected in control**.** Table 3 shows that red *C. nitida* seedlings treated with 50mg/L GA_3 recorded the highest mean value in sodium (7.90mg/100g dry matter), calcium (7.63mg/100g dry matter), iron (5.66mg/100g dry matter), magnesium (5.20mg/100g dry matter) and zinc (5.65mg/100g dry matter)

respectively. Similarly, the highest value of potassium (114.43mg/100g dry matter) was detected in 200mg/L IAA and the least was obtained in control. Potassium has the highest mean value of all the mineral content assayed when treated with various plant growth regulators at different concentrations and the controls. Significant differences were obtained in all the mineral element content analyzed and the control except for seedlings treated with 100mg/L IAA, 200mg/L IAA, 100mg/L kinetic acid and 200mg/L kinetic acid for potassium, 200mg /L IAA, and 200mg/L kinetic acid for phosphorus and 50mg/L GA_3 and 100mg/L GA_3 for zinc respectively. These concentrations of calcium and phosphorus in the leaves of the treated seedlings are very important because calcium is known to enhance to quality of bone and teeth (Okwu and Ekeke, 2003). Calcium content ranged from 4.01 mg/100g dry matter to 7.24 mg/100g dry matter when treated with 50mg/L GA_3. These values were higher than the calcium content of 2.10mg/100g contained in exudates from *Raphiahookeri* (Okwu and Nnamdi, 2008) and calcium contents of 1.31mg/100g recorded in *S. mombin* leaves by Njoku and Akumefula, (2007). It is worthy to note that magnesium, sodium, phosphorus, calcium and potassium are present in the leaves of treated seedlings of *C. nitida*. The combination of these elements with fluoride may have therapeutic, protective and preventive roles in teeth (Olabanji *et al.,* 1996, Okwu and Ekeke, 2003). Lack of calcium or phosphorus in the diet causes a disease known as rickets (Fliedner and Teichman, 1965) and osteoporosis (Hunt *et al.,* 1980 and Okwu and Emenike, 2007). In osteoporosis condition, the bone mass is so decreased that adequate mechanical support can no longer be provided and sustained, spontaneous fractures often results (Hunt *et al.,* 1980; Okwu and Emenike, 2007). The quantitative phytochemical screening of white *C.nitida* seedlings showed that the leaves contain tannin, saponin, flavonoid, anthraquinone, caffeine, theobromine, kolatin and polyphenol. The quantitative estimate of phytochemical contents of white *C. nitida* seedlings given hormone treatments of plant growth regulators at 24MAP is presented in Table 4 The result showed that flavonoid, alkaloid, caffeine and kolatin were highest in *C. nitida* seedlings treated with 50mg/L GA_3 with values of 0.42g/100g, 4.96g/100g, 0.039g/100g and 0.008g/100g respectively. Anthraquinone and theobromine recorded the highest mean value of 0.36g/100g and 0.0204g/100g in *C. nitida* seedlings given 100mg/L GA_3 hormone treatment at 24MAP. 50mg/L kinetin has the highest in tannin (0.35g/100g) and 200mg/l GA_3 have the highest in polyphenol (0.36g/100g). Table 4 showed that all the values for the hormone treatments were significantly different from those of the controls. Table 5 showed the quantitative phytochemical screening of pink *C. nitida* seedlings treated with different concentrations of plant growth regulators. From the result, *C. nitida* seedlings treated with 50mg/100g have the highest in flavonoid (0.42g/100g) and caffeine (0.0038g/100g) respectively. Similar result was detected in *C. nitida* seedlings where 100mg/L GA_3 have the highest in tannin (0.34g/100g) and saponin (0.44g/100g). *C. nitida* seedlings treated with 200mg/L GA_3 recorded the highest in anthraquinone (0.37g/100g), theobromine (0.0204g/100g), kolatin (0.008g/100g) and polyphenol (0.36g/100g) respectively. Significant differences were obtained for all the phytochemical content assayed and the control except for saponin treated with 50mg/L GA_3, 100mg/L GA_3, 50mg/L kinetin and 200mg/L kinetic acid, theobromine treated with 200mg/L GA_3 and 200mg/L kinetic acid and kolatin given hormone treatment of 100mg/L GA_3 and 200mg/L GA_3 respectively. Control recorded the least mean value in all the phytochemical content assayed. The quantitative phytochemical screening of red *C. nitida* seedlings at 24MAP shows that seedlings treated with 200mg/L GA_3 recorded the highest mean value in all phytochemical content that were screened and the control except for polyphenol and were significant. The values includes tannin (0.34g/100g), saponin (0.69 g/100g), flavonoid (0.35 g/100g), anthraquinone (0.39 g/100g), caffeine (0.040 g/100g), theobromine (0.024 g/100g) and kolatin (0.009 g/100g) respectively. Alkaloids have the highest mean value treated with 200mg/L IAA and was significant. Similar result was detected for polyphenol where 100mg/L GA_3 recorded the highest mean value. Red *C. nitida* seedlings had the highest in flavonoid with value 0.33g/100g when compared with white (0.32g/100g) and pink (0.31g/100g) respectively. The biological functions of flavonoids include protection against allergies, inflammation, free radicals scavenging, platelets aggregation, microbes, ulcers, hepatoxins, viruses and tumors (Okwu, 2005; Okwu and Emenike, 2006). As antioxidants, flavoniods provide anti-

inflammatory actions (Okwu 2001a; Okwu, 2001b). This may be the reason for the use of *C. nitida* leaves in the treatment of intestinal troubles in herbal medicines (Okwu and Okwu, 2004.

The result in Table 7 reveals no distinct trend in the distribution of the anti- nutrient content among the treated seedlings and controls. The highest mean value of anti- nutrient content treated with hormone treatments at 24MAP were recorded in trypsin inhibitor (0.23mg/100g) for 20% C.M, oxalate (0.53mg/100g) and (0.46mg/100g) for phytate respectively. No significant difference were obtained for trypsin inhibitor of *C. nitida* seedlings treated with plant growth regulators and the control except for 20% C M. similar result was detected in phytate except for 200mg/L IAA. Effect of hormone treatment of different concentrations on the anti- nutrient content of pink *C. nitida* seedlings is presented in Table 8. The result reveals no distinct trend in the distribution of the anti- nutrient content among the treated seedlings and controls. The highest anti- nutrient content in the seedlings of pink *C. nitida* treated with hormone treatments at 24MAP were recorded for the following anti-nutrient, trypsin inhibitor (0.23mg/100g) for 20% C.M, oxalate (0.53mg/100g) and (0.46mg/100g) for phytate respectively. No significant difference were obtained for trypsin inhibitor of *C. nitida* seedlings treated with plant growth regulators and the control except for 20% C W. similar result was detected in phytate except for 200mg/L IAA. Anti-nutrient in Table 9 reveals that no general trends were observed among the treated and the control. 20% C.W has the highest in trypsin inhibitor. Red *C. nitida* seedlings treated with 100mg/L IAA has the highest in oxalate (0.53g/100g) while red *C. nitida* seedlings treated with 100mg /L GA_3 has the highest in phytate (0.54mg/100g). Significant differences were detected in all anti-nutrient content that were assayed except for 100mg/L IAA, 200mg/L IAA, 50mg/L GA_3, 100mg/L GA_3, 200mg/L GA_3, 100mg/L kinetic acid and 200mg/L kinetic acid respectively. The concentrations of oxalate found in the seeds are not high. High oxalate diet can increase the risk of renal calcium absorption and has been implicated as a source of kidney stones (Chai, 2004). The level of oxalate in the sample is not high to pose any health treat.The problem with phytate in food is that it can bind some essential mineral nutrients in the digestive tract and can result in mineral deficiencies (Bello, 2008). The phytate composition of the sample might not pose any health hazard when compared to a phytate diet of 10-60mg/g which if consumed over a long period of time that has been reported to decrease bioavailability of minerals in monogastric animals (Thompson, 1993).

CONCLUSION AND RECOMMENDATION

This study shows that application of plant growth substances enhances the mineral and phytochemical content of *C. nitida* seedling of different colours when compared to the control and the presence of phytochemicals (secondary plant metabolites) justifies their therapeutic functions.

REFERENCES

Adebola, P. O. 2003. Genetic characterization and biosystematics studies in the genus
cola Schott and Endlicher. Ph.D. Thesis, submitted to the University of Ibadan, Nigeria,

AOAC 2000. Official Methods of Analysis. International 17th edition. Association of Official Analytical Chemists, Washington D.C. USA.

Ayensu, E.S. (1978). "Medicinal plant of West Africa," Reference publication International, Michigan, Michigan B-9 upon growth, development and organic compounds in *Primula*

Ebofin, A. O., Agboola, D. A., Ayodele, M. S and Aduradola, A. M. 2004. Effect of some growth hormones on seed germination and seedlings growth of some savannah tree legumes. *Nigerian Journal of Botany* 16: 64-75.

Chai, W. and Liebman, M. 2004. Assessment of Oxalate Absorption from Almonds and Black Beans With and Without the Use of an Extrinsic Label 172: 953-957.

Hamzat, R and Babatunde, B.B. (2001) Performance characteristics of broiler finishers fed kola (*Cola nitida*)Vent. (Schott & Endl) pod husk-based diets. *Moor Journal of Agricultural Research.*2(2): 153-158.

Hamzat, R. A and Longe, O. G. 2002. Potential of kola testa as a sole feed for (*Archachantinamarginata*) snails raised under kola plantation. *Nigeria Journal of Tree crops research*. 4(4):1-9

Hamzat, R. A. (2001) Processing of kola testa into snail feeds. Paper presented at a two-

day collaborative workshop on awareness generation on the use of kola and its by-products organised by Centre for Rural Development (CERUD), Lagos and CRIN, November 7 – 8, 2001, Ikorodu, Lagos. 10pp.

Hamzat, R. A.; Jayeola, C. O. and Longe, O. G. (2002a) Nutritional quality of snails (*Archachatinamarginata*) fed fresh kola testa as a sole feeding stuff. In: Book of Proceedings NSAP Conference held at Federal University of Technology, Akure, Nigeria. pp. 295 – 297.

Hamzat, R. A.; Olubamiwa, O.; Taiwo, A. A.; Tiamiyu, A. K.; Longe, O. G. and Adeleye, I. O. A. (2000) Potentials of kola testa and pod husks in animal feeds. In: Book of Proceedings, 24th Annual NSAP Conference held at Umudike, Nigeria. p.112.

Hamzat, R. A.; Omole, A. J.; Oredein, A.O. and Longe, O. G. (2002b) Growth performance of immature African Giant Snail (*Archachatinamarginata*) fed dried kola testa/palm kernel cake mixture under kola plantation. *African Journal of Livestock Extension* 1(2), in press.

Hamzat, R.A., Jayeola, C.O. and Longe, O.G. (2002) Nutritional quality of snails (*Archachatinamarginata*) fedsolely with fresh kola testa. *Nutrition & Food Science.* Vol 32(4): 134-136.

Harborne, J.B. 1964. Biochemistry of phenolic compounds. Academic, London. p. 511-543.

Hemingsway, C. A. (2004). Plants and People Edible Plant J., P.1

Hunt, S., Goff, J.L. and Holbrook, J. 1980. Nutrition Principle and Chemical Practices. John Wiley and Sons. New York, pp: 49 – 52.

Irgolic I., (1982) Analytical method of caffeine determination in Okuade and Lale (1998) Assessment of damage to andloss of kolanut (Cola nitida Schott &Endl.) caused by kola weevils (Balanogastris and Saphrorhinusspp) in Maiduguri. Lale, N.E.S., Molta, N.B.,

Irvine FR. 1961. *Woody plants of Ghana with special references to their uses*. Oxford University Press: London; 145-148.

Kakade, M.C., Racks,J.J. McGhee, J.E. and Puski, G. 1974. Determination of Trypsin Inhibitor Activity ofSoy Products: A Collaborative analysis of An Improved Procedure. Cereal Chemistry, 51: 376-382.

Kirk, H and Sawyer, R. 1998. Frait Pearson Chemical Analysis of Food. 8th edition. Longman Scientific and Edinburgh. 211-212.

Macrae, R., Robinson, R.K., Sadler, M.J. 1997:. Encyclopedia of Food Science and Food Technology and Nutrition Vol. 3 Academic Press Ltd. Volume 3 Pp. 2163-2175.

Mokwunye, F. C. 2009. Functionality of kolanuts powder in Beverage production. An MSc. Dissertation submitted to the department of F.S.T. university of Agriculture, Abeokuta, Nigeria, pp. 1-69.

Nickalls, R. W. D. 1986. The discovery that kola nuts contain caffeine. *Pharmaceutical Journal* 236, 401-402

Njoku, P.C. and Akumefula, M.I. 2007. Phytochemical and Nutrient Evaluation of *SpondiasMombin*Leaves. *Pakistan Journal of Nutrient 6 (6): 613 – 615.*

Odoemelam, S.A., 2005. Proximate Composition and Selected Physicochemical Properties of the Seeds of African Oil Bean (*Pentaclethramarcrophylla*). *Journal of Nutrition*4: 382-383.

Ogutuga, D.B.A. 1975. Chemical composition and potential commercial uses of kola nuts, *Cola nitida* Vent. (Schott and Endlicher). *Ghana journal of Agricultural Science*.8:121-125

Okwu and Emenike, I. N. 2007. Nutritive value and mineral content of different varieties of citrus fruits. *Journal of Food Technology 5: 105 – 108.*

Okwu, D.E and Nnamdi, F. U. 2008. Evaluation of the chemical composition of *Dacryodesedulis and Raphiahookerimann and wendl*exudates used in Herbal medicine in South Eastern Nigeria. *African Journal. Trinidad CAM* 5 (1): 194 – 200.

Okwu, D.E. 2001a. Improving the nutrition value of cassava tapioca meal with local spices.*Nutracentical, functional and medicinal food,* 3:43

Okwu, D.E. 2001b. Evaluation of the chemical composition of indigenous spices and flavoring agents. *Global Journal of Pure and Applied. Science* 8:455 – 459.

Okwu, D.E. and Ekeke, O. 2003. Phytochemical screening and mineral composition of *Chewing* Stick in South Eastern Nigeria. *Global Journal of Pure and Applied Sciences 9:235 – 238*

Okwu, D.E. and Emenike. I. N. 2006. Evaluation of the phytonutrients and vitamins contents of citrus fruits.

International Journal of Molecular Medicine and Advance Science. 2(1):1 – 6.

Okwu, D.E. and Okwu, M.E. 2004: Chemical Composition of *SpondiaMombin*Plants. *Journal of Sustainable Agriculture and Environment* 6: 140-147.

Onyeka, E.U. and Nwambekwe, I.O. 2007. Phytochemical profile of some green leafy vegetables in South East, Nigeria. *Nigerian Food Journal, Volume. 25* No. 1. (2007), pp.67 – 76.

Opeke, L. K. 1992. Tropical Tree Crops. Spectrum Book Limited; Ibadan. 124-174

Opeke, L.K. 2005. Tropical Commodity Tree Crops. 2nd Edition, Spectrum books Limited; Ibadan. 180-186

Oyebade, T.I. 1973. Some aspect of developmental physiology of the Nigerian kola, *Cola nitida*, fruit. *Economic Botany. 27*: 417 – 422.

Oyenuga, V.A. and B.L. Fetuga, 1975. First Nutritional Seminar on Fruits and Vegetables. In: Proc and Recom and Papers by NIHORT, Ibadan.

Pearson D (1976). The chemical Analysis of Foods. 7ed; Churchill Livingstone, London.

Stuart, N. W., and Cathay H. M. 1961. Applied aspects of the gibberellins. Annual Review of Plant Physiology 12: 369-394.

Thompson, L. U. 1993. Potential Health Benefits and Problems Associated With Anti Nutrients in Foods. *International Journal of Food Resources*26:131-149.

Ugioro, O., Kadiri, M., Idrisu, M., Adeosun, S.A., Olaniyi, O.O., and Asowata, F.E. (2015). Nutrient and anti-nutrient evaluation of wonderful kola (*C. nitida* vent) of fresh nut at different sizes and colours. *International journal of Biosciences*. 79. ISSN: 2229-712X, pp 30721-30724.

Webmaster, 2006. Tannins: Fascinating but sometimes dangerous molecules. Accessed http:www.ansci.cornell.edu/ansci.html.

Williams, S.O. 1979. Prospect of Kola Chocolate processing and consumption CRIN. (Seminar Paper 4)

Yahaya, L. E.; Hamzat, R. A. and Aroyeun, S. O. (2001) Utilization of kola pod husk in liquid soap production. *Moor Journal of. Agricultural Research* 3(2), 252 – 256

Table 1: Mineral (mg/100g dry matter) content of white *C. nitida* seedlings given hormone treatment of different concentrations at 24MAP.

Treatments	Na	Ca	K	P	Fe	Mg	Mn	Zn
50mg/L IAA	6.04^{g}	6.06^{f}	113.63^{ab}	47.38^{h}	4.56^{e}	3.95^{f}	2.23^{d}	4.54^{d}
100mg/L IAA	7.10^{c}	6.35^{e}	113.25^{ab}	50.30^{f}	4.69^{c}	4.25^{e}	2.27^{c}	4.90^{b}
200mg/L IAA	7.42^{a}	6.63^{c}	113.12^{ab}	52.30^{c}	4.50^{f}	4.65^{d}	2.28^{b}	5.37^{a}
50mg/L GA_3	7.45^{a}	7.33^{a}	114.32^{ab}	53.27^{b}	5.03^{b}	4.85^{c}	2.36^{a}	5.34^{a}
100mg/L GA_3	7.14^{c}	7.00^{b}	117.35^{a}	53.80^{a}	5.09^{a}	5.50^{a}	2.16^{e}	4.69^{c}
200mg/L GA_3	7.28^{b}	7.29^{a}	114.00^{ab}	51.79^{e}	4.64^{d}	5.37^{b}	1.93^{h}	4.55^{d}
50mg/L KT	6.28^{e}	5.60^{g}	112.52^{ab}	45.87^{i}	3.50^{i}	3.11i	1.69^{i}	3.57^{g}
100mg/L KT	6.99^{d}	6.50^{d}	113.64^{ab}	49.62^{g}	3.67^{h}	3.26^{h}	2.06^{g}	3.68^{f}
200mg/L KT	6.12^{f}	7.03^{b}	13.92^{ab}	51.86^{d}	3.94^{g}	3.80^{g}	2.09^{f}	4.19^{e}
20% CW	5.50^{h}	5.00^{h}	110.51^{ab}	39.86^{j}	2.80^{j}	2.68^{j}	1.44^{j}	2.80^{h}
Control	5.21^{i}	4.32^{i}	85.56^{b}	37.52^{k}	2.67^{k}	2.27^{k}	1.16^{k}	2.74^{i}

Means followed by the same letters on the same columns are not significantly different according to Duncan Multiple Range Test at 5% probability level.

Footnote:Na- Sodium,Ca-Calcium, K-Potassium, P- Phosphorus, Mg- Magnesium, Fe- Iron,Mn, Manganese and Zn- Zinc.IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 2: Mineral content of pink *C. nitida* seedlings given hormone treatment of different concentrations at 24MAP.

Treatments	Na	Ca	K	P	Fe	Mg	Mn	Zn
50mg/L IAA	6.29^{i}	6.83^{d}	110.50^{f}	50.02^{h}	4.66^{f}	4.10^{e}	2.07^{d}	4.66^{e}
100mg/L IAA	7.09^{f}	6.40^{f}	113.82^{c}	56.11^{c}	5.49^{b}	4.32^{e}	1.97^{f}	4.85^{d}
200mg/L IAA	7.34^{c}	6.42^{f}	113.40^{e}	56.36^{b}	5.60^{a}	4.81^{d}	1.93^{g}	4.95^{c}
50mg/L GA_3	7.22^{d}	7.01^{c}	106.70^{i}	51.18^{f}	4.87^{e}	5.22^{c}	2.11^{c}	3.68^{h}
100mg/L GA_3	7.65^{a}	7.46^{a}	114.17^{b}	55.81^{d}	5.22^{c}	5.64^{b}	2.16^{b}	5.52^{b}
200mg/L GA_3	7.54^{b}	7.24^{b}	114.29^{a}	57.31^{a}	5.41^{c}	5.92^{a}	2.22^{a}	5.85^{a}
50mg/L KT	6.36^{h}	6.13^{g}	108.18^{h}	45.51^{i}	3.65^{i}	3.07^{i}	1.90^{h}	3.63^{i}
100mg/L KT	6.99^{g}	6.42^{f}	110.35^{g}	50.87^{g}	4.17^{h}	3.36^{h}	1.69^{i}	3.99^{g}
200mg/L KT	7.13^{e}	6.52^{e}	113.67^{d}	55.17^{e}	4.64^{g}	3.95^{g}	1.99^{e}	4.49^{f}
20% CW	5.50^{j}	5.10^{h}	96.74^{j}	40.54^{j}	2.88^{j}	2.86^{k}	1.68^{j}	3.04^{j}
Control	4.64^{k}	4.06^{i}	66.54^{k}	33.99^{k}	2.48^{k}	2.16^{l}	1.38^{k}	3.02^{k}

Means followed by the same letters on the same columns are not significantly different according to Duncan Multiple Range Test at 5% probability level.
Footnote: Na- Sodium,Ca-Calcium, K-Potassium, P- Phosphorus, Mg- Magnesium, Fe- Iron,Mn, Manganese and Zn- Zinc. IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 3: Mineral content of red *C. nitida* seedlings given hormone treatment of different concentration at 24MAP.

Treatments	Na	Ca	K	P	Fe	Mg	Mn	Zn
50mg/L IAA	6.80^{f}	6.59^{e}	113.61^{ab}	51.81^{g}	5.30^{c}	4.15^{d}	2.07^{bc}	4.89^{c}
100mg/L IAA	7.09^{e}	6.55^{e}	114.17^{a}	61.36^{b}	5.42^{b}	4.23^{d}	2.19^{ab}	5.38^{b}
200mg/L IAA	6.98^{e}	6.33^{g}	114.43^{a}	63.73^{a}	4.64^{d}	4.52^{c}	2.29^{a}	5.44^{b}
50mg/L GA_3	7.90^{a}	7.63^{a}	108.76^{c}	51.55^{f}	5.66^{a}	5.20^{a}	1.91^{cd}	5.65^{a}
100mg/L GA_3	7.58^{b}	7.58^{b}	110.41^{bc}	54.91^{e}	5.52^{b}	5.08^{ab}	1.97^{cd}	5.64^{a}
200mg/L GA_3	7.69^{b}	7.35^{c}	111.59^{abc}	57.41^{d}	5.29^{c}	4.82^{b}	2.09^{bc}	4.68^{d}
50mg/L KT	6.26^{g}	6.20^{h}	112.54^{ab}	48.81^{h}	3.94^{f}	3.09^{e}	1.90^{cd}	4.11^{e}
100mg/L KT	7.30^{d}	6.44^{f}	114.10^{a}	59.52^{c}	4.41^{e}	3.11^{e}	1.89^{cd}	4.55^{d}
200mg/L KT	7.44^{c}	6.90^{d}	114.26^{a}	62.73^{a}	4.61^{d}	4.04^{d}	2.14^{bcd}	4.69^{cd}
20% CW	5.67^{h}	4.20^{i}	89.69^{d}	40.26^{i}	3.16^{g}	2.82^{f}	1.87^{d}	3.52^{f}
Control	4.37^{i}	3.64^{g}	70.44^{e}	38.05^{j}	2.49^{h}	2.35^{g}	1.48^{e}	3.46^{f}

Means followed by the same letters on the same columns are not significantly different according to Duncan Multiple Range Test at 5% probability
Footnote: Na- Sodium,Ca-Calcium, K-Potassium, P- Phosphorus, Mg- Magnesium, Fe- Iron,Mn, Manganese and Zn- Zinc. IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 4: Phytochemical content of white *C. nitida*s eedlings given hormone treatment of different concentration at 24MAP

Treatments	Tannin	Saponin	Flavonoid	Alkaloid	Anthraquinone	Caffeine	Theobromine	Kolatin	Polyphenol
50mg/L IAA	0.30^{d}	0.37b^{c}	0.27^{de}	4.53^{bc}	0.27^{g}	0.033^{d}	0.0147^{d}	0.005^{c}	0.29^{c}
100mg/L IAA	0.29^{e}	0.36^{c}	0.29^{d}	4.54^{bc}	0.29^{e}	0.032^{e}	0.0168^{c}	0.006^{b}	0.28^{d}
200mg/L IAA	0.29^{e}	0.36^{c}	0.29^{d}	4.44^{c}	0.32^{c}	0.031^{f}	0.0186^{b}	0.006^{b}	0.28^{d}
50mg/L GA_3	0.29^{e}	0.42^{a}	0.42^{a}	4.96^{a}	0.30^{d}	0.039^{a}	0.0170^{c}	0.008^{a}	0.29^{c}
100mg/L GA_3	0.29^{e}	0.41^{ab}	0.39^{b}	4.74^{ab}	0.36^{a}	0.036^{b}	0.0204^{a}	0.007^{a}	0.29^{c}
200mg/L GA_3	0.28^{f}	0.40^{abc}	0.38^{b}	4.56^{bc}	0.34^{b}	0.035^{bc}	0.017^{c}	0.005^{c}	0.36^{a}
50mg/L KT	0.35^{a}	0.43^{a}	0.35^{c}	4.39^{c}	0.28^{f}	0.031^{f}	0.0148^{d}	0.004^{d}	0.31^{b}
100mg/L KT	0.31^{c}	0.41^{ab}	0.35^{c}	4.50^{bc}	0.31^{d}	0.032^{e}	0.0173^{c}	0.006^{b}	0.30^{bc}
200mg/L KT	0.30^{d}	0.45^{a}	0.34^{c}	4.57^{bc}	0.33^{b}	0.034^{c}	0.0197^{a}	0.006^{b}	0.29^{c}
20% CW	0.33^{b}	0.36b^{c}	0.28^{de}	4.38^{c}	0.31^{d}	0.029^{h}	0.0137^{e}	0.005^{c}	0.28^{d}
Control	0.28^{f}	0.44^{a}	0.25^{e}	3.90^{d}	0.24^{h}	0.026^{i}	0.0124^{f}	0.003^{e}	0.27^{e}

Means followed by the same letters on the same columns are not significant different according to Duncan Multiple Range Test at 5% probability level
Footnote: IAA-Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 5 Phytochemical content of pink *C. nitida* seedlings given hormone treatment of different concentration at 24MAP

Treatment	Tannin	Saponin	Flavonoid	Alkaloid	Anthraquinone	Caffeine	Theobromine	Kolatin	Polyphenol
50mg/L IAA	0.30^{d}	0.36b^{c}	0.29^{d}	4.53^{bc}	0.27^{h}	0.033^{d}	0.015^{d}	0.005^{c}	0.29^{c}
100mg/L IAA	0.29^{e}	0.35^{c}	0.28^{d}	4.74^{ab}	0.29^{gf}	0.032^{e}	0.017^{c}	0.006^{b}	0.29^{c}
200mg/L IAA	0.29^{e}	0.35^{c}	0.28^{d}	4.96^{a}	0.32^{c}	0.031^{f}	0.019^{b}	0.006^{b}	0.28^{d}
50mg/L GA_3	0.29^{e}	0.42^{a}	0.42^{a}	4.44^{c}	0.30^{ef}	0.038^{a}	0.017^{c}	0.005^{c}	0.29^{c}
100mg/L GA_3	0.34^{a}	0.44^{a}	0.39^{b}	4.54^{bc}	0.34^{b}	0.036^{b}	0.018^{c}	0.007^{a}	0.29^{c}
200mg/L GA_3	0.28^{f}	0.40^{abc}	0.38^{b}	4.59^{bc}	0.37^{a}	0.035^{bc}	0.020^{a}	0.008^{a}	0.36^{a}
50mg/L KT	0.33^{b}	0.43^{a}	0.35^{c}	4.39^{c}	0.28^{g}	0.029^{f}	0.015^{d}	0.004^{d}	0.31^{b}
100mg/L KT	0.31^{c}	0.41^{ab}	0.35^{c}	4.50^{bc}	0.31^{d}	0.031^{e}	0.017^{c}	0.006^{b}	0.30^{bc}
200mg/L KT	0.30^{d}	0.45^{a}	0.34^{c}	4.57^{bc}	0.33^{b}	0.035^{bc}	0.020^{a}	0.006^{b}	0.29^{c}
20% CW	0.28^{f}	0.36b^{c}	0.29^{d}	4.37^{c}	0.31^{d}	0.028^{h}	0.014^{e}	0.005^{c}	0.28^{d}
Control	0.28^{e}	0.35^{c}	0.25^{e}	3.90^{d}	0.24^{i}	0.026^{i}	0.012^{f}	0.003^{e}	0.28^{e}

Means followed by the same letters on the same columns are not significantly different according to Duncan Multiple Range Test at 5% probability level.
Footnote: IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 6: Phytochemical content of red *C. nitida* seedlings given hormone treatment of different concentration at 24MAP

Treatments	Tannin	Saponin	Flavonoid	Alkaloid	Anthraquinone	Caffeine	Theobromine	Kolatin	Polyphenol
50mg/L IAA	0.30^{b}	0.35^{d}	0.31^{e}	4.53^{c}	0.33^{f}	0.034f	0.016^{d}	0.005^{b}	0.29^{c}
100mg/L IAA	0.29^{c}	0.35^{d}	0.32^{d}	4.47^{c}	0.35^{d}	0.039^{b}	0.017^{d}	0.007^{b}	0.29^{c}
200mg/L IAA	0.28^{d}	0.35^{d}	0.33^{c}	4.93^{a}	0.38^{b}	0.038^{c}	0.022^{b}	0.009^{a}	0.28^{cd}
50mg/L GA_3	0.29^{c}	0.43^{b}	0.34^{b}	4.53^{c}	0.31^{h}	0.032^{h}	0.016^{e}	0.006^{b}	0.28^{cd}
100mg/L GA_3	0.29^{c}	0.42^{b}	0.35^{a}	4.53^{c}	0.35^{d}	0.035^{e}	0.019^{c}	0.006^{b}	0.34^{a}
200mg/L GA_3	0.34^{a}	0.69^{a}	0.35^{a}	4.87^{b}	0.39^{a}	0.040^{a}	0.024^{a}	0.009^{a}	0.29^{c}
50mg/L KT	0.29^{c}	0.41^{b}	0.28^{g}	5.00^{c}	0.29^{i}	0.030^{i}	0.015^{f}	0.004^{b}	0.29^{c}
100mg/L KT	0.29^{c}	0.41^{b}	0.29^{f}	4.56^{c}	0.32^{g}	0.033^{g}	0.019^{c}	0.005^{b}	0.28^{cd}
200mg/L KT	0.28^{d}	0.40^{b}	0.31^{e}	4.57^{c}	0.36^{c}	0.036^{d}	0.022^{b}	0.007^{b}	0.28^{cd}
20% CW	0.28^{d}	0.39^{c}	0.28^{g}	4.39^{d}	0.34^{e}	0.031^{i}	0.014^{f}	0.005^{b}	0.33^{b}
Control	0.27^{e}	0.32^{e}	0.26^{h}	4.16^{e}	0.27^{g}	0.023^{j}	0.012^{g}	0.003^{b}	0.27^{d}

Means followed by the same letters on the same columns are not significantly different according to Duncan Multiple Range Test at 5% probability level.
Footnote: IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 7.Anti-nutrient content (mg/100g) of white *C. nitida* seedlings given hormone treatment of different concentration at 24MAP.

Treatments	Trypsin inhibitor	Oxalate	Phytate
50mg/L IAA	0.118^{b}	0.52^{ab}	0.52^{a}
100mg/L IAA	0.116^{bc}	0.50^{ab}	0.52^{a}
200mg/L IAA	0.115^{c}	0.50^{ab}	0.52^{a}
50mg/L GA_3	0.121^{a}	0.54^{a}	0.32^{ab}
100mg/L GA_3	0.118^{b}	0.53^{ab}	0.52^{a}
200mg/L GA_3	0.115^{c}	0.50^{ab}	0.52^{a}
50mg/L KT	0.118^{b}	0.32^{b}	0.12^{b}
100mg/L KT	0.116^{bc}	0.52^{ab}	0.32^{ab}
200mg/L KT	0.112^{d}	0.50^{ab}	0.52^{a}
20% CW	0.109^{e}	0.11^{c}	0.11^{b}
Control	0.121^{a}	0.11^{c}	0.11^{b}

Means followed by the same letters on the same columns are not significant different according to Duncan Multiple Range Test at 5% probability level.
Footnote: IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 8: Anti-nutrient content of pink *C. nitida* seedlings given hormone treatment of different concentration at 24MAP.

Treatments	Trypsin inhibitor	Oxalate	Phytate
50mg/L IAA	0.13^{b}	0.11^{b}	0.11^{b}
100mg/L IAA	0.12^{b}	0.11^{b}	0.11^{b}
200mg/L IAA	0.12^{b}	0.53^{a}	0.46^{a}
50mg/L GA_3	0.13^{b}	0.11^{b}	0.11^{b}
100mg/L GA_3	0.12^{b}	0.54^{a}	0.11^{b}
200mg/L GA_3	0.12^{b}	0.51^{a}	0.11^{b}
50mg/L KT	0.13^{b}	0.11^{b}	0.11^{b}
100mg/L KT	0.12^{b}	0.53^{a}	0.11^{b}
200mg/L KT	0.11^{b}	0.51^{a}	0.11^{b}
20% CW	0.23^{a}	0.10^{b}	0.11^{b}
Control	0.13^{b}	0.12^{b}	0.12^{b}

Means followed by the same letters on the same columns are not significantly different according to Duncan Multiple Range Test at 5% probability
Footnote: IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

Table 9: Anti-nutrient content of red *C. nitida* seedlings given hormone treatment of different concentration at 24MAP.

Treatments	Trypsin inhibitor	Oxalate	Phytate
50mg/L IAA	0.123^{bcd}	0.10^{b}	0.11^{d}
100mg/L IAA	0.122^{cd}	0.53^{a}	0.25^{bcd}
200mg/L IAA	0.116^{f}	0.51^{a}	0.53^{ab}
50mg/L GA_3	0.126^{ab}	0.51^{a}	0.11^{d}
100mg/L GA_3	0.125^{abc}	0.50^{a}	0.54^{a}
200mg/L GA_3	0.120^{de}	0.51^{a}	0.46^{abc}
50mg/L KT	0.120^{de}	0.10^{b}	0.19^{c}
100mg/L KT	0.118^{ef}	0.52^{a}	0.25^{bcd}
200mg/L KT	0.116^{f}	0.51^{a}	0.33^{abcd}
20% CW	0.128^{a}	0.11^{b}	0.32^{abcd}
Control	0.111^{g}	0.12^{b}	0.12^{d}

Means followed by the same letters on the same columns are not significantly different according to Duncan Multiple Range Test at 5% probability
Footnote: IAA- Indole-3-acetic acid, GA_3- Gibberellic acid, KT- Kinetin, C.W- Coconut water

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ORGANO-MINERAL FERTILIZER EFFECT ON PERFORMANCE OF CUCUMBER (*CUCUMIS SATIVUS* L.) IN UMUDIKE, SOUTHEAST NIGERIA

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ABSTRACT
A two-year field experiment was conducted during the cropping seasons of 2019 and 2020 to examine the influence of different organic manure sources, N:P:K-(15:15:15) fertilizer and combined application of organic manure and N:P:K-(15:15:15) fertilizer on the growth and yield of cucumber at Michael Okpara University of Agriculture, Umudike situated in a rain forest agro-ecology. The experiment was laid out in a randomized complete block design with three replications. The treatments were sole application of organic manures (poultry manure, goat manure and rabbit manure at 10 t/ha, N:P:K-(15:15:15) fertilizer at 300 kg/ha and combination of organic manures and N:P:K fertilizer at 5 t/ha and 150 kg/ha, respectively. The results showed that the application of poultry manure closely followed by a combined application of poultry manure and N:P:K-(15:15:15) fertilizer significantly ($P<0.05$) increased the vine length, number of leaves per plant, leaf area, leaf area index, fruit weight, fruit length, fruit diameter, number of fruits and fresh fruit yield compared to the other treatments investigated. The highest fresh fruit yield per hectare was recorded in year 2019 cropping season, which was higher by 24.56% compared to year 2020 cropping season while the interaction between poultry manure and year 2019 gave the highest fresh fruit yields. Therefore, poultry manure source or a combination of poultry manure and N:P:K-(15:15:15) fertilizer can be adjudged to be better sources of high soil nutrients for cucumber production in Umudike, Abia State, Nigeria.

Keywords: *organo-mineral, cucumber, combined analysis of variance, relationship*.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an important vegetable and one of the most popular members of the Cucurbitaceae family (Yang and Walters, 1992). It is a major vegetable crop worldwide and develops rapidly with a shorter time from planting to harvest than for most crops (Wehner and Guner, 2004). It requires high amount of soil nutrients from seedling stage to maturity, and highly sensitive to excessive water or water logged environment; adequate soil tillage for easy fragile root penetration is required prior to sowing (Nweke *et al.*, 2014). Production of cucumber in Nigeria has increased probably due to awareness being created by its market demand and economic returns, short duration in maturity or due to its nutritional and medicinal values. Hence it has become a popular vegetable crop in Nigeria (Nweke *et al.*, 2014). Fertilizers are substances which supply one or more plant nutrients to the soil when added. They are important to crops, especially cucumber (Harts and Nelian, 2000). Organic manure is a compound fertilizer that contains one or more kinds of organic matter such as such as goat, poultry or rabbit manures among others, and the ingredients may be animal or vegetable matter or a combination of the two. Manure is natural and does not destroy the soil. It provides macronutrients (nitrogen, calcium, phosphorus, potassium and sulphur) and micronutrients (iron, boron, zinc, cobalt, molybdenum) (Samadi, 2010). Farm yard manure and other organic manures release nutrients slowly and steadily and activate soil microbial biomass (Ayuso *et al.*, 1996; Belay *et al.*, 2001). Inorganic fertilizer (referred to as synthetic fertilizer) is manufactured artificially and contains minerals or synthetic chemicals typically made from petroleum or natural gas including phosphorus, potassium and other trace elements often mined from the earth. The proper use of inorganic fertilizer can improve crop yield, soil pH, total nutrient content and nutrient availability to plants (Akande *et al.*, 2010). The complementary use of organic and inorganic fertilizer has been recommended for sustenance of long-term cropping in the tropics (Ipimoroti *et al*., 2002). Mbah and Onweremadu (2009) reported that nutrients from mineral fertilizer enhance the establishment of crops while those from mineralization of organic manures promote yield when both fertilizers were combined. Therefore, integrating nutrient sources can help

boost the production of cucumber and meet up with the quantity demanded by the society as cucumber is a short duration crop that requires fast release of nutrients in the field, which conventional fertilizer can do better than organic manure (Marjan, 2005). In spite of the increasing dietary relevance of cucumber in Nigeria, especially in southeast Nigeria, low fruit yield is predominant in most farmers' fields because of declining soil fertility due to continuous cropping and inadequate attention to soil amendment measures (Mahamod *et al*., 1999). It is necessary to increase the production of cucumber to supplement the high intake of carbohydrate and improve the dietary status of farmers in Nigeria. Therefore, the objectives of the study were to determine the effects of sole and combined application of different organo-mineral fertilizers on performance of cucumber in Umudike, Nigeria.

MATERIALS AND METHODS

Two field experiments were conducted across two cropping seasons in 2019 and 2020 respectively at Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The area is located in the rain forest zone of Nigeria with longitude 07^0, 33′ E and latitude 05^0, 29′ N, with an altitude of 122 m above sea level (Nwosu 2011). The experimental field was cleared manually of existing vegetation. The total land area for the experiment was 378 m^2 which was then mapped out into 8 plots per block measuring 3.5 m x 3 m with an intra-plot spacing of 0.5 m and inter block spacing of 1 m with 3 replicates giving a total of 24 plots in each experimental year. In each trial year, a composite soil sample was collected with soil auger at a depth of 0-20 cm prior to the application of treatment and planting to determine the physico-chemical properties of the soil. The experiment was laid out in a randomized complete block design with three replications. The treatments were as shown in Table 1. The organic manures were incorporated into the appropriate experimental plots at the rate of 10 t ha^{-1} and 5 t ha^{-1} two weeks before sowing of seeds while NPK 15:15:15 fertilizer at 300 kg/ha and 150 kg ha^{-1} was applied to the appropriate plots at two weeks after sowing (WAS) of seeds. The cucumber seeds were sown at 0.75 m x 0.75 m plant spacing with two seeds per hole which was later thinned to one plant per stand to give a plant population of 17,778 plants ha^{-1}. Supply of missing stands was done at 10 days after sowing. Manual hoe weeding was carried out at 3 and 6 WAS. Staking of the cucumber vines was done at 3 WAS. Growth parameters were collected at 6 WAS, while the yield parameters were assessed when the immature fruits were fully developed. Data collected were subjected to analysis of variance (ANOVA) for randomized complete block design (RCBD) using Genstat Release 10.3 DE software (2014) and significant mean differences separated using least significant differences (F-LSD) at 0.05 probability level. Correlation analysis was carried out with the aid of IBM SPSS for Windows, Statistics Version 25.

RESULTS

The results of the physical and chemical analyses of the soil of the experimental site in 2019 and 2020 showed that the soil was texturally loamy sand; the soil pH was moderately acidic (5.13 and 5.20) and the soil was low to moderate in nutrient compositions (Table 2). The result of the chemical analysis of organic manures used in the experiment indicated that nitrogen content in poultry manure was highest relative to goat and rabbit manure (Table 3). The analysis of variance showed significant ($P<0.05$) variations in the growth parameters (vine length, number of branches per plant, number of leaves per plant and leaf area index) measured in 2019 and 2020 cropping seasons (Table 4). In 2019 cropping season, poultry manure + NPK combination closely followed by poultry manure gave the highest vine length and number of branches per plant. However, the trend was not the same in 2020 cropping season. The application of organo-mineral fertilizer significantly increased the number of leaves per plant and leaf area index, which ranged from 5.50 to 33.0 and 0.06 to 1.25, respectively in 2019 and from 9.10 to 30.80 and 0.19 to 1.13, respectively in 2020 with poultry manure exhibiting the greatest effect on the two growth parameters. The control (no organo-mineral) had the least values in the growth parameters in both cropping seasons. The results of the analysis of variance (Table 5) indicated significance ($P<0.05$) in yield parameters (fruit length, fruit diameter, number of fruits per plot, weight of fruits per plot and fresh fruit yield ha^{-1}) in both cropping seasons. Poultry manure application closely followed by poultry + N:P:K combination gave the longest fruit length, widest fruit diameter, highest number of fruits per plot, fruit length and fruit diameter, poultry + N:P:K

combinations indicated the highest values in all the measured parameters compared to the other treatments.

The main effects (manure source and year) and the interaction showed significant variations in all the growth parameters measured (Table 6). Among the manure sources studied, except poultry manure + N:P:K combination that gave the highest number of branches per plant, poultry manure application significantly gave the longest vine length, highest number of leaves per plant, leaf area and leaf area index compared to the others while no organo-mineral application (control) had the least values in all the tested parameters. The year 2020 cropping season had the highest values in all the parameters compared to year 2019 cropping season. The interaction of manure sources and year effect on the growth parameters indicated strong variations amongst the interaction treatments with vine length ranging from 17.00 to 158.80 cm and number of branches from 0.01 to 1.56. The interaction, no organo-mineral application (control) × 2019 gave the shortest vine length and least number of branches per plant. The interaction of poultry manure × 2019 gave the highest number of leaves per plant, leaf area and leaf area index compared to the interactions while no organo-mineral application (control) × 2019 had the least values in all the tested parameters. Combined analysis of variance of yield and yield components of cucumber (Table 7) indicated that manure sources, year of cropping and the interaction between manure source and year of cropping significantly affected all the yield parameters measured. The results showed that number of fruits per plant ranged from 0.72 under no organo-mineral (control) to 4.67 under rabbit manure application. The application of poultry manure significantly affected cucumber fruit length, fruit diameter, number of fruits per plot, weight of fruits per plant, weight of fruits per plot and fresh fruit yield compared to the other sources of manure investigated. The none application of organo-mineral (control) had the least values in all the measured parameters. The analysis of variance further indicated that the highest fruit weight per plant, fruit weight per plot and fresh fruit yield were recorded under 2019 cropping season while 2020 cropping season gave the highest number of fruits per plant, longest fruit length, widest fruit diameter and highest number of fruits per plot. The interaction of manure source and year of cropping showed that poultry manure + N:P:K x year 2020 had the highest number of fruits per plant and number of fruit per plot compared to the other interaction treatments while poultry manure x year 2020 gave the longest fruit length (29.00 cm) and biggest fruit diameter (6.24 cm) compared to the other interactive treatments. Poultry Manure x year 2019 interaction closely followed by poultry manure + N:P:K x year 2019 had the heaviest weight of fruits per plant.

Pearson's correlation analysis indicated highly significant and positive correlation amongst the parameters tested in the matrix in 2019 and 2020 cropping seasons (Table 8). The number of fruits per plot and weight of fresh fruits per plot exhibited very strong and positive correlation with fresh fruit yield per hectare with correlation coefficients of 0.94 and 1.00 per cent, respectively (2019) and 0.83 and 1.00 per cent, respectively (2020), compared with the other highly significant associations in the matrix. All the other parameters exhibited different degrees of positive and significant correlation relationships amongst themselves. The relationship between leaf area index and fresh fruit yield of cucumber was poly-linear and positive (Figures. 1a and b) indicating increase in fresh fruit yield·ha^{-1} as the leaf area index increased from zero and then started to flatten as the variable (LAI) increased beyond unity in 2019 and 2020 cropping seasons. This showed that LAI contributed positively in increasing the fruit yield of cucumber. The relationship between fruit diameter and fresh fruit yield of cucumber was linear and positive (Figures. 2a and b) indicating increase in fresh fruit yield·ha^{-1} as the fruit diameter increased. The trend was the same in 2019 and 2020 cropping seasons, indicating that fruit diameter contributed positively in increasing the fruit yield of cucumber.

DISCUSSION

The increase in the number of leaves per plant recorded in the study might be attributed to the role of poultry manure application, which made the soil more fertile and favourable for plant vegetative growth. The findings corroborate similar results by Mangila *et al.* (2007) and Enujeke *et al.* (2013) who reported that poultry manure (which is a superior animal manure) contained more nutrients that improved the physical conditions of the soil for plant growth and development. The increase in vine length might be due to more organic matter in the soil, which improved the water holding capacity and release of more nutrients in the soil. In such

situation, the rates of plant metabolic processes are improved leading to increased vine length. The results were in consent with the findings of Ewulo *et al.* (2008) and Adekiya and Ojeniyi (2002) which confirmed that poultry manure was not only a rich source of nutrients but it also helps to make available those nutrients, which are present already in the soil. The combination of poultry manure and NPK fertilizer produced the highest number of branches per plant. Atijegbe *et al.* (2013) reported an increase in cucumber growth parameters with the application of NPK and poultry manure. Tisdale *et al.* (1990) reported that organic matter from manure provides energy for microbial activity, increases water-holding capacity and yields of crops. This, in turn, increases the vegetative growth; accelerate the division of meristem associated tissues and metabolic reactions and the plant takes more food as a result of which there is increase in the number of fruits per plant. The high fruit weight recorded with application of poultry manure was probably due to improved nutrient availability in the soil. This study is in conformity with Dauda *et al.* (2008) who reported increased number of fruits and average weight attributed to the ability of poultry manure to increase meristem associated and physiological activities in the plant and improvement in soil properties, resulting in synthesis of more photo-assimilates used in producing fruits. However, in this study, sole application of poultry manure produced the highest fresh fruit yield in cucumber plant. The background of high yield was more number of leaves per plant which captured more sunlight to promote the photosynthesis and respiration and as a result the plant produced the highest yield. The findings were similar to the results of O' Hare (2001) who reported that high crop yield can be attributed to vigorous vegetative growth of plants.

CONCLUSION

On the basis of the present study, the result showed that the sole application of poultry manure only and combined application of poultry manure and N:P:K fertilizer gave the best vegetative growth and fruit yield of cucumber. More so, the interaction of poultry manure and year 2019 cropping season gave the highest fresh fruit yield. Therefore, on the strength of high cost of inorganic fertilizer and its negative impact on the ecosystem, poultry manure source or a combination of poultry manure and N:P:K fertilizer can be adjudged better sources of nutrients for cucumber production in Umudike, Nigeria.

REFERENCES

Adekiya, S.O. and Ojeniyi, S.O. (2002). Evaluation of Tomato growth and soil properties under methods of seedling bed preparation in an alfisol in the rainforest zone of South west Nigeria. Soil and Tillage Res., 64:2785-279.

Akande, S.R; Olakoje, S.A; Ajayi, S.A; Owolade, O.F; Adetumbi, J.A; Adeniyan, O.N. and Ogunbode, B.A. (2012). Planting date affects cowpea seed yield and quality at southern guinea savanna of Nigeria. Proofs, 34:79-88.

Atijegbe, S.R; Nuga, B.O; Lale, M.E.S. and Nwanna, R.O. (2013). The growth of cucumber (*Cucumis sativus* L.) in the humid tropics and the incidence of insect pests as affected by organic and inorganic fertilizers. J. Applied Sci. Agric., 8(7):1172-1178.

Ayuso, M.A; Paschal, J.A; Carcia, C. and Hermandez, T. (1996). Evaluation of urban wastes for urban agricultural use. Soil Sci. Plant Nutr., 42:105-111.

Belay, A; Classen, A.S; Wehner, F.C. and De Beer, J.M. (2001). Influence of residual manure on selected nutrient elements and microbial composition of soil under long term crop rotation. S. African J. Plant Soil., 18:1-6.

Dauda, S.N; Ajayi, F.A. and Ndor, E. (2008). Growth and yield of watermelon (*Citrullus lenatus*) as affected by poultry manure application. J. Agric. Social Sci., 121-124.

Enujeke, E.C. (2013). Growth and yield responses of cucumber to five different rates of poultry manure in Asaba area of Delta State, Nigeria. Int. Res. J. Agric. Sci. Soil., 3 (11):369-375.

Ewulo, B.S; Ojeniyi, S.O; Akanni, D.A. (2008). Effect of Poultry manure on selected soil physical and chemical properties, growth yield and nutrient status of tomato. African J. Agric. Res., 3(9): 612-616.

GenStat. (2014). Genstat for windows. Release 4.23 DE Discovery Edition, VSN. International Limited, Hemel Hempsteins, UK. WWW. Discovery. Genstat.co.uk.

Harts, J. A. and Neilan, R, (2000). Fertilizing Your Garden, Vegetables Fruits and Ornaments, Oregon State University Extension Services.

Ipimoroti, R.R; Daniel, M.A. and Obatelu, R. (2012). Effects of Organic mineral fertilizer

on tea growth at Kusuku Mabila Plateau Nigeria. Moor J. Agroic. Res. 3:180-183.

Mahamod, T; Saeed, R; Ahmadu, R. and Gahaffer, A. (1999). Water Potassium Management for Enhanced, Maize Productivity. Inter. J. Agric. Bio. 1:314-317.

Mangila, E; Tabilican, F.P; Naguil, M.R.A and Malate, R. (2007). Effects of organic fertilizer on the yield of watermelon. Held 2, January–December, 2007. Pp 27-35.

Marjan, K. (2005). Fertilizer South California Master Gardener Training Manual. E.C. 678:1-8.

Mbah, C.N. and Onweremadu, E.U. (2009). Effect of oganic and mineral fertilizer inputs on soil and maize grain yield in an acid ultisol in Abakaliki, South eastern Nigeria. American-Eurasian J. Agronomy, 2(1): 07-12.

Nweke, I.A; Okoli, P.S.O. and Enyioko, C.O. (2014). Effect of different rates of poultry droppings and plant spacing on soil chemical properties and yield of cucumber. Elixis Agriculture, 70: 23934-23940.

O'Hare, G.W.N. (2001). Nutritional constraints on root nodule, bacteria effecting symbiotic nitrogen fixation. A review Australian Journal of expert Agriculture, 47: 417-433.

Samadi, B. (2010). Teknik Budidaya Mentinum, Kanisus, Yogyakarta Glirir, Penerbit Swadaya.

Tisdale, S.L; Nelson, W.L. and Beaton, J.D. (1990). Soil fertility and fertilizer: Elements Required in Plant Nutrition, 4th Edu. Maxwell Macmillian Pub. Singapore OP: 52-92.

Wehner, T.C. and Guner, N. (2004). Growth stage, flowering pattern, yield and harvest date prediction of four types of cucumber tested at 10 planting dates. Proc. XXVI. Advances in Vegetable Breeding (Eds.) Mccreight, J.D. and Ryder, E.J. Acta. Hort., 637.

Table 1: Organo-mineral treatments of the experiment

0 Fertilizer (Control),
10 t ha^{-1} poultry manure (11.75 kg $plot^{-1}$),
10 t ha^{-1} rabbit manure (11.75 kg $plot^{-1}$),
10 t ha^{-1} goat manure (11.75 kg $plot^{-1}$),
(N:P:K - 15:15:15) 300 kg ha^{-1} (0.353 kg $plot^{-1}$),
5 t ha^{-1} poultry manure + (N:P:K - 15:15:15) 150 kg ha^{-1} (5.9 kg $plot^{-1}$ + 0.177 kg $plot^{-1}$),
5 t ha^{-1} rabbit manure + (N:P:K - 15:15:15) 150 kg ha^{-1} (5.9 kg $plot^{-1}$ + 0.177 kg $plot^{-1}$),
5 t ha^{-1} goat manure + (N:P:K - 15:15:15) 150 kg ha^{-1} (5.9 kg $plot^{-1}$ + 0.177 kg $plot^{-1}$)

Table 2. Soil Physico-chemical properties of the experimental sites in 2019 and 2020 cropping seasons

Soil characteristics	2019	2020
Physical properties		
Sand (%)	79.22	81.40
Silt (%)	9.17	7.0
Clay (%)	11.61	11.60
Textural Class	Loamy sand	Loamy sand
Chemical Properties		
pH (H_2O)	5.13	5.20
Available P (mg kg^{-1})	13.78	17.6
Total N (%)	0.10	0.07
Organic Carbon (%)	1.13	0.99
Organic Matter (%)	1.95	1.71
Exchangeable Base (cmol kg^{-1})		
Ca	1.82	3.60
Mg	1.08	2.0
K	0.24	0.08
Na	0.12	0.16
Exchangeable acidity	1.49	0.40
Effective CEC	4.75	6.23
Base saturation (%)	68.63	93.60

Table 3. Chemical analysis of the organic manure used for the experiments

Mineral elements (%)	Organic manure type					
	Goat		Poultry		Rabbit	
	Year		Year		Year	
	2019	2020	2020	2019	2019	2020
N	2.20	2.02	2.41	2.10	2.30	1.89
P	0.54	0.49	0.70	1.25	0.59	0.58
K	0.50	0.52	1.53	1.67	1.31	1.62
Ca	3.41	3.30	12.12	10.02	4.21	3.08
Na	0.50	0.30	0.59	0.25	0.29	0.25
Mg	1.34	1.28	1.73	1.23	1.58	0.85

Table 4. Influence of organo-minerals on growth attributes of cucumber in 2019 and 2020 cropping seasons

	Vine length (cm)	Number of branches plant	Number of leaves plant	Leaf area index	Vine length (cm)	Number of branches plant	Number of leaves plant	Leaf area index
Treatment	2019				2020			
Goat Manure	86.30	1.22	19.10	0.69	158.80	0.67	21.00	0.58
Poultry Manure	144.30	1.55	33.00	1.25	138.60	1.80	30.80	1.13
Rabbit Manure	90.70	0.33	19.00	0.54	122.90	1.10	17.00	0.51
NPK	74.90	0.67	16.60	0.39	123.90	0.87	15.77	0.43
Goat Manure + N:P:K	67.40	0.44	13.90	0.298	153.40	1.43	20.53	0.60
Poultry Manure + N:P:K	144.60	1.56	26.30	0.90	151.40	1.67	21.57	0.82
Rabbit Manure + N:P:K	52.100	0.22	12.00	0.25	136.70	0.53	13.87	0.40
Control	17.00	0.00	5.50	0.06	56.20	0.10	9.10	0.19
$LSD_{(0.05)}$	40.66	1.07	8.86	0.54	39.76	0.63	6.78	0.28

Table 5. Influence of organo-minerals on yield and yield attributes of cucumber in 2019 and 2020 cropping seasons

	Fruit length (cm)	Fruit diameter (cm)	Number of fruits/ plot	Weight of fruits/ plot (kg)	Fruit yield (t ha^{-1})	Fruit length (cm)	Fruit diameter (cm)	Number of fruits/ plot	Weight of fruits/ plot (kg)	Fruit yield (t ha^{-1})
Treatment	2019					2020				
Goat Manure	17.41	4.89	64.50	20.10	17.90	26.13	5.81	68.70	16.70	14.80
Poultry Manure	26.44	6.18	113.30	58.20	51.70	29.00	6.24	117.30	34.00	30.20
Rabbit Manure	20.41	5.18	51.10	25.00	22.20	26.00	5.92	72.70	15.30	13.60
NPK	18.28	5.15	64.50	14.80	13.20	25.93	5.81	71.30	13.30	11.90
Goat Manure + N:P:K	18.89	5.13	51.10	13.50	11.90	28.07	6.09	68.70	14.70	13.00
Poultry Manure + N:P:K	21.33	5.59	104.50	47.70	42.40	28.60	6.05	118.00	36.00	32.00
Rabbit Manure + N:P:K	16.65	4.96	51.10	14.500	12.90	27.47	5.77	57.300	14.70	13.00
Control	4.22	4.25	15.50	3.60	3.20	19.17	4.69	13.30	4.20	3.70
$LSD_{(0.05)}$	3.74	0.94	26.76	12.93	11.49	4.50	0.44	27.78	10.76	9.57

Table 6. Combined analysis of variance of growth attributes of cucumber across two years

Treatments	Vine length (cm)	Number of branches/Plant	Number of leaves/Plant	Leaf area index
Manure source (M)				
Goat manure	104.60	1.16	18.07	0.60
Poultry manure	151.60	1.11	27.02	0.91
Rabbit manure	121.10	1.00	20.28	0.68
N:P:K	99.40	0.77	16.17	0.41
Goat manure + N:P:K	103.00	1.12	22.33	0.71
Poultry manure + N:P:K	149.00	1.50	23.43	0.75
Rabbit manure + N:P:K	94.40	0.38	12.93	0.33
Control	36.60	0.05	7.32	0.13
$LSD_{(0.05)}$	26.72	0.61	5.22	0.30
Year (Y)				
2019	84.70	0.75	18.18	0.55
2020	130.20	1.02	18.70	0.58
$LSD_{(0.05)}$	13.36	0.31	2.61	0.15
M × Y (Interaction)				
Goat manure x year 2019	86.30	1.22	19.13	0.70
Poultry manure x year 2019	144.30	1.55	33.03	1.25
Rabbit manure x year2019	90.70	0.33	19.00	0.54
N:P:K x year 2019	74.90	0.67	16.57	0.40
Goat manure + N:P:K x year 2019	67.40	0.44	13.87	0.30
Poultry manure + N:P:K x year 2019	144.60	1.56	26.33	0.90
Rabbit manure + N:P:K x year 2019	52.10	0.22	12.00	0.25
Control x year 2019	17.00	0.01	5.53	0.06
Goat manure x year 2020	158.80	0.67	21.00	0.58
Poultry manure x year 2020	138.60	1.80	30.80	1.13
Rabbit manure x year2020	122.90	1.10	17.00	0.51
N:P:K x year 2020	123.90	0.87	15.77	0.43
Goat manure + N:P:K x year 2020	153.40	1.43	20.53	0.60
Poultry manure + N:P:K x year 2020	151.40	1.67	21.57	0.82
Rabbit manure + N:P:K x year 2020	136.70	0.53	13.87	0.40
Control x year 2020	56.20	0.10	9.10	0.19
$LSD_{(0.05)}$	37.78	0.86	7.38	0.42

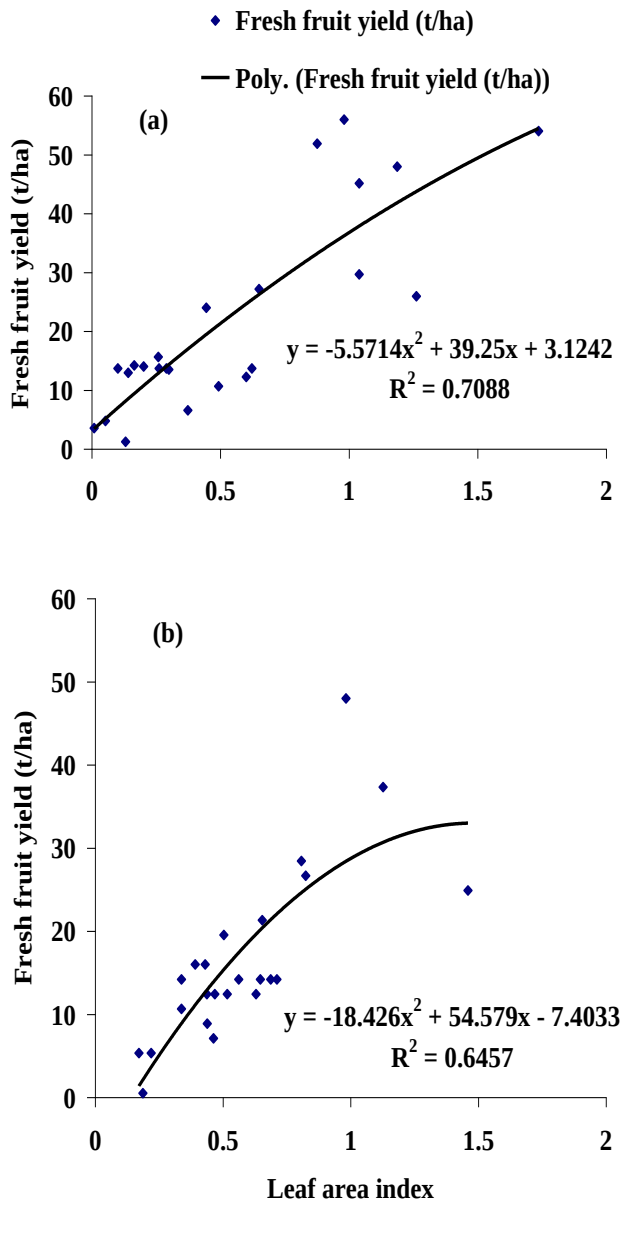
Table 7. Combined analysis of variance of yield and yield attributes of cucumber across two years

Treatments	Number of fruits/Plot	Fruit length (cm)	Fruit diameter (cm)	Weight of fruit /Plant (kg)	Fruit yield (t ha^{-1})
Manure source					
Goat manure	68.60	21.70	5.40	0.89	15.76
Poultry manure	91.00	26.29	5.99	1.87	33.27
Rabbit manure	93.40	24.51	5.61	1.53	27.11
N:P:K	61.20	22.11	5.48	0.70	12.50
Goat manure + N:P:K	84.20	23.95	5.69	1.19	21.09
Poultry manure + N:P:K	86.60	24.70	5.84	1.56	27.70
Rabbit manure + N:P:K	54.20	22.06	5.36	0.73	12.95
Control	14.40	16.69	4.47	0.20	3.47
$LSD_{(0.05)}$	9.40	2.83	0.48	0.44	7.79
Year					
2019	65.00	19.20	5.17	1.23	21.93
2020	73.40	26.30	5.79	0.93	16.54
$LSD_{(0.05)}$	4.70	1.42	0.24	0.22	3.89
Manure source x year (Interaction)					
Goat manure × year 2019	64.50	17.41	4.89	1.01	17.89
Poultry manure x year 2019	113.30	26.44	6.18	2.91	51.73
Rabbit manure x year2019	68.90	20.41	5.18	1.25	22.22
N:P:K x year 2019	51.10	18.28	5.15	0.74	13.16
Goat manure + N:P:K x year 2019	51.10	18.89	5.13	0.67	11.97
Poultry manure + N:P:K x year 2019	104.5	21.33	5.59	2.38	42.37
Rabbit manure + N:P:K x year 2019	51.10	16.65	4.96	0.72	12.86
Control x year 2019	15.50	14.22	4.25	0.18	3.200
Goat manure x year 2020	68.70	26.13	5.81	0.83	13.63
Poultry manure x year 2020	117.30	29.00	6.24	1.70	14.82
Rabbit manure x year2020	72.70	26.00	5.92	0.77	32.00
NPK x year 2020	71.30	25.93	5.81	0.67	11.85
Goat manure + N:P:K x year 2020	68.70	28.07	6.09	0.73	30.22
Poultry manure + N:P:K x year 2020	118.00	28.60	6.05	1.80	13.04
Rabbit manure + N:P:K x year 2020	57.30	27.47	5.77	0.73	13.04
Control x year 2020	13.30	19.17	4.69	0.21	3.733
$LSD_{(0.05)}$	13.30	4.01	0.68	0.15	0.62

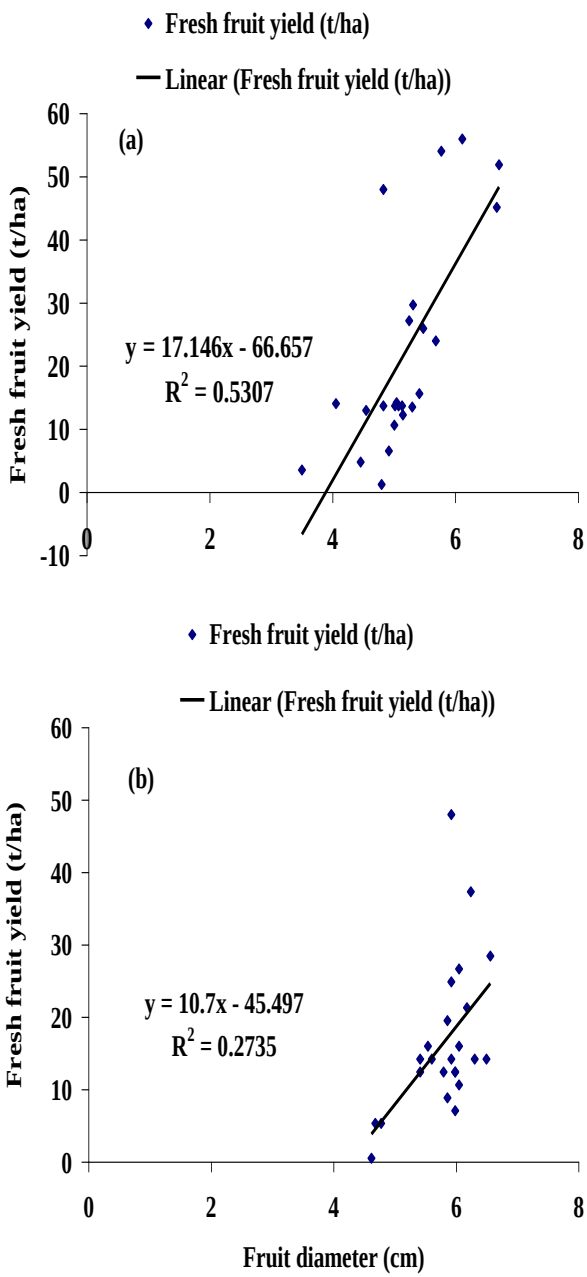
Table 8. Correlation matrix of growth and yield attributes of cucumber in 2019 and 2020 cropping season

	Fruit yield (t ha^{-1})	Vine length	Number of leaves	Leaf area index	Fruit length	Fruit diameter	Number of fruits /plot	Weight of fruits /plot
Fruit yield (t ha^{-1})	1.00	0.57**	0.67**	0.77**	0.55**	0.52*8	0.83**	1.00**
Vine length (cm)	0.90**	1.00	0.62**	0.58**	0.71**	0.74**	0.62**	0.58**
Number of leaves	0.91**	0.92**	1.00	0.97**	0.55**	0.61**	0.73**	0.67**
Leaf area Index	0.84**	0.80**	0.87**	1.00	0.56**	0.60**	0.76**	0.77**
Fruit length (cm)	0.83**	0.85**	0.80**	0.77**	1.00	0.85**	0.63**	0.55**
Fruit diameter (mm)	0.73**	0.75**	0.66**	0.62**	0.85**	1.00	0.67**	0.52**
Number of fruits /plot	0.94**	0.94**	0.88**	0.87**	0.84**	0.78**	1.00	0.83**
Weight of fruit /plot (kg)	1.00**	0.90**	0.91**	0.84**	0.83**	0.73**	0.94**	1.00

**, Significant level $P \leq 0.01$ (2-tailed).



Figs. 1



Figs. 2

Figs. 1: Relationship between leaf area index and fresh fruit yield of cucumber (t ha^{-1}) with quadratic regression curve in 2019 cropping season (a) and 2020 cropping season (b).

Figs. 2: Relationship between fruit diameter and fresh fruit yield of cucumber (t ha^{-1}) with linear regression line in 2019 cropping season (a) and 2020 cropping season (b).

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EFFECT OF APPLICATION OF TITANIUM DIOXIDE IN THE MANAGEMENT OF FUSARIUM WILT AND FRUIT YIELD OF SOME TOMATO ACCESSIONS

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ABSTRACT
Tomato (*Solanum lycopoersicum* L.) is often threatened by wilt disease caused by *Fusarium oxysporium* f.sp *lycopersici*. Titanium dioxide (TiO_2) has been reported to promote plant growth and reduce disease severity. This experiment was carried out to investigate the effects of TiO_2 application on incidence and severity of *Fusarium* wilt as well as yield indices of three susceptible tomato accessions. The experiment consisted of a 3 x 5 factorial experiment fitted into Completely Randomized Design and Randomized Complete Block Design in the screenhouse and the field, respectively. All experiments were set up with three replications. The treatments consisted of three tomato accessions (CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195) and with four concentrations of TiO_2 (0.3, 0.7, 1.0 and 1.3 ml/l) applied using soil drenching. Plots without TiO_2 application served as the control. In both screenhouse and the field, application of 1.3 ml/l TiO_2 significantly reduced the incidence and severity of *Fusarium wilt* with better yield of tomato fruit in the three accessions than the control plots and pots. The study concluded that application of TiO_2 at 1.3 ml/l reduced incidence and severity of *Fusaruim* wilt of tomato and increased the yield of tomato.

Keywords: *Titanium dioxide, Fusarium wilt, Tomato, disease*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) was native to tropical America, but yet grown all over the world (Arah *et al*., 2015). Tomatoes production accounts for about 4.8 million hectares of harvested land area globally with an estimated production of 16.2 million tonnes (FAOSTAT, 2014). China leads world tomato production with about 50 million tonnes followed by India with 17.5 million tonnes (FAOSTAT, 2014). In Africa, total tomato production for 2012 was 17.938 million tons with Egypt leading the continent with 8.625 million tonnes, followed by Nigeria with 1.56 million tonnes (Arah *et al*., 2015). Tomato production can serve as a source of income for most rural and peri-urban producers in most developing countries. The tomato industry has been identified as an area that has the ability for poverty reduction because of its potential for growth and employment creation (Anang *et al*., 2013). Tomato has become an important cash and industrial crop in many parts of the world (Ayandiji *et al*., 2011) not only because of its economic importance but also its nutritional value to human diet and subsequent importance in human health (Willcox *et al*., 2003). In Nigeria, production of tomato has improved the livelihood of most rural and peri-urban farmers (Adenuga *et al*., 2013). Some of the common problems of tomato production are pest and diseases. Diseases which include *Fusarium* wilt, Bacterial wilt, Anthracnose, Verticillium wilt etc (Ebimieowei *et al*., 2013). These pathogens low quality and insufficient quantity of tomato (Robinson and Kolavalli, 2010). *Fusarium oxysporum* f.sp. *lycopersici* (Sacc.) Snyder and Hans, is a soil borne plant pathogen that causes *Fusarium* wilt specifically on tomato (Rai *et al*., 2011). *Fusarium oxysporum* f. sp. *lycopersici* has become one of the most damaging pathogens wherever tomatoes are grown intensively because it grows endophytically and persists in infested soils (Agrios, 1997). *Fusarium oxysporum* f.sp. *lycopersici* is a known pathogen of tomato plant which is an economically important crop (Suarez-Estrella *et al*., 2007). Tomato yield is significantly reduced by the pathogen. Healthy plants can become infected if the soil in which they are growing is infested with the pathogen (Agrios, 1988). Once an area becomes infected with *F. oxysporum*, it usually remains so indefinitely (Agrios, 1997). The pathogen invades the vascular tissues, grows in the vascular bundles and inhibits water flow consequently causing wilting and ultimately

leading to death of the plant (Davies, 1982). *Fusarium* wilt leads to an average yield loss of 50 % in tomato, reduces farmer's income and family intake of vitamin A (Ajigbola *et al*., 2013). It constitutes serious threat to food security in Sub-Saharan Africa, especially in the coastal regions (Popoola *et al*., 2012). Frequent use of synthetic fungicides to tackle this lethal disease of tomato has often resulted in environmental damage and increases pathogen resistance (Ogzonen *et al*., 2001). Resistance of *F. oxysporum* f. sp. *lycopersici* to synthetic fungicides necessitates the use of alternative control method to wilt caused by the pathogen (Ogzonen *et al*., 2001). Application of TiO_2 has been found to show an excellent efficacy in rice (*Oryza sativa* L) and maize (*Zea Mays* L) by reducing the effect of *Curvularia* leaf spot and bacterial leaf blight disease incidence and severity (Chao *et al*. 2005; Hamzat *et al*., 2022). Hence, the objective of this work was to examine the effect of application of Titanium dioxide in the management of *Fusarium* wilt and fruit yield of three tomato accessions.

MATERIALS AND METHODS

Experimental site, designs and treatments: The experiment was carried out at Federal University of Agriculture Abeokuta (FUNAAB) DelPHE-5 Research farm, Ogun State, Nigeria. The location enjoys tropical climate with uni-modal peak rainfall between June and November, average annual and monthly rainfall of 1, 220 mm and 102 mm, respectively, as well as monthly maximum and minimum temperature ranges of 29–36 and 22–35^{0}C, respectively (Kilanko-Oluwasanya, 2009). Humidity is lowest (37%–54%) at the peak of dry season in February and highest at the peak of the rainy season between June and September (78%–85%) (Adeleke *et al*., 2015). The level of porosity of the soil was indicated by the presence of organic carbon (1.53%) while pH was confirmed to be 5.65 and the soil texture of the site was sandy-loam of which 76,15 and 9% were values for sand, clay and silt, respectively (Ganiyu *et al*., 2018). During the late planting season, a 3 x 5 factorial experiment fitted into Completely Randomized Design and Randomized Complete Block Design in both the screenhouse and the field, respectively. All experiments were set up with three replications. The experiment consisted of three tomato accessions, (CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195). Titanium dioxide (TiO_2) was prepared at four concentrations (0.3,0.7, 1.0, and 1.3 ml/l) while plots without TiO_2 served as untreated control.

Isolation and identification of *F. oxysporum* f. sp. *lycopersici* : Wilted tomato plants with yellow leaves were collected from wilt- endemic tomato field at Teaching and Research Farms of Federal University of Agriculture, Abeokuta and taken to the laboratory for fungal isolation. Tomato plant stems showing vascular discoloration were rinsed thoroughly in tap water and then macerated with a sterile scalpel. The macerated tomato plant stems were then surface sterilized using 1 % sodium hypochlorite, NaOCl for two (2) minutes, rinsed in three changes of sterile distilled water and dried on sterile filter paper. Segments from the stems were placed on Potato Dextrose Agar (PDA) medium amended with streptomycin sulphate (300 mg L^{-1}) in petri-dishes and incubated at room temperature for 4 days. Sub-culturing of fungal isolates was done to obtain pure cultures of fungal isolate. Sub-culturing was done by single-spore isolation method on dried agar cultures. Identification of *F. oxysporum* f. sp. *lycopersici* was done under the light microscope and fungal structures were placed on slides, stained with methylene blue. Further identification using characteristic taxonomic and morphological features for *F. oxysporum* f. sp. *lycopersici* was conducted as contained in the work of (Leslie *et al*., 2006).

Screenhouse experiment

Nursery and tomato transplanting: Three tomato seedlings were transplanted into each pot filled with 9 kg of steam-sterilized soil which was later thinned to one. There were forty–five (45) experimental pots altogether and each pot was arranged in rows of six with spacing of 0.5 m between the pots and 1 m between replicates.

Preparation and application of inoculum and TiO_2: Conidia suspension of seven-day old pure cultures of isolated *F. oxysporum* f.sp. *lycopersici* were washed with sterile distilled water to obtain suspension of inoculums of the pathogen. The suspension was then filtered through one layer of Mira cloth, centrifuged, washed with sterile water and adjusted to a concentration of 10^6 conidia per ml and was used to inoculate the four-week-old tomato seedlings at one week after transplanting. Inoculation of the tomato seedlings was carried out using root-dip inoculation method at the rate of 1 ml / hole (Amini, 2009).

Field experiment

Land preparation: The land was cleared, ploughed, harrowed. The experimental plot size was 3 m x 3 m with 1 m border row between plots were made. The experiment consisted of forty–five (45) experimental plots with thirty-six (36) tomato plants per plot.

Transplanting of tomato and application of TiO_2: Tomato seedlings were transplanted at a spacing of 0.5 m x 0.5 m in the evening on the already prepared land. Tomato plants were treated with TiO_2 at 2, 4 and 6 weeks after transplanting using soil drenching while plots TiO_2 without served as control.

Data collection and analysis*:* Data were collected on five sample plants at the middle of each experimental plot were plant height (cm), number of leaves/plant, number of flowers/plant, number of tomato fruits/plant, and fruit yield (tons/ha), disease incidence and disease severity. Disease assessment commenced at 4 and 6 weeks after transplanting.

Disease incidence was calculated by:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected tagged plant per plot}}{\text{Total number of tagged plant per plot}} \times 100$$

Severity was monitored through a visual scale (Lebeda and Buczkowski, 1986).

Scale	Description
1	Symptomless, stems and leaves free of any visual symptoms
2	Very limited wilting , 5% leaves yellowed and wilted
3	Limited wilting, 6-10% leaves yellowed and wilted
4	Moderate wilting, 11-20% leaves yellowed and wilted
5	Severe wilting, 21-50% leaves yellowing and wilted
6	Very severe wilting, above 50% leaves yellowed and wilted

Data was subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS), 9.1 package and means were separated using the Duncan's Multiple Range Test ($p \leq 0.05$).

RESULTS

Table 1 shows the effect of TiO_2 application on incidence of *Fusarium* wilt of tomato in both screenhouse and field experiments at four and six weeks after transplanting (WAT). Results from the screenhouse and field experiment indicated that the four treatments of TiO_2 significantly reduced the incidence of *Fusarium* wilt in the three accessions of tomato compared to the control pots. However, treatment of TiO_2 applied at 1.3ml/l concentration contributed to the lowest incidence of *Fusarium* wilt in both the screenhouse and field evaluation. In the screenhouse, the highest disease incidence of 52.00% and 82.20% were recorded in the untreated control pot containing CPTTO/19/193 and CPTTO/19/195 accessions, which were significantly different ($p \leq 0.05$) from the lowest disease incidence of 2.30% and 10.10% recorded for CPTTO/19/191 treated with TiO_2 at 1.3ml/l concentration at 4 and 6 WAT, respectively. On the field experiment, in untreated control plots at 4WAT, the highest disease incidence (60.00, 64.00 and 60.90%) were recorded for CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195 accessions, respectively. These values were significantly higher than the lowest incidence of 3.50% recorded for CPTTO/19/191 treated with TiO_2 at 1.3 ml/l concentration 4 WAT. Similarly, at 6 WAT the highest incidence (87.30, 92.80% and 90.10%) were recorded for CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195 accessions, respectively, in the untreated control plots and were significantly different from the lowest incidence (20.70, 17.90 and 16.60%) recorded for each, treated with TiO_2 at 1.3 ml/l concentration. Table 2 shows the effect of TiO_2 application on severity of *Fusarium* wilt of tomato in both screenhouse and field experiments at four and six weeks after transplanting. Application of TiO_2 at 1.3 ml/l concentration showed significant reduction of *Fusarium* wilt severity in the three accessions of tomato used in both screenhouse and field experiments. In both the screenhouse and the field experiment, disease severity was generally at the peak on untreated control plants, ranged from 3.35-6.00 followed by 2.00-5.00 observed

on tomato plants treated with TiO_2 at 0.3 ml/l concentration. In screenhouse, lowest disease severity of 1.00 and 1.20 (CPTTO/19/191), 1.34 and 1.17 (CPTTO/19/193) and 1.00 and 1.63 (CPTTO/19/195) were recorded on plants treated with TiO_2 at 1.3 ml/l concentration at 4 and 6WAT, respectively. These values were significantly different ($p \leq 0.05$) from 4.43 and 5.00 (CPTTO/19/191), 3.35 and 4.43 (CPTTO/19/193) and 4.40 and 5.00 (CPTTO/19/195) obtained from untreated control plots. Similar trend was observed on the field. At 6WAT, the three accessions recorded highest disease severity (6.00) in untreated control plots while the lowest severity (1.67) was recorded in CPTTO/19/193 and CPTTO/19/195 treated with TiO_2 at 1.3 ml/l concentration. The effect of TiO_2 on tomato plant indicated that the lowest value of plant height (3.40 cm, 3.43 cm and 3.44 cm) in the screenhouse at 2 WAT was recorded in the control pots for CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195, respectively (Table 3). The highest plant height (19.33 cm) was recorded in pots containing CPTTO/19/195 treated with TiO_2 at concentration of 0.7 ml/l. CPTTO/19/191 treated with TiO_2 at 1.3 ml/l concentration had the highest plant heights of 30.53 cm and 46.32 cm and were significantly different from the shortest plant heights (9.65 cm and 16.23 cm) observed in the control pot containing CPTTO/19/193 and CPTTO/19/191 at 4 and 6WAT, respectively. On the field, there were significant differences ($p \leq 0.05$) as the highest plant heights of 21.33 cm and 21.50 cm were recorded for CPTTO/19/193 and CPTTO/19/195 treated with TiO_2 at concentration of 1.3 ml/l at 2WAT. Inversely, the shortest plant height of 5.50 cm, 5.33 cm and 5.67 cm were recorded for CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195 accessions in the control plots. At 6WAT, there was significant difference ($p \leq 0.05$) as CPTTO/19/195 treated with TiO_2 at concentration of 1.3 ml/l recorded significant higher plant height (49.30 cm) while the shortest plant height (23.70 cm) was recorded in the control plot with CPTTO/19/193. Number of leaves per plant differed significantly ($p \leq 0.05$) among the three accessions as shown in Table 4. At 2WAT, in screenhouse, the highest number of leaves (6.87) was recorded in CPTTO/19/193 treated with TiO_2 at concentration of 1.00 ml/l while the lowest number of leaves (2.01) was recorded in CPTTO/19/195 treated with TiO_2 at concentration of 0.3 ml/l. At the 4 and 6WAT, CPTTO/19/193 treated with TiO_2 at concentration of 1.3 ml/l recorded the highest number of leaves (13.56 and 19.65), respectively while the lowest number of leaves (5.34) at 4WAT was recorded in the control pot of CPTTO/19/191. Also, control pot of CPTTO/19/193 recorded the lowest number of tomato leaves (10.54) at 6 WAT. On the field, the number of leaves 9.00 in CPTTO/19/193 when treated with TiO_2 at concentration of 1.3 ml/l at 2WAT, was significantly higher than the lowest number of leaves 3.67 recorded in the control plot of CPTTO/19/195. At 4WAT, the three accessions, CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195, recorded the highest number of leaves (16.00, 15.67 and 16.00), respectively, when treated with TiO_2 at concentration of 1.3 ml/l. When treated with TiO_2 at concentration of 1.3 ml/l, the number of leaves in CPT/19/193 (21.00) and CPTTO/19/195 (21.67) were significantly higher than the lowest number of leaves (12.33) recorded for CPTTO/19/191 in the control plots at 6WAT. At 4 WAT, CPTTO/19/195 treated with TiO_2 at concentration of 1.3 ml/l recorded the highest number of flowers (8.38) which was significantly different from the lowest number of flowers (1.34) was recorded in control pot of CPTTO/19/191. The highest number of flowers (10.97) at 6 WAT was recorded in CPTTO/19/195 treated with TiO_2 at concentration of 1.3 ml/l which was significantly different from the lowest number of flowers (3.62) was recorded in the control pot of CPTTO/19/193. On the field, highest number of flowers (6.67) was recorded in CPTTO/19/195 treated with TiO_2 at concentration of 1.3 ml/l at 4 WAT which was significantly different from the lowest number of flowers (1.67) was recorded in the control plot of CPTTO/19/191. Furthermore, at 6 WAT, number of flowers (11.67) in CPTTO/19/195 treated with TiO_2 at concentration of 1.3 ml/l was significantly higher than the number of flowers (3.67) recorded in the control plot of CPTTO/19/191 and CPTTO/19/193. Table 6 shows the effect of TiO_2 application on fruit yield (t/ha^{-1}) of tomato. In screenhouse, CPTTO/19/193 treated with TiO_2 at concentration of 1.3 ml/l had 2.74 t/ha^{-1} fruit yield, which was significantly higher than 0.59 t/ha^{-1} recorded for CPTTO/19/195 in the control pot. On the field, fruit yield of 28.00 t/ha^{-1} was recorded for CPTTO/19/193 treated with TiO_2 at

concentration of 1.3 ml/l which was significantly higher than fruit yields (5.30,4.50 and 6.70 t/ha^{-1}) recorded for CPTTO/19/191, CPTTO/19/193 and CPTTO/19/195 in the control plots, respectively.

DISCUSSION

The results obtained showed that application of TiO_2 at higher concentration of 1.3 m/l significantly reduced the incidence and severity of *Fusarium* wilt of the tomato accessions compared to the other level of treatment application. This confirmed earlier result that demonstrated that TiO_2 were potent on soil borne fungi (Frazer, 2001). TiO_2 has also been shown to be effective in controlling *Fusarium* wilt of Basil (*Ocimum basilicum*) caused by (*Fusarium oxysporum* f.sp. *basilici*) (Adams *et al*., 2003). Application of TiO_2 at lower concentration may not show only the right direction impact but also caused a positive impact on plant growth and control of fungal and bacteria diseases. Disease incidence and disease severity were significantly reduced with corresponding increase in the number of leaves, plant height, number of flower and yield by the application of TiO_2 at higher concentrations. The application of TiO_2 at concentration of 1.3 ml/l had the best positive effect on tomato. The higher the concentration the higher the yield in the three tomato accessions treated with TiO_2 while a lower yield and other parameters were recorded in the control treatment. Unlike on disease incidence and severity, the higher the concentration the lower the disease exhibited by the plant treated with TiO_2. The control plant showed the highest disease. This result is in accordance with what was reported by (Chao *et al*., 2005), that the application of titanium dioxide (TiO_2) on food crops promote plant growth, increase the photosynthetic rate, reduce disease severity and enhance yield by 30%. Titanium dioxide (TiO_2) has also been shown to possess a strong oxidation reaction, which can target organic compounds. It has also been shown to be very effective in inactivating avian influenza virus (Cui *et al*., 2010). Titanium dioxide (TiO_2) has also been recommended for control of other plant diseases (Cui *et al*., 2009). *Fusarium* wilt disease of tomato is economically important infection to the crop worldwide. *Fusarium* wilt is controlled through many strategies such as usage of resistant varieties, biological control, host defense induction and integrated management. The use of titanium dioxide has been proven to be a useful tool for induced resistance studies in tomato as observed in this study.

CONCLUSION

The overall result of this research work provided a basis for a major conclusion. Higher concentration of titanium dioxide application (TiO_2) at concentrations of 1.3 ml/l had significant effect on *Fusarium* wilt of tomato; it reduced the incidence and severity of *Fusarium* wilt of tomato. Also, its application resulted in a significant increase in the yield of tomato. The protection of plants against pathogen using titanium dioxide is a promising control strategy. It can become an important component of pest management programs, particularly in cases where current control measures are less effective. Obviously, one of the outcomes of the use of titanium dioxide should be a reduction of the use of fungicides which is of major concern in the preservation of environment. Therefore, application of TiO_2 at 1.3 m/l for the management of *Fusarium* wilt of tomato is feasible.

REFERENCES

Adams, P. D., Kokalis-Burelle, N. and Basinger, W. H.(2003). Efficacy of Plantpro 45 as a seed and soil treatment of managing *Fusarium* wilt of Basil" *Horticultural Technology* 13(1): 77-80.

Adenuga, A.H., Muhammad-Lawal, A. and Rotimi, O. A. (2013). "Economics and Technical Efficiency of Dry Season Tomato Production in Selected Areas in Kwara State, Nigeria. *Agris on-line Papers in Economics and Informatics* 5 (1): 11-19.

Agrios, G.N. (1997). Plant pathology Fourth Edition London: Academic Press, pp. 635. Antagonistic activity of bacteria and fungi from horticultural compost against *Fusarium oxysporum* f. sp. *melonis*.

Agrios, G.N. (1988). Plant Pathology. Third Edition, Academic Press, Inc., New York.

Agrios, G.N. (1997). Control of Plant Diseases. In: Plant Pathology, Fouth Edition, Academic Press, San Diego, 200-216.

Ajigbola, C.F. and Babalola, O.O. (2013). Integrated Management Strategies for Tomato *Fusarium* Wilt. *Biocontrol Sciences*. 18 (3): 117-127.

Amini, J. (2009). Physiological Race of Fusarium oxysporum F.sp. Lycopersici in Kurdistan Province of Iran and Reaction of

Some Tomato Cultivars to Race 1 of Pathogen, "*Plant Pathology Journal*: Vol. 8 (2):68-73, 2009.

Anang, B.T, Zakaria, A.Z, Suleiman, Y. (2013). Production Constraints and Measure to Enhance the Competitiveness of the Tomato Industry in Wenchi Municipal District of Ghana, "*journal of Experimantal Agriculture international*, 824-838.

Arah, I.K., Kumah, E.K., Anku, E.K. and Amaglo, H. (2015). "An overview of post-harvest losses in tomato production in Africa: causes and possible prevention strategies," *Journal of Biology, Agriculture and Healthcare*,. 5 (16): 78–88.

Ayandiji, A., Adeniyi, O.R. and Omidiji, D. (2011). Determinant Post Harvest Losses among Tomato Farmers in Imeko-Afon Local Government Area of Ogun State, *Nigeria. Global Journal of Science Frontier Research*. Volume 11(5): 22-28.

Benson, D.M., Hall, J.L., Moorman, G.W., Daughtrey, M.L., Chase, A.R. and Lamour, K.H. (2002). The history and diseases of poinsettia, the Christmas flower. *Plant Health Programme* 1: 202-212.

Chao, S.H.L. and Choi, H.S. (2005). Method for providing enhanced photosynthesis. Korea Research Institute of Chemical Technology, Jeonju, *South Korea. Bull*. 11: 1-34.

Cui J, Kaandorp J A, Ositelu O O, Beaudry V, Knight A, Nanfack Y F, Cunningham K W. (2009). Simulating calcium influx and free calcium concentrations in yeast. Cell Calcium 45(2):123-32.

Cui H X, Sun C J, Liu Q, Jiang J, Gu W (2010), Applications of nanotechnology in agrochemical formulation, perspectives challenges and strategies. International conference on Nano Agri, Sao Pedro, Brazil, pp 28-33.

Davies, D.A. and Morgan, T.H. (1982). Performance of ewes and lambs on perennial ryegrass, cocksfoot, tall fescue. *Journal Agricultural Science*, 99 (1): 145-151.

Ebimieowei, E and Ebideseghabofa, E. (2013). Postharvest Quality of Commercial Tomato (Lycopersicon Esculentum Mill.) Fruits Brought in Yenegoa Metropolis from Northern Nigeria. "*Journal of Biology, Agriculture and Healthcare, ISSN 2224-3208*, Vol.3 No.11,2013

FAOSTAT (2014). Online statistical database of the Food and Agricultural Organisation of the United Nation. [Internet]. Available at: http://faostat.fao.org/. Accessed: 31st July 2014.

Ganiyu S.A., Popoola, A.R., Enikuomehin, O.A. and Bodunde, J.G. (2016). Tube grafting reduces incidence and severity of bacterial wilt in two tomato cultivars in *Journal of Agricultural Science and Environment Abeokuta, Nigeria*. 16 (1): 96-104,

Ogzonen, T., Lemanceau, N.P. and Alabouvette, C. (2001). Biocontrol of Fusarium diseases by fluorescent pseudomonads and non-pathogenic Fusarium. *Crop Protection*. 10:279-286,

Popoola, A.R., Ercolano, M. R., Kaledzi, P.D., Ferriello, F., Ganiyu, S.A., Dapaah, H. K., Adegbite, D.A., Falana, Y. and Adedibu, O. B. (2012). Molecular and phenotype screening of tomato genotypes for resistance to *Fusarium* wilt. *Ghana Journal of Horticulture*. 10: 61-67.

Rai, R *et al*.(2011). Small ubiquitin-related modifier ligase activity of Mms21 is required for maintenance of chromosome integrity during the unperturbed mitotic cell division cycle in Saccharomyces cerevisiae. *Journal Biological Chem* 286 (16): 14516-30.

Robinson, Elizabeth J. Z. and Kolavalli, Shashi L. (2010)."The case of tomato in Ghana: Productivity"19, International Food Policy Research Institute (IFPRI).

Suárez-Estrella F, C Vargas-Garcia, MJ Lopez, C. Capel and J. Moreno (2007). Crop Protection 26 (1): 46-53.

Table 1: Effect of TiO_2 application on incidence of *Fusarium* wilt of tomato at four and six weeks after transplanting

Accession	TiO_2 (ml/l)	Screenhouse		Field	
		4WAT†	6 WAT	4WAT	6WAT
CPTTO/19/191	0.3	33.70^{bc}	62.90^{a-c}	43.30^{bc}	71.90^{a-c}
	0.7	13.20^{bc}	43.50^{cd}	23.30^{ef}	55.50^{cd}
	1.0	9.30^{f-h}	32.00^{de}	11.30^{f-h}	43.00^{de}
	1.3	2.30^{h}	10.10^{f}	3.50^{h}	20.70^{f}
	Control	50.00^{a}	77.50^{ab}	60.00^{a}	87.30^{ab}
CPTTO/19/193	0.3	37.00^{b}	63.00^{a-c}	47.20^{b}	73.20^{a-c}
	0.7	20.60^{c-e}	38.2^{de}	30.70^{c-e}	48.00^{de}
	1.0	11.90^{e-g}	18.50^{ef}	18.90^{e-g}	28.80^{ef}
	1.3	9.10^{f-h}	11.90^{f}	9.80^{f-h}	17.90^{f}
	Control	52.00^{a}	81.50^{ab}	64.00^{a}	92.80^{a}
CPTTO/19/195	0.3	22.20^{b-d}	64.60^{bc}	40.10^{b-d}	70.60^{bc}
	0.7	18.30^{de}	38.40^{de}	28.10^{de}	48.60^{de}
	1.0	8.60^{f-h}	12.30^{ef}	11.60^{f-h}	28.60^{ef}
	1.3	4.10^{gh}	10.20^{f}	6.10^{gh}	16.60^{f}
	Control	50.30^{a}	82.20^{ab}	60.90^{a}	90.10^{ab}

Means in the same column with different alphabet are significantly different (P≤0.05) according to Duncan's Multiple Range Test, †WAT: Weeks After Transplanting

Table 2: Effect of TiO_2 application on severity of *Fusarium* wilt of tomato plant at four and six weeks after transplanting

Accession	TiO_2 (ml/l)	Screenhouse		Field	
		4WAT†	6 WAT	4WAT	6WAT
CPTTO/19/191	0.3	2.33^{cd}	4.03^{a}	3.66^{cd}	5.00^{a}
	0.7	2.20^{de}	3.33^{de}	3.00^{de}	4.00^{de}
	1.0	1.03^{fg}	2.30^{f}	2.00^{fg}	3.00^{f}
	1.3	1.00^{h}	1.20^{g}	1.30^{h}	2.00^{g}
	Control	4.43^{a}	5.00^{a}	5.33^{a}	6.00^{a}
CPTTO/19/193	0.3	2.00^{de}	3.53^{b-d}	3.00^{de}	4.33^{b-d}
	0.7	2.34^{de}	2.34^{f}	3.00^{de}	3.33^{f}
	1.0	1.35^{fg}	1.77^{f}	2.00^{fg}	2.67^{f}
	1.3	1.34^{gh}	1.17^{g}	1.33^{gh}	1.67^{g}
	Control	$3..35^{bc}$	4.43^{a}	4.33^{bc}	6.00^{a}
CPTTO/19/195	0.3	3.45^{c}	4.00^{bc}	4.00^{c}	5.00^{bc}
	0.7	2.24^{de}	3.24^{b-d}	3.00^{de}	4.33^{b-d}
	1.0	1.33^{ef}	2.53^{ef}	2.33^{ef}	3.33^{ef}
	1.3	1.00^{h}	1.63^{g}	1.00^{h}	1.67^{g}
	Control	4.40^{ab}	5.00^{a}	5.00^{ab}	6.00^{a}

Means in the same column with different alphabet are significantly different (P≤0.05) according to Duncan's Multiple Range Test, †WAT: Weeks After Transplanting

Table 3: Effect of TiO_2 application on plant height (cm) of tomato in the screenhouse and field test

Accession	TiO_2 (ml/l)	Screenhouse			Field layout		
		2WAT†	4WAT	6WAT	2WAT	4WAT	6WAT
CPTTO/19/191	0.3	8.67^{c}	18.43^{c-e}	29.03^{c-f}	10.67^{c}	22.67^{c-e}	33.00^{c-f}
	0.7	10.43^{bc}	23.32^{a-d}	32.33^{a-f}	13.33^{bc}	27.83^{a-d}	36.50^{a-f}
	1.0	13.37^{abc}	26.83^{ab}	36.34^{abc}	16.17^{abc}	30.83^{ab}	40.80^{abc}
	1.3	15.86^{a}	30.53^{a}	46.32^{ab}	18.83^{a}	34.83^{a}	47.70^{ab}
	Control	3.4^{d}	10.47^{fg}	16.23^{ef}	5.50^{d}	$14.17f^{g}$	24.80^{ef}
CPTTO/19/193	0.3	10.54^{c}	18.87^{de}	29.54^{cdef}	12.50^{c}	21.67^{de}	32.30^{cdef}
	0.7	14.30^{abc}	21.21^{bcde}	33.45^{abcde}	16.00^{abc}	25.33^{bcde}	37.80^{abcde}
	1.0	15.47^{ab}	25.23^{abc}	36.65^{abc}	18.67^{ab}	29.17^{abc}	40.80^{abc}
	1.3	19.22^{a}	28.13^{ab}	44.87^{ab}	21.33^{a}	32.33^{ab}	47.00^{ab}
	Control	3.43^{d}	9.65^{fg}	19.12^{f}	5.33^{d}	13.83^{fg}	23.70^{f}
CPTTO/19/195	0.3	9.13^{c}	16.50^{ef}	27.24^{c-f}	11.17^{c}	20.50^{ef}	31.30^{c-f}
	0.7	19.33^{c}	21.21^{b-e}	30.98^{b-f}	11.83^{c}	25.33^{b-e}	34.50^{b-f}
	1.0	15.33^{ab}	27.20^{ab}	35.34^{a-d}	18.00^{ab}	30.00^{ab}	39.70^{a-d}
	1.3	19.23^{a}	30.27^{a}	44.45^{a}	21.50^{a}	34.17^{a}	49.30^{a}
	Control	3.44^{d}	10.23^{g}	22.43^{d-f}	5.67^{d}	13.5^{g}	26.00^{d-f}

Means in the same column with different alphabet are significantly different (P≤0.05) according to Duncan's Multiple Range Test, †WAT: Weeks After Transplanting

Table 4: Effect of TiO_2 application on number of leaves of tomato plant in the screenhouse and field tests

Accession	TiO_2 (ml/l)	Screenhouse			Field		
		2WAT†	4WAT	6WAT	2WAT	4WAT	6WAT
CPTTO/19/191	0.3	3.34^{e-g}	6.32^{e-g}	11.23^{e-g}	5.00^{e-g}	9.00^{e-g}	14.00^{e-g}
	0.7	3.43^{d-f}	7.39^{d-f}	13.30^{d-g}	5.33^{d-f}	10.33^{d-f}	15.00^{d-g}
	1.0	3.47^{de}	10.12^{a-c}	15.78^{a-e}	5.67^{de}	13.67^{a-c}	18.00^{a-e}
	1.3	5.54^{bc}	13.30^{a}	17.54^{a-c}	7.33^{bc}	16.00^{a}	20.67^{a-c}
	Control	2.43^{f-i}	5.34^{fg}	19.34^{g}	4.00^{f-i}	8.00^{fg}	12.33^{g}
CPTTO/19/193	0.3	4.03^{c-e}	7.43^{d-f}	11.45^{d-g}	6.00^{c-e}	10.33^{d-f}	14.67^{d-g}
	0.7	4.67^{b-d}	9.45^{c-e}	12.54^{c-f}	6.67^{b-d}	11.33^{c-e}	16.67^{c-f}
	1.0	6.87^{b}	10.23^{bc}	14.45^{a-e}	7.67^{b}	13.33^{bc}	18.00^{a-e}
	1.3	6.43^{a}	13.56^{ab}	19.65^{ab}	9.00^{a}	15.67^{ab}	21.00^{ab}
	Control	3.40^{e-g}	5.56^{e-g}	10.54^{fg}	5.00^{e-g}	8.67^{e-g}	13.00^{fg}
CPTTO/19/195	0.3	2.01^{e-g}	7.05^{e-g}	13.87^{d-g}	5.00^{e-g}	9.00^{e-g}	15.67^{d-g}
	0.7	3.98^{e-h}	7.45^{d-f}	12.54^{b-f}	5.00^{e-h}	10.67^{d-f}	17.00^{b-f}
	1.0	4.31^{b-e}	9.73^{cd}	14.34^{a-d}	6.33^{b-e}	12.67^{cd}	18.67^{a-d}
	1.3	5.43^{bc}	12.03^{a}	19.56^{a}	7.33^{bc}	16.00^{a}	21.67^{a}
	Control	2.60^{i}	5.54^{g}	10.40^{fg}	3.67^{i}	7.00^{g}	13.00^{fg}

Means in the same column with different alphabet are significantly different (P≤0.05) according to Duncan's Multiple Range Test, †WAT: Weeks After Transplanting

Table 5: Effect of TiO_2 application on number of flowers of tomato plant in the screenhouse and field tests

Accession	TiO_2 (ml/l)	Screenhouse		Field	
		4 WAT†	6 WAT	4 WAT	6 WAT
CPTTO/19/191	0.3	4.65^{b-f}	6.76^{bc}	3.67^{b-f}	6.00^{bc}
	0.7	3.78^{b-f}	6.65^{bc}	3.67^{b-f}	6.00^{bc}
	1.0	4.78^{a-e}	7.39^{bc}	4.33^{a-e}	7.33^{a-c}
	1.3	7.65^{ab}	9.97^{ab}	5.67^{ab}	8.67^{ab}
	Control	1.34^{f}	3.78^{c}	1.67^{f}	3.67^{c}
CPTTO/19/193	0.3	3.34^{c-f}	5.66^{bc}	3.00^{c-f}	4.67^{bc}
	0.7	3.48^{b-f}	4.97^{bc}	3.67^{b-f}	5.67^{bc}
	1.0	5.80^{b-f}	7.40^{bc}	4.00^{b-f}	6.00^{bc}
	1.3	7.67^{ab}	9.87^{ab}	5.67^{ab}	8.67^{ab}
	Control	2.65^{ef}	3.62^{c}	2.00^{ef}	3.67^{c}
CPTTO/19/195	0.3	4.38^{a-e}	6.38^{a-c}	4.33^{a-e}	7.33^{a-c}
	0.7	5.67^{a-d}	7.66^{a-c}	4.67^{a-d}	7.67^{a-c}
	1.0	8.38^{a-c}	9.21^{ab}	5.33^{a-c}	8.67^{ab}
	1.3	8.29^{a}	10.97^{a}	6.67^{a}	11.67^{a}
	Control	2.66^{d-f}	3.87^{bc}	2.67^{d-f}	4.67^{bc}

Means in the same column with different alphabet are significantly different (P≤0.05) according to Duncan's Multiple Range Test, †WAT: Weeks After Transplanting

Table 6: Effect of TiO_2 application on fruit yield (t/ha^{-1}) of tomato

Accession	TiO_2 (ml/l)	Screenhouse	Field
		6WAT†	6 WAT
CPTTO/19/191	0.3	1.12^{g}	8.34^{g}
	0.7	1.65^{f}	12.00^{f}
	1.0	1.50^{cd}	15.00^{cd}
	1.3	2.42^{a}	25.70^{a}
	Control	0.83^{h}	5.30^{h}
CPTTO/19/193	0.3	1.02^{g}	10.80^{g}
	0.7	1.23^{e}	13.30^{e}
	1.0	2.23^{bc}	17.50^{bc}
	1.3	2.74^{a}	28.00^{a}
	Control	0.73^{h}	4.50^{h}
CPTTO/19/195	0.3	1.20^{g}	15.00^{g}
	0.7	1.28^{f}	12.70^{f}
	1.0	1.25^{de}	16.00^{de}
	1.3	2.30^{ab}	22.30^{ab}
	Control	0.59^{h}	6.70^{h}

Means in the same column with different alphabet are significantly different (P≤0.05) according to Duncan's Multiple Range Test,†WAT: Weeks After Transplanting.

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EFFECT OF DOSAGE AND SPRAY FREQUENCY OF HENNA (*Lawsonia inermis* L.) ON *Alternaria* LEAF SPOT DISEASE OF CUCUMBER MELON (*Cucumis sativus* L.) IN MAIDUGURI, NORTHEASTERN NIGERIA

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ABSTRACT
Field trials were conducted in 2018 and 2019 cropping season at Teaching and Research Farm of the Faculty of Agriculture, University of Maiduguri to assess the effect of dosage and spray frequency of botanical leaf extracts in the management of *Alternaria* leaf spot disease of cucumber melon. The experimental plots were laid in a strip plot design replicated three times. Different dosages (50, 75 and 100 g/L) were assigned as the vertical factor while spray frequency (no spray, spray once, twice, thrice, and four times) as the horizontal factor. Results showed that spray frequency at spray three or four times and dosage at 100g/L significantly ($P<0.05$) affected the disease incidence and severity of the leaf spot disease. Yield increase was also observed under the same condition. Spraying of cucumber melon three or four times is very crucial in the reduction of the leaf spot disease.

Keywords: *Alternaria leaf spot, Cucumber melon, Dosage, Henna, Spray frequency*

INTRODUCTION

Cucumber (*Cucumis sativus* L.) originated from either India, China, or the Far East (Bisognin, 2002). It belongs to the Cucurbitaceae family of the plants cucurbits, (Bello,*et al*., 2014). Eifediyi and Remison (2010) reported that cucumber ranked fourth after Tomatoes, Cabbage and Onion, it is a vegetable crop use in many dishes as salads which is eaten raw or in mixture with lettuce and cabbage. Its health benefits includes; treatment of heartburns, ulcers, inflammation due to arthritis, improvement in eye sight and in the skin care industry (Sunday and Haernetta, 2012; Naganatha and Hartline, 2015; Abbey *et al*., 2017). The world production figure for cucumber in the year 2020 was put at 91,258,272 metric tonnes, China was by far the largest producer accounting for nearly 80% of the global production, (FAOSTAT, 2020). In Nigeria, the cucumber profile is rising due to wide spread knowledge of its health benefit (Iyabo and Olabunmi, 2016). Ojeifor, *et al*. (2008), FAO, (2014) and Veggie (2022) reported the production figure of cucumber in Nigeria to be put at about 30 metric tonnes of fruit melon with a yield of 43,257 kg/ha compared with a yield of per unit area of 53.86kg in China, (FAOSTAT, 2020). Low yield in Nigeria was attributed to so many factors such as; inappropriate agronomic practices (Garba *et al*., 2020), inadequate fertilizer application, low quality improved seed (Okafor and Yaduma, 2021), higher insect pest infestation (Yirngau, 2020), as well as fungal diseases (Pareek and kavandia, 1988). Among the fungal diseases are; Anthracnose, damping-off, *Cercospora* leaf spot, Downy mildew, Powdery mildew, and *Alternaria* leaf spot. The *Alternaria* leaf spot disease caused by *Alternaria alternata* is a very common and a limiting factor in the production of cucumber melon, it can devastate crops with yield losses ranging between 5 and 30% in southeastern Nigeria (Onovo, 1992). Consequently, the use of synthetic pesticides has been the most embraced control measure use by farmers, however, drawback sets by its high toxicity and damage to the environment has necessitated the need for an alternative means. Natural products have long played an important role as pest control agent. Natural derived pesticide contained natural compounds and are safe to use as they leaves no hazardous effect on environment (Gunjar *et al*., 2012). Several plants have been screen for antifungal properties and many of them were promising. Henna (*Lawsonia inermis* L.) is a shrub belonging to the family Lythraceae also known as mehndi in Arabic (Muhammad and Mustafa, 1994), in northern Nigeria it is known

as "Lalle". It contains the active ingredient lawsone which have the antimicrobial and fungicidal properties (Buddhava and Buddhava, 2016), natural naphthoquinones like alkannin and shikonin are the substances responsible for the antimicrobial and fungicidal properties in henna (Jain and Sharma, 2016). The yield of cucumber could be substaintially increased through the use of proper dosage of pesticide as well as repeated spraying. Pesticide dosage is very important in plant disease control, when dose are release into the environment and at the same time reaching the intended targets and killing the most tolerant target pest gives the best result (Duke, 2017). Furthermore, Kumar and Ajaykumara, (2022) stated that proper dose of pesticide results in proper control with no adverse, residual and polluted effect in harvested products and the environment. *Lawsonia inermis* as a pesticide in this study is readily available in the study area, cheap, and easy to process. This investigation was therefore initiated to determine the effect of dosage and spray frequency of *Lawsonia inermis* plant leaves extracts in the management of *Alternaria* leaf spot disease of cucumber melon in Maiduguri.

MATERIALS AND METHODS

Cucumber melon (*cv.* Lege) was used for the experiment in the 2017 and repeated in 2018 wet seasons at the Teaching and Research Farm, Faculty of Agriculture, University of Maiduguri, Nigeria. The seeds were sown on a flat land which was earlier ploughed and harrowed and pulverized into fine tilth, two seeds were sown per stand and spaced 75cm apart. The plots (size 3 x 3) was laid out in a strip plot design where dosage was assigned as the vertical factor and spray frequency as the horizontal factor, replicated three times. Plot was separated by a gap of 0.5m and replication separated by a 1.0m gap. NPK (20:10:10) fertilizer was applied at the rate of 30kg/ha. At land preparation 16kg/ha fertilizer was applied at 3weeks after sowing (WAS) and the remaining 14kg/ha was applied at 6 WAS (Odeleye *et al*., 2006), plants were thinned to two plants per stand at two weeks after emergence.

Henna (*Lawsonia inermis*) fresh leaves was collected and dried for one week in a shade. The dried leaves was lightly crushed and weigh into 50g, 75g and 100g which was dissolved differently into 2L bucket containing 1000ml of portable water, the mixture was allowed to stay overnight. The mixture was later sieved using a fine cloth. The filtrate was then poured into a handheld prayer (3L capacity). Spraying commences at 4WAS and was followed by three other sprays at two weeks interval until harvesting. The control plots received no spray.

The disease incidence and severity was first assessed 3WAS followed by assessments on every 14 days. Disease incidence was calculated by counting the number of plants with leaf spots per plot which was then expressed as percentage of the total number of plants with leaf spots per plot.

The disease severity was assessed using a visual scale of 0 – 5 as adopted by Bhat *et al*. (2013), the scale is as follows: 0 = no infection, 1 = 0.1 – 10%, 2 = 10.1 – 25%, 3 = 25.1- 50%, 4 = 50.1 – 75% and 5 = above 75% infection on the foliage. The disease severity was calculated using the following formula;

$$Disease\ Severity\ \ \% \ = \frac{\sum n}{N\ x\ 5} X\ 100$$

Where: ∑n = Summation of Individual rating
N = Total no. of plant assessed
5 = Highest score on the severity scale

RESULTS

The main effects of dosage and spray frequency on incidence of *Alternaria* leaf spot disease of cucumber melon in Maiduguri during the 2017 wet season is presented in Table 1. Significantly ($P<0.05$) lower disease incidence occurred in fungicide treated plots than that of the unsprayed, plots spray with 100g/L of the leaf extracts had significantly ($p<0.05$)lower disease incidence compare with the other concentration of the leaf extracts. Similarly, plots sprayed three or four times had significantly ($p<0.05$) lower disease incidence compare with the other spray regimes. However, in 2018 (Table 2), there was no significant difference in disease incidence with regards to the concentration of the leaf extracts except at 9WAS. The frequency of spray indicate that plants sprayed three or four times (Table 2) had lower disease incidence during the period of the research. There was generally rapid increase in the number of infected plants from 5 to 9 weeks after sowing. However, plants treated with 100g/L and spray four times had significantly ($P<0.05$) lower rate of leaf spot disease compared with the other treatments. Regardless of the dosage and spray frequency, disease incidence was generally higher in 2017 than in 2018 respectively.

The main effects of dosage and spray frequency on disease severity in 2017 is presented in Table 3. There was significant difference in disease severity among the treated and the untreated plots. Significantly ($P<0.05$) lower disease severity was observed in plots spray four times with 100g/L of plant extracts than in the other plots treated with lower concentration of the extracts. Disease severity was generally higher in 2017 wet season. Similar trend was observed in 2018 (Table 4).

Results for the effects of dosage and spray frequency on yield of cucumber melon is presented in Table 5. Lower yields was generally observed in plots sprayed with lower concentration of the plant extracts. Higher yield was obtained in plots treated with 100g/L spray three and four times in 2017 (7 tonnes/ha) and 2018 (9.76 tonnes/ha) wet seasons respectively. Although, fungicidal spray at 75g/L and 100g/L did not affect yield of the cucumber melon significantly. Generally yield was higher in 2018 than in 2017 wet season.

DISCUSSION

The result in this study indicate that Alternaria leaf spot disease was significantly reduced by plant extracts compared with plants in untreated plots. This is in agreement with the findings of Sanjeev *et al*. (2019), where they reported the potency of *Lawsonia inermis* leaf extracts in the control of *Alternaria* leaf spot disease of other field crops. Similar observation have also been reported by, (Sahu *et al*., 2012; Lok *et al*., 2020). Disease incidence and severity were generally lower in the treated than in the untreated plots. Similarly, plots treated with higher concentration of *Lawsonia inermis* leaf extracts had significantly lower value for disease incidence and severity than plots treated with lower dosage of the fungicides, similar observation was reported by Gaikwad *et al*. (2014) where they observed that 100% concentration of *Lawsonia alba* was most effective in the control of *Alternaria porri* of onion. Nahunnaro and Bayaso, (2011) also reported higher dosage of plant extracts drastically reduces the radial growth of *Alternaria solani* in-vivo. This implied that disease incidence and severity was directly proportional to the concentration of plant extracts. Moreover, reduction in disease cause by each dose was decrease with increase in the spray frequency. This may clearly support others that spray frequency play an important role in influencing disease development or secondary spread of disease. The results of this study are in conformity with that of Stephen, *et al*. (2013) and Wegulo, *et al*. (2015)

Phytochemical study in *L.inermis* have shown the presence of naphthaquinone derivatives, aliphatic compounds, triterpenes, sterols, phenolic, coumarins, xanthones and flavonoids, (Jeny *et al*., 2010) so, the potent activity of *L.inermis* on the leaves of cucumber melon reduces the severity of *Alternaria altanata* most likely due to the presence of different classes of bioactive compounds. Hence, in this study, yield was significantly affected by fungicidal spray, although dose of 100g/L spray four times had significantly higher yield compare with the other dosage of the same extracts. This study revealed that *Lawsonia inermis* leaf extracts has fungicidal properties and effective against *Alternaria* leaf spot disease of cucumber melon.

REFERENCES

Abbey, B. W., Nwachukwu, N., Ikiroma, G. N. (2017). Nutritional value of cucumber cultivated in three selected states of Nigeria. *Biochemistry and Analytical Biochemistry*, 6(1): 328 – 336.

Bello, M. O., Owoeye, G., Abdulhameed, M., and Yekeen, T. A. (2014). Characterization of guard fruit (Cucurbitaceae) for dietary values and antinutrition constituents. *Journal of pharmacy, biology, chemistry sciences*, 6(1): 7575 – 7585

Bhat, H. A.,Ahmad, K., Rayes, A. A., Qazi, N. A., Nisar, A, D and Ganie, S. A (2013). Status and symptomatology of Alternaria leaf blight (*Alternaria alternata*) in Kashmir valley. *African Journal of Agricultural Research*, 8(9): 819-823

Bisognin, D.A., (2002). Origin and evolution of cultivated cucurbits. *Ciencia Rural, Santa Maria*, 32(5): 715-723

Buddhava, S. G and Buddhava S. S, (2016). Ayurvedic medicinal plant *Lawsonia inermis* Linn: A complete review. *An International Journal of Pharmaceutical Sciences*, 7(2):240 – 248

Duke, S. O, (2017). Pesticide dose: Effects on environment and target and nontarget organism, 1 – 13

Eifediyi, E.K and Remison, S.U (2010). Growth and yield of cucumber (*Cucumis sativus* L.) as influence by farmyard manure and inorganic fertilizer. *Journal of plant breeding and crop science*, 2(2):216-220

FAO. (2014). Food and agricultural organization cooperate statistical database. Pp 232

FAO. (2020). World Food and Agricultural Statistic year book, Rome. Pp 208

Garba, I.I., Buhari, F.Z. and Samaila, B.K. (2020). Response of cucumber (*Cucumis sativus* L.) to differential pruning under green house. Journal of dryland Agriculture, 6(2): 10-16

Gaikwad, K.N., Jadhav, S.U. and Kakulte, V.R (2014). Management of fungal diseases of onion (*Allium cepa L.*) by using plant extract. *International journal of life sciences and pharmaceutical research*, 4(1): 28-30

Gunjar, M.S, Ali, S.,Akhtar, M. and Singh,K.S (2012). Efficacy of plant extracts in plant disease management. *Agriculture science*, 3(1): 425-429

Iyabo, B.A and Olabunmi, L.B. (2016). Profitability and efficacy of cucumber production among small holder farmers in Oyo state, Nigeria. National horticultural research institute (NIHORT), Ibadan, Nigeria.

Jain,N. and Sharma, M.(2016). Screening of *Lawsonia inermis* essential oil against fungi causing dermatophytic infection in human. *Asian journal of pharmacy and clinical research*,1(4): 67-69

Jiny, V.K., Silvipriya, K.S., Resmi, S. and Jolly, C.I. (2010). *Lawsonia inermis* (Henna): A natural dye of various therapeutic uses- A review. *Inventi Journals*, 1(1): 1-5

Kumar, M. and Ajaykumara, K. M. (2022). Importance of pesticide dose in pest management. *Indian entomologist*, 3(1): 51 – 54

Lok, B. P., Kamal, C., Pandy, A and Paudel, R (2020).In-vitro evaluation of botanical extracts, chemical fungicides and *Trachoderma harzianum* against *Alternaria brassicola* causing leaf spot of cabbage. *Nepalese horticultural*, 14(1): 68-76

Mohammed, Z. and Mustafa, A. M (1994). Traditional Malay medicinal plants. Kuala Lumpur: Fajar Bakti sdn phd, 12

Naganathan, S. and Hartline, R. (2015). Cucumber nutrition fact. *Journal of vegetable nutrition*, 15(1): 1419 – 1440

Nahunnaro, H. and Bayaso, I. (2011). Inhibitory activity of plant extracts on the early blight pathogen *Alternaria solani* growth. *Global journal of agricultural science*, 11(1) 57-62

Odeleye, O.M.O and Adedokun, (2006). Response of cucumber to time of fertilizer application. 2006 research review report of NIHORT (90-91)

Ojeifor, I.M., Nzekwe, U and Akpovwovwo, L U. (2008). Growth and yield of five varieties of cucumber (Cucumis sativus L.) in southern Nigeria. *Journal of Agriculture, Forestry and Social sciences*, 6(2)

Okafor, B. N and Yaduma, J.J. (2021). Soil and agronomic management for cucumber production in nigeria.DOI

Onovo, J.A. (1992). Survey of disease incidence and severity of cucurbitaceous crops in the southeast, Annual Cropping Scheme Report, Vegetable Research Programme, National Horticultural Research Institute, Mbato. 47pp.

Pareek, B.L and Kavandia, V.S. (1988). Economics insecticidal control of two major pest of musk melon (*Cucumis melo*) in Rajastan, India. *Tropical pest management*, 34(1):32-38

Sahu, S. K., Pattnaik, M. M and Kar, M (2012). Bioefficacy of some plant extracts on growth pattern and control of diseases in *Lycopersicum esculentum. Asian journal of plant science and research*, 2(2): 129-142.

Sanjeev, M., Meena, B. and Sharma, K. (2019). *Lawsonia inermis* (Henna) leaf extract. A potent natural antifungal against plant pathogenic fungi. *International journal for research in applied science and engineering technology*, 7(5): 2015-2018

Stephen, N. W., William, W. B., John, F. H. N., Kamaranga, H. S. P and Floyd, E. D (2013). Integration of fungicide application and cultivar resistance to manage Fusarium head blight in wheat. *American phytopathological society*, 1(1): 241-295

Sunday, E. K and Harnetta, O. O, (2012). Nutrition composition of common fruits and vegetable in Nigeria. *Journal of biotechnology*, 1(1): 45 – 48

Umeh, A. O. and Ojiako, F. O. (2018). Limitations of cucumber (Cucumis sativus L.) production for nutrition security in southeast Nigeria. RESEARCH GATE, https://www.researchgate.net, download on 17/9/2022.

Veggie Concept, (2020). Cucumber Farming in Nigeria – A guide. Veggieconcept. ng/cucumber-farming-in-Nigeria

Wegulo, S.N., Baenziger, P.S., Nopsa, J.H., Bockus, W.W., and Adams, H.H (2015). Management of Fusarium head blight of

wheat and barley. *Crop protection*, 1(73): 100-107

Yirngau, M.B. (2020). Effect of crop cultivars and insecticides on the management of melon beetles (*Aulacophora Africana* (WEISE)) and *Scymnus andosiaca* (SIC)) on cucumber melon (*Cucumis sativus* L.) in Sudan Savanna of Borno State, Nigeria. PhD Thesis, Department of Crop Protection, University of Maiduguri, Nigeria. 90pp

Table 1: Effect of dosage and spray frequency of *Lawsonia inermis* leaf extracts on incidence of *Altanaria* leaf spot disease of cucumber melon in Maiduguri in 2017

Treatment	Disease Incidence (%) (2017)			
Dosage (A)	3 WAS	5 WAS	7 WAS	9 WAS
50g/l	37.74[a]	52.51[a]	67.79[a]	77.83[a]
75g/l	31.14[b]	39.69[b]	46.58[b]	49.21[b]
100g/l	29.52[b]	36.04[b]	41.34[c]	42.11[c]
SE ±	1.92	2.37	1.76	0.81
Spray (B)				
No Spray	40.66[a]	70.61[a]	95.81[a]	100.01[a]
Spray Once	33.77[b]	43.34[b]	51.81[b]	56.04[b]
Spray Twice	30.11[b]	34.82[c]	41.20[c]	47.03[c]
Spray Thrice	29.70[c]	34.48[c]	37.96[c]	40.53[d]
Four Times	29.68[c]	30.49[c]	31.89[d]	38.33[d]
SE ±	2.08	2.93	2.20	1.70
A x B	*	*	*	*

* Means within a column followed by the same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 2: Effect of dosage and spray frequency of *Lawsonia inermis* leaf exracts on incidence of *Altanaria* leaf spot disease of cucumber melon in Maiduguri in 2018

Treatment	Disease Incidence (2018)			
Dosage (A)	3 WAS	5 WAS	7 WAS	9 WAS
50g/l	25.29[a]	34.58[a]	50.16[a]	57.27[a]
75g/l	23.01[ab]	32.28[a]	42.65[a]	49.16[b]
100g/l	19.06[b]	27.69[a]	42.30[a]	21.05[c]
SE ±	1.69	2.60	3.18	1.90
Spray (B)				
No Spray	28.38[a]	56.14[a]	80.95[a]	99.78[a]
Spray Once	21.49[b]	25.09[b]	39.11[b]	56.77[b]
Spray Twice	22.09[b]	27.43[b]	44.02[b]	55.24[b]
Spray Thrice	19.95[b]	24.20[b]	30.46[c]	44.80[c]
Four Times	20.36[b]	24.70[b]	30.66[c]	39.22[d]
SE ±	1.59	3.05	3.01	2.13

* Means within a column followed by the same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 3: Effect of dosage and sprayed frequency of *Lawsonia inermis* leaf extract on severity of *Altanaria* leaf spot disease of cucumber melon in Maiduguri in 2017

Treatment	Disease Severity (2017)			
Dosage (A)	4 WAS	6 WAS	8 WAS	10 WAS
50g/l	23.49[a]	29.32[a]	36.74[a]	45.65[a]
75g/l	21.94[a]	23.76[ab]	25.07[b]	28.99[b]
100g/l	17.71[b]	20.64[b]	23.30[b]	25.72[b]
SE ±	1.10	2.42	1.96	2.41
Spray (B)				
No Spray	30.56[a]	41.03[a]	51.31[a]	65.22[a]
Once Spray	20.40[b]	21.88[b]	25.04[b]	29.70[b]
Twice Spray	19.35[bc]	21.66[b]	23.36[b]	26.33[bc]
Thrice Spray	18.28[bc]	20.50[b]	23.22[bc]	24.79[cd]
Four Spray	16.65[c]	17.80[b]	18.91[c]	21.22[d]
SE ±	1.39	2.12	2.11	2.27
A X B	*	*	*	*

* Means within a column followed by the same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 4: Effect of dosage and spray frequency of *Lawsonia inermis* leaf extract on severity of *Altanaria* leaf spot disease of cucumber melon in Maiduguri in 2018

Treatment	Disease Severity (%) (2018)			
Dosage (A)	4 WAS	6 WAS	8 WAS	10 WAS
50g/l	17.59[a]	22.16[a]	28.54[a]	34.60[a]
75g/l	17.57[a]	21.16[a]	24.74[b]	28.89[b]
100g/l	11.75[b]	13.92[b]	18.88[c]	26.60[b]
SE ±	0.43	0.85	0.94	1.40
Spray (B)				
No Spray	21.77[a]	28.49[a]	41.04[a]	55.97[a]
Once Spray	16.05[b]	19.00[b]	25.09[b]	30.72[b]
Twice Spray	16.07[b]	18.92[b]	23.47[b]	28.03[b]
Thrice Spray	14.08+c	16.53[c]	19.15[c]	22.37[c]
Four Spray	10.21[d]	12.53[d]	13.17[d]	12.82[d]
SE ±	0.58	1.01	1.57	1.48
AXB	*	*	*	*

Means within a column followed by the same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 5: Effect of dosage and spray frequency of *Lawsonia inermis* leaf extracts on the fruit yield of cucumber melon affected by *Altanaria* leaf spot disease in Maiduguri in 2017 and 2018

Treatment	Fruit Yield (Tha^{-1})	
Dosage (A)	2017	2018
50g/l	5.00^{c}	5.13^{b}
75g/l	6.21^{b}	5.45^{b}
100g/l	7.17^{a}	6.99^{a}
SE ±	0.21	0.30
Spray (B)		
No Spray	3.44^{d}	2.87^{d}
Once Spray	6.28^{c}	5.25^{c}
Twice Spray	6.68^{b}	6.20^{b}
Thrice Spray	7.02^{a}	6.55^{b}
Four Spray	7.37^{a}	8.42^{a}
SE ±	0.32	0.21
A X B	*	*

Means within the column followed by the same letter are not significantly different according to Duncan Multiple Range Test (DMRT)

NIGERIAN JOURNAL OF HORTICULTURAL SCIENCE (NJHS)

Journal of horticultural society of Nigeria (HORTSON)

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NJHS Authors guide

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