The effect of solid (granular) and liquid (foliar) fertilizers application on the growth and yield of *Zea mays L* in soils of Obubra campus of the Cross River University of Technology teaching and research farm, Cross River State, Nigeria

ABSTRACT

Research was carried out on the month of April, 2018 to determine the effect of solid (granular) and liquid (foliar) fertilizers application on the growth and yield of maize was carried out at the Cross River University of Technology teaching and research farm. Composite soil sample was collected at the depth of 0-20 cm from the soil for the analysis of physicochemical properties before application of the fertilizers. The experimental layout was randomized Complete Block Design (RCBD) with five replications, a plot area of 25 m x 20 m (500 m^2) which corresponds to 0.05 ha^{-1}. The plot was designed and blocked into subplots, each measuring 6 m x 4 m (24 m^2). Each block was separated from the other with a distance of one meter (1 m) apart and between subplots 0.5 m apart. Three treatments made up of treatment one (T_1) zero application ha^{-1}, treatment two (T_2) liquid (foliar) N.P.K 20:20:20 ha^{-1} and treatment three (T_3) solid (granular) N.P.K 20:20:20 ha^{-1} were replicated five times making a total of fifteen (15) subplots. Parameters observation of plant heights and number of leaves were observed at 6 weeks and at 8 weeks after planting. Plant heights, number of leaves, number of cobs, weight of 1000 seeds in each subplot and weight of grain after shelling were analyzed respectively. Results on soil analyses showed that the soil texture was sandy loam with deficiencies in primary nutrients and other nutrients. On the plant heights, the result was significant and on the number of leaves, analysis of the result for 6 weeks was not significant while that of 8 weeks was significant. On the number of cobs, 1000 seeds and weight of grain after shelling were also significant. The solid (granular) fertilizer showed to be more effective than liquid (foliar) fertilizer and should therefore be recommended for the growth and yield of maize in the area.

Keywords: Maize, Fertilizer, Crop yield, Treatment, Experimental Plot

INTRODUCTION

Maize, other names corn, Indian corn, mealis (English), mais (French), milho (Portuguese), maize (Spanish), Dura ash shahami (Opabic), makai, butta (Hindi) belongs to the family *poaceae*. Tribe - *maydeae*, Genus - *Zea* and Specie - *mays*. However, there are a number of theories regarding the origin of maize but it seems most probable that it originated in Mexico or Central America [8] where it has been in cultivation for more than 700 years [20]. Maize was brought to Europe by Columbus and was introduced into Africa by the Portuguese. Maize today is probably the next most important grain cereal after wheat in the world [19]. It is now found all over the world and its natural habitat is the tropics. In Nigeria, Maize is one of the major staple foods, fodder and industrial crop for commercial and subsistence level where it is grown in all agro ecological zones as put by [18] and [9]. Maize is predominantly the Cereal crop of Southern Nigeria, just as sorghum and millet are those of the Northern Nigeria [18]. The crop to some extent is cultivated practically throughout the country. Maize is one of the oldest and widely cultivated World's cereals and strong annual crop/grass, usually producing one stem and growing to a height of 1- 4.5 m. Its ability to strive under different ecological condition in Nigeria has led to increase production. Older/local varieties of the crop mature after 100 – 120 days but more rapidly maturing varieties are now available. Maize has prop roots emanating from the basal nodes to support the plant. The stems are solid, the root un-branching, hence produce a fibrous network on the soil [9]. The internodes at the stem are shorter and fairly at the base but longer and thicker in the middle while it tappers toward the apex to end with the male inflorescence [13]. The leaf is green and has clasping sheath that envelopes each internodes. The leaf itself has a declared midrib, hairy surface, rough and waxy edges and generally lanceolate (pointed edge) in nature. The male inflorescence called a tassel for hybrid varieties is produce after 50 – 60 days as a continuation of the main stem. The female inflorescence, called the ear or cob is a modified spike formed on a short branch in the axils of the largest foliage leaves. The silk which are the stigma of the flowers when receptive, will lead to seed formation. The seed developed on the cob which is condensed spike of pairs of spikelet arranges in a spiral.

To obtain maximum growth and yield of maize, the use of high growing, yielding, well adapted varieties, seeded at optimum plant density, coupled with favorable environmental conditions such as adequate availability of nutrients, soil moisture and moreover the application of fertilizers is require to improving its growth and yield. Fertilizer is any material of natural or synthetic origin that is applied to soils or to plant tissues to supply one or more plant nutrients essential for the growth of plants [14]. Many research findings have shown that neither organic nor inorganic fertilizers alone can result in sustainable productivity [23]. Liquid (foliar) fertilizer is a form of fertilizer obtained by dissolving NPK 20:20:20 or NPK 15:15:15 in water to form soluble substance [16]. This dissolution can be made in a can bottle or any container. The fertilizer is spread to the leaf of the plant where quantities of the major plants food can be absorbed through the leaf at one time. Liquid (foliar) on crops boasts the yield of plants. It is estimated that increased in yield of any leafy crops came from the use of liquid (foliar) fertilizers. It enhances vigorous growth of plants against stunting, yellowing of leaves and eventual death in case of its deficiency. The solid (granular) fertilizers have different nutrient elements required by plants in its composition, but the most essential ones are nitrogen, phosphorus and potassium. The nitrogen contain 1- 5 % weight by plant and exist as nitrate (NO_3^-), ammonium ion (NH_4^+) and urea (Co $(NH_2)_2$). The nitrate form dominates in moist warm and aerated soils and it is the preferred form of nitrogen in plants. The phosphorus varies in concentration from 0.1 – 0.4 % in plant and available as phosphate ion ($H_2PO_4^-$), orthophosphate (HPO_4^{2-}). Here the phosphate ion dominates in soil with optimal pH values. Other forms like phosphate are component of fertilizers and form orthophosphate during hydration. These phosphate ions are involved in the major soil chemical reactions and numerous metabolic pathways in plant nutrition with the most essential being the storage and transfer of energy [11].

Crop yield tend to decrease when soil depleted in its nutrients [5]. To balance the nutrients in soils for increased growth and yield of crops, soil analysis is important in order to recommend fertilizer application. The soils of the Tropical Rain Forest are heavily leached of plant nutrients due heavy rainfall in the area [10]. The soils of Obubra belong to the soil order, Ultisols which are extensively weathered [2]. The soils are highly leached and therefore acidic in reaction probably due to high amounts of rainfall in the area [8]. Their major constraints include the sandy nature of the surface, prone to severe and internal erosion, low potassium reserve and high acidity thus necessitating regular liming as reported by [24] and [12]. The soils are generally suitable for most arable crops and cash crops [12]. Therefore, the objective of this study was to investigate the comparison of the effect of solid granulated and liquid (foliar) fertilizers application on the growth and yield of *Zea mays L*.

MATERIALS AND METHODS

Study area

This research was carried out at the Cross River University of Technology teaching and research farm at the major farm road, Ovonum, Obubra Local Government Area of Cross River State, Nigeria. Obubra lies between Latitude 06^0 5' 8.466" N and 08^0 3280" E. The rainfall distribution had a mean annual rainfall of 2250 – 2500 mm [2].

Experimental site, Procedures, Treatments and Experimental design

The research site is about 0.5 km away from the University Lecture Halls. The experimental plot was cleared during the month of March in the 2016 farming season. The plot was designed and blocked into subplots, each measuring 6 m x 4 m (24 m^2). Fifteen subplots containing eight ridges each were constructed making a total of one hundred and twenty ridges in the experimental plot. The total area of the experimental plot was 25 m x 20 m which gives a total of 500 m^2 (0.05 ha^-). Each block was separated from the other with a distance of 1 m apart and between subplots 0.5 m apart. The experimental design used was Randomized Complete Block Design (RCBD) with five replications in three (3) treatments namely treatment one (T1) - Zero application**,** treatment one (T1) - Solid fertilizer (NPK 20:20:20/ha) and treatment two (T2) – liquid fertilizer (NPK 20:20:20/ha).

Table 1: Treatments, treatment and replication, fertilizer rate and rate applied on each plot

TRTS.	Treatment & Replication	Fertilizer rate in hectare	Rate applied on each plot
T_1	T_1R_1, T_1R_2, T_1R_3, T_1R_4 & T_1R_5	0kg/ha	0 kg
T_2	T_2R_1, T_2R_2, T_2R_3, T_3R_4 & T_2R_5	NPK 20:20:20	0.32 kg
T_3	T_3R_1, T_3R_2, T_3R_3, T_3R_4 & T_3R_5	NPK 20:20:20	140 mils

Seed collection, Sampling and data collection

The maize seeds for planting were obtained from local market of Ikom, Cross River State, Nigeria. The central row plants were used for data collection where growth parameters namely plant height, number of leaf per plant with yield components such as number of cobs; number of seeds per row and weight of grain after shelling were recorded. Plant height (cm) was measured from the base of the plant to the upper of the top most leaves. The numbers of functional leaves per plant was a visual count of the green leaves. The number of cobs was through counting from randomly selected cobs and the grain after shelling was weighed.

Laboratory analyses

Soil samples collected from the site were air-dried, gently crushed with pestle and mortar and sieved through a 2.00 mm sieve to obtain the fine earth fraction for the analysis. Particle size analysis was determined by Bouyoucos hydrometer methods using sodium hexametaphosphate (VII) as dispersant [25]. Soil texture was determined using USDA soil textural triangle [22]. Bulk density was determined using 100 cm^3 metallic cores to collect undisturbed soil samples and oven-dried at 105^0C to constant weight and the bulk densities were calculated. The pH was determined potentiometrically with a glass electrode pH meter in water at 1:2.5 soil: water ratio [3]. Organic Carbon was determined following the Walkley and Black wet oxidation method as outlined by [17]. Total nitrogen was determined by the micro-kjeldhal method [25]. Available phosphorus was determined by extraction with Bray P-I extractant as described by [4]. Exchangeable acidity was determined by successive leaching of soil with neutral unbuffered 1N KCl using 1:10 Soil: Liquid ratio. The amount of H^+ and Al^{3+} in the leachate was determined by the titration method. Exchangeable cations were determined with 1N ammonium acetate (pH 7.0) using 1:10 Soil: Water ratio. Ca^{++} and Mg^{++} in the filtrate were determined with an atomic adsorption spectrophotometer (AAS) while Na^+ and K^+ were determined with a flame photometer as described by [25]. Cation exchange capacity (CEC) was determined by the neutral ammonium acetate (pH 7.0) method. While effective cation exchange capacity was calculated by summing up exchangeable H^+ and Al^{3+} and exchangeable cations. Base saturation was determined the summation of exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) by the total exchangeable bases and acidity and multiply by 100 percent.

Data analysis

Data collected on various growths and yield parameters were subjected to analysis of variance (ANOVA) in Randomized Complete Block Design (RCBD). The treatments mean were separated using F-LSD test at 0.05 probabilities level.

RESULTS AND DISCUSSIONS

Soil properties before trial of fertilizer

The result on the soil physical and chemical properties before trial of fertilizer is shown in Table 2. The results showed that the soil was sandy loam texture with high proportion of sand content and deficient in nutrients. The soil pH (5.4) show very strongly acidic milieu [15]. The organic carbon, total N, and available phosphorus were low. The low contents in organic carbon, total N and available P could be attributed to the effects of intensive cultivation of the soils in the area. This conforms to the work of [21]; [16] who stated that continuous cultivation of land results in the reduction of soil nutrients especially organic carbon. The low content of available P might be attributed to the pH. The exchangeable bases were also low. This might be attributed to high rainfall in the areas which leaches the basic cations down the profile. The exchangeable bases were generally low with no Mg^{2+}. This is an indication of how the cations are leached by rain. The exchangeable acidity was high indicating the acidic condition of the soil. The soil requires fertility management practices.

Table 2: Results on soil properties before application of fertilizer

Physico-chemical properties	**Quantity**
Sand (%)	74.0
Silt (%)	16.0
Clay (%)	10.0
pH (H_2O)	5.4
Org. Carbon (%)	1.13
Total nitrogen (%)	0.14
Av. P (mg/kg)	15.63
Exchangeable cations (cmol/kg)	
Ca^{2+}	2.4
Mg^{2+}	0
K^{+}	0.09
Na^{+}	0.07
Exchangeable acidity (cmol/kg)	
Al^{3+}	1.32
H^{+}	2.36
ECEC	6.64
B.S (%)	44.58
Textural Class	**Sandy loam**

Plant height (cm)

The plant heights were measured in centimeters (cm) in each subplot. The result is presented in Table 3. The result analyzed for the 6 and 8 weeks after planting were highly significantly ($p<0.05$) difference. Treatment three (T_3) recorded the highest plant height, mean values of 57.94 and 64.02 followed by treatment two (T_2) which recorded mean values of 52.24 and 58.24, followed by treatment one (T_1) which recorded the least number in plant height, mean values of 41 and 53.08. Treatment three (T_3) that recorded the highest followed by treatment two (T_2) could be attributed to the effect of fertilizers applied which enhance the increase of growth and yield. This agrees with [1] who elucidated that there was high significant difference in maize plant height in plots treated with fertilizers compared to zero application.

Table 3: Results of plant heights at 6 weeks and 8 weeks after planting

	6WAP							8WAP						
TRTS.	R1	R2	R3	R4	R5	TOTAL	MEAN	R1	R2	R3	R4	R5	TOTAL	MEAN
1	40.1	35.6	40	43.2	46.1	205	41	55	50	56.1	49.8	54.5	265.4	53.08
2	50.1	50.2	53.5	56.2	51.2	261.2	52.24	50	56	65.2	59.5	60.5	291.2	58.24
3	60	45	60.1	60.5	64.1	289.7	57.94	64	61.5	68.5	69.4	56.7	320.1	64.02
BLK Total	150.2	130.8	153.6	169.9	161.4	755.9		169	167.5	189.5	178.7	171.7	876.7	
F-LSD (0.05)	*							**F-LSD (0.05)**	*					

WAP = Week after Planting R = Replication, TRTS =Treatments, * = Significant

Number of leaves

Numbers of leaves per plant on 10 plants in the middle row were counted and their mean obtained for each treatment at 6 and 8 WAP. The result is presented in Table 4. The result shows that analysis of result for 6 weeks was not significant while that of 8 weeks was significant with treatment three (T_3) recording the highest number of leaves, mean values of 10.62 and 13.6 respectively, followed by treatment two (T_2) which recorded mean values of 10.12 and 12.08 and treatment (T_1) recording the least mean values of 8.6 and 10.12 at both 6weeks and 8 weeks after planting. The highest number of leaves recorded in treatment three (T_3) followed by treatment two (T_2) was due to the fertilizer application which boasted the growth of vegetative part of the plant.

Table 4: Results of number of leaves at 6 weeks and 8 weeks after planting

	6WAP							8WAP						
TRTS.	R1	R2	R3	R4	R5	TOTAL	MEAN	R1	R2	R3	R4	R5	TOTAL	MEAN
1	9.2	10	7.5	8.2	8.1	43	8.6	10.5	9.5	10.6	10	10	50.6	16.12
2	9.7	9.6	10.6	10.2	10.1	50.6	10.12	13	11	13	12	11.4	60.4	12.08
3	11.1	11	10.2	9.3	11.5	53.1	10.62	14	13.5	13	12.5	15	68	13.6
BLK Total	30	30.6	28.3	27.7	30.1	146.7		37.5	33.8	36.6	34.5	36.4	179	
F-LSD (0.05)	**							**F-LSD (0.05)**	*					

WAP = Week after Planting R = Replication, TRTS =Treatments, * = Significant, ** = not significant

Number of cobs (kg)

The result on the number of cobs in each subplot is presented in Table 5. The result shows that treatment three (T_3) recorded the highest number of cobs, a mean value of 7.4 followed by treatment two (T_2) which recorded the mean value of 6.3 and treatment one (T_1) recorded the least mean value of 5.3. There was high significant ($p<0.05$) difference in the number of cobs. This could be attributed to application of fertilizer resulting to taller plant which bears more cobs. This conforms to [7] who noticed that plant height is an important parameter of yield of maize as usually taller plant bears more cobs and offers more yield.

Table 5: Results of number of cobs in each subplot

TRTS.	R1	R2	R3	R4	R5	TOTAL	MEAN
1	5	5.5	5.5	5	5.5	26.5	5.3
2	6.5	6.5	6.5	6	6	31.5	6.3
3	7	8	7	7	7	37	7.4
BLK Total	18.5	20	19	19	18.5	95	
F-LSD (0.05)	*						

WAP = Week after Planting R = Replication, TRTS =Treatments, * = Significant

1000 seeds (g)

The result of 1000 seeds weight in each subplot is presented in Table 6. The result shows that treatment three (T_3) recorded the highest with mean value of 0.28 g followed by 0.18 g recorded in treatment two (T_2) and treatment one (T_1) recorded the least mean value of 0.1. The result analyzed was significant. The highest weight of seeds was recorded in treatment three (T_3) followed by treatment two (T_2) which might be attributed to the effect of fertilizers applied for better growth and grain filling of maize of crop.

Table 6: Result of 1000 seeds weight in each subplot

TRTS	R1	R2	R3	R4	R5	TOTAL	MEAN
1	0.1	0.1	0.1	0.1	0.1	0.5	0.1
2	0.2	0.1	0.2	0.2	0.2	0.9	0.18
3	0.3	0.2	0.3	0.3	0.3	1.4	0.28
BLK Total	0.6	0.4	0.6	0.6	0.6	2.8	
F-LSD (0.05)	*						

WAP = Week after Planting R = Replication, TRTS =Treatments, * = Significant

WEIGHT OF GRAIN AFTER SHELLING

The result on the weight of grain after shelling is shown in Table 7. The result shows that there was significant ($p<0.05$) difference. Treatment three (T_3) recorded the highest number, mean value of 1.52 followed by treatment two (T_2) which recorded the mean value of 1.34 and treatment one (T_1) recorded the least, mean value of 1.02. The high values recorded in treatment three (T_3) and treatment two (T_2) could be attributed to the fertilizers applied resulting in maximum grain numbers. The result agrees with [19] who reported that maize crop fertilized with fertilizers produced maximum grain number per cob.

Table 7: Result of weight of grain after shelling in kg.

TRTS	R1	R2	R3	R4	R5	TOTAL	MEAN
1	0.9	0.8	1.2	1.0	1.2	5.1	1.02
2	1.3	1.4	1.4	1.3	1.3	6.7	1.34
3	1.3	1.6	1.5	1.7	1.5	7.6	1.52
BLK Total	3.5	3.8	4.1	4.0	4.0	19.4	
F-LSD (0.05)	*****						

WAP = Week after Planting R = Replication, TRTS =Treatments, * = Significant

CONCLUSION AND RECOMMENDATION

The study concludes that the soil was generally deficient in nutrients for growth of maize. The treatments applied in statistical form using Randomized Complete Block Design (RCBD) showed that treatment three (T_3) performed the best, followed by treatment two (T_2) while treatment one (T_1) came least in both growth and yield. The effect of solid (granular) fertilizers was found to be more effective and should therefore be recommended for maize production in the area. Nutrient management should be adopted for the soil if it is to be put into agricultural use.

References:

1. Adekayode, FO and Ogunkoya, MOEffect of quantity and placement distances of inorganic 15-15-15 fertilizers in improving soil fertility status and the performance and yield of maize in tropical rain forest zone of Nigeria, 2010. *J. Soil Sci. Environ. Manage*. 1: 155-163.
2. Agba, OB, Ubi, BE, Abam, P, Ogechi, J, Akeh, M, Odey, S and Ogar, N. Evaluation of Agronomic performance of Maize (Zea mays L) under Different Rates of poultry manure application in Ultisol of Obubra, Cross River State, Nigeria, 2012. *Inter. J. of Agric. and For*. 2 (4): 138 – 144
3. Bates, RG. Determination of pH theory and practice, 1973. Wiley
4. Bray, RH and Kurtz, LT. Determination of total, organic and available forms of phosphorus in soils.1945. Soil Sci., 59: 39-46
5. Chavez, MD, Berentsen, PBM, Onenema, O and Lansink, AG. Potential for increasing soil nutrient availability via soil organic organic matter improvement using pseudo panel data. 2014. Agric. Sci. 5: 743 -753
6. Chikezie, IA., Eswaran, IA, Asawalam, DO & Ano, AO. Characterization of two benchmark soils of contrasting parent materials in Abia State, Southern Nigeria, 2010. *Global J. of Pure Applied Sci.* 16:23-29
7. Dilshad, MD, Lone, MD, Jilani, G., Malik, MA., Yousaf, M, Khalid, A and Shamin, F Integrated Plant Nutrient Management on maize under rainfed condition, 2010. *Pak. J. of Nutr.* 9: 896-901
8. Dowswell, CR, Paliwal, RL and Cantrell, RP. Maize in the Third World, 1996. West View Press, Colorado, USA. ISBN- 13: 9780813389639. Page 268
9. Eleweanya, NP, Uguru, MI, Enebong, E E. and Okocha, PI. Correlation and path coefficient analysis of grain yield related characters in maize (Zea mays L) under Umudike conditions of Southeastern Nigeria, 2005. *Agro – Science J. of Trop. Agric., Food, Environ. and Ext*. 1, 24-28
10. Ezeaku, PL. Optimum NPK fertilizer rates based on soil data for grain maize (Zea mays L) production in some soils of Southeastern Nigeria, 2008. *Agricultural J.* 3 (1): 36-41
11. Gualem, P, Gustafson, DM and Wicks, III."Phosphorus Concentration uptake and Dry Matter Yield of corn Hybrids", 2011. *World J. of Agricultural Sciences,* 7 (4): 418-424, ISSN: 1817 – 3047
12. Ibia, TO, Uko-Itakha, IB, Edem, SO, Ogban, PI & Obi, JC. Evaluation of the Acid Soils for sanitary Landfills in Akwa-Ibom State, Southern Nigeria, 2011. *Nigerian J. of Soil Sci.*. Vol 21(1):1-5
13. Irisch, EE. "Class 11 tassel seed mutations provide evidence for multiple types of inflorescence meristems in maize (Poaceae)", 1997. *American J. of botany*. 84 (11): 1502 – 1515
14. Mills, HA, and Jones Jr, JB. Plant Analysis Handbook II: A practical Sampling Preparation Analysis and Interpretation Guide, 1996. ISBN 1-878148-05-2
15. Myers, RJ. One – Hundred years of pH, 2010. *J. of Chemical Education*. **87**: 30 - 33

16. Negassa, W and Gebrekidan, H. Forms of phosphorus and status of available micronutrients under different land use systems of alfisols in Bako area of Ethiopia. 2003. *J. Nat. Resour.* 5: 17-37

17. Nelson, OW and Sommers, LE. Total Carbon, Organic Carbon and Organic. In O. L. Sparks (ed). Methods of Soil Analysis Part 3, Chemical Methods, 1996. Soil Science Society of America Book Series Number 5. American Society of Agronomy, Madison WIE, pp 961-1010.

18. Onasanya, RO, Aiyelari, OP, Onasanya, AW, Wilene, FE. and Onyelakin, OO. Effect of different level of Nitrogen and phosphorus fertilizers on the growth and yield of maize (Zea mays L) in Southwest Nigeria, 2009. *Nigeria International. J. of Agricultural Res.* 4: 193 -203

19. Rasheed, M, Ali, H and Mahmood, T. Impact of Nitrogen and sulfur application on growth and yield of maize (Zea mays L) crop, 2004. *J. Res. Sci.* 15: 153-157

20. Rhodes, LL and Eagles, HA. "Origins of maize in Zealand", 1984. *Zealand J. of Agricultural Research.* 27 (2): 151-156

21. Salk, H, Varadachari, Cand Gosh, K.. Changes in carbon, nitrogen and phosphorus levels due to deforestation and cultivation, 1998. A case study in Simpal National Park.

22. Soil Survey Staff . Soil Survey Manual. US Department of Agriculture, 1999. Hand Book 18. US Govt. Printing Office, Washington.

23. Tadesse, T, Dechassa, N, Bayu, W and Gebeyehu, S. Effects of farmyard manure and inorganic fertilizer application on soil physicochemical properties and nutrient balance in rain-fed lowland rice ecosystem 2013. *Am. J. Plant Sci.*, 4: 309-316.

24. Thomas, EE, Kristin, MH and Mary, LS. Marginal Horticulturists or Maize Agriculturists: Archaeobotanical, Paleopathological and Isotopic Evidence Relating to Landford Tradition Maize Consumption, 2005. Midcontinental *J. of Archaeology*. 30 (1):67-118

25. Udo, EJ, Ibia, TO, Ogunwale, JA, Ano, AO and Esu, IE. Manual of soil, plant and water analysis, 2009. Sibon books limited Lagos Nigeria. pp.183.