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Screening effect of organic manure on the vegetative growth of maize (*Zea mays* L.)

Abubakar, Z. A. and Ali, A. D.

Biological Sciences Department, Gombe State University, Nigeria

✉ For any information: ask.author@journalbinet.com

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ABSTRACT

The study which aimed at evaluating the effect of different organic manure on the growth of maize was conducted at the Allies Gardens and Landscaping, Gombe State, Nigeria. The study was conducted from March 2017 to May ending 2017, experimental period was 12 weeks. Treatments were the three sources of nutrients and control; poultry manure (PM), cattle dung (CD), inorganic fertilizer NPK. Different treatment rates of PM, CD and NPK were replicated 4 times, a total of 48 experimental poly pots were used in the research. The parameters measured were number of leaves, plant height, leaves area root shoot and plant biomass. The study revealed the effect of applied organic manures (PM and CD) on the vegetative growth of the maize crop which suggests an improvement in growth and future yield of the maize plant. This is anticipated to replace the use of NPK.

Key Words: *Organic manure, Poultry manure, Cattle dung, Inorganic manure and NPK*

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I. Introduction

Maize grow successfully in the northern part of Nigeria. Maize grain contains higher percentage of carbohydrate with little protein and fat, of all cereal, maize has the largest amount of oil, the average chemical composition is starch 68±70%, protein 10% and 3.6-5% (Mulvaney *et al.* 2001). It prefers high open land and requires manure as it exhausts the soil (Bray and Kurtz, 1945). Its leaves and stem form a good fodder and the grain is good in nutritional content. Maize flourish both in hot and cold climates. Maize cobs may be 15-25 cm in length and the grain is golden yellow, dull yellow, red or white. The grains are taken as a substitute for other cereal grains and prepared by boiling, they are also often fried. Usually they are grounded into fine flour called corn flour and sometimes powdered starch. The young tender grains are nutritious and may be eaten raw roasted or boiled in milk (Moritsuka *et al.* 2007). Maize is sown at 25 cm - 75 cm between row and for one plant per stand sown

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at 90 cm between row and 40 cm within row for two plant stands. To sow one hectare, 25 kg of seed is required and one should make sure the space due to un-germinated seeds are replanted within one week (Schrmpt, 2008). Maize seedlings are poorly adapted to drought stress condition, for crop to grow supplemented irrigation may be required in Sudan and Sahel Savannah. Early planting is advised with the first rain (Walter, 2005). Maize generally requires heavy fertilizer dosage, a considerable amount of nutrient especially in relation to nitrogen and potassium is also needed (Bray and Kurtz, 1945). This crop requires the use of fertilizers for maintaining high yield. The choices of suitable forms of fertilizer for the proper growth of the plant are governed by local natural conditions and variations in soil and climate with regard to their suitability for maize cultivation (Thomson and Asiegbu, 2013). According to Thompson (2007) fertilizers are sources of plant nutrient that can be added to supplement soil natural fertility. They are intended to supply plant needs directly rather than indirectly as though modification of soil pH and structure. Great improvement on both quality and quantity of grain result when appropriate quantities are added at appropriate stages of plant growth (Nwodoka *et al.* 2016). In areas with negligible cattle stock or where stable manure is produced in small amount in other countries where stabling is almost non-existent, green manuring can provide available organic supplement in maize cultivation (Tani, 2004). Mechole (2011) showed that maize react very favorable to green manuring in temperate zone. Schaffer (2013) reported that maize make heavy demand on Nitrogen, whole main significance in the maintenance of normal physiological functioning of the cell. Tolera *et al.* (2014) suggested that breeders should select maize varieties that combine high grain yield and desirable characteristics because of large differences that exist between cultivars. Odeleye and Odeleye (2001) reported that maize varieties differ in their growth characters, yield and its components. Therefore suggested that breeders must select most promising combiners in their breeding programme. Subsistence farmers apply organic manure directly to the soil as a natural means of recycling nutrients in order to improve soil fertility and yield of crops. Reijnties *et al.* (1992) and Adepetu *et al.* (2005) remarked that the downward trend in food production should prompt farmers to amend the soil with different materials in order to enhance growth and yield of crops. Several organic materials such as cattle dung, poultry dropping, pig dung and refuse compost have been recommended to subsistence farmers in West Africa as soil amendments for increasing crop yield (Sobulo, 2000; Ismail *et al.* 2001; Olayinka, 2012; Olayinka *et al.* 2009). Enujeke (2013) recommended the application of 450 $kgha^{-1}$ of NPK 20: 10:10 or 30 t/ha of poultry manure for increased grain yield of maize. The report further argued that poultry dropping and cattle dung increases root growth of maize and the crop extracts soil water more efficiently for increased grain yield. The steady decline in maize yield can be attributed to rapid reduction in soil fertility caused by intensive use of land and reduction of fallow period as reported by Directorate of Information and Publications of Agriculture (DIPA, 2006), use of inappropriate plant spacing which determines plant population and final yield (Zeidan *et al.* 2006), negligence for soil amendment materials such as organic manure and inorganic fertilizers which improve soil condition and enhance crop yield and high cost of NPK fertilizer in the market. The study aimed to compare the effects of different organic manure on the growth of maize and aslo determine which of the growth parameter is effective in measuring the growth of maize plant under the influence of organic manure.

Nitrogen, phosphorus and potassium requirements in Maize

Yield of maize varies from variety to variety and it depends on the availability of essential factors such as soil nutrient status and application of fertilizers. Nitrogen is a vital plant nutrient and a major yield determining factor required for maize production (Adediran and Banjoko, 2003; Shanti *et al.* 2007). Its availability in sufficient quantity throughout the growing season is essential for optimum maize growth. Most farmers in developing countries usually rely on the natural soil fertility for crop production. Opening of a long fallow land may provide adequate nutrient to food crop. But cropping of such land is only successful within few years after opening of the fallowed land. Afterwards, subsequent cropping requires additional fertilizer input, most importantly that of nitrogen to maintain good yields. Phosphorus (P) is another limiting nutrient in maize production. Various factors could be responsible for P availability to crop plants. These include the form of native soil P, the type of P applied to the soil and soil reaction. It has been reported that total P was higher in forest soils than in the savanna (Adepetu, 2000). Agricultural crops show different response to P fertilization. Results of various fertilizer experiments carried out in Nigeria have led to fertilizer recommendations that gave blanket nutrient requirements for maize in ecologies having varying soil conditions and under varying levels of soil management (FPDD, 2003). This practice is aimed at giving farmers an appreciable

economic return from the fertilizer input. For example, hybrid maize cultivation was found to require high fertilizer rate for optimum yield. Findings from these research work indicated that maize responded to nitrogen better in the Savanna than in the forest ecology (Sobulo, 2000). It was further suggested that 60-70 kg N ha served as economic rate for maize in the rainforest and over 100 kg N ha in the Savanna. Difference between the two zones was, however, attributed to the presence of higher insulation in the savanna (Sobulo, 2000). Some works carried out with phosphorus (P) fertilizer indicated positive response of maize to low rates of P (Anon, 2005; Amon and Adetunji, 2001). Application of high rate of NPK was reported to be capable of causing nutrient imbalance and consequently yield depression of Western yellow maize (Osiname, 2009).

Maize production

Land area under maize increased at about 2,800 ha per year from the years 1982-2002 (Fakorede *et al.* 2003). Increase in area of cultivation and quantity of maize grain produced in Nigeria in recent years has become stable. Savanna ecology can well be called the corn Belt of Nigeria. Availability of fertilizer at affordable price generally determines the increase in land area under maize production in any year. Thus, areas cultivated to maize decrease as fertilizer subsidies are withdrawn. Trends for grain yields and production were like those of land areas, although average annual increase in total production was much higher than the annual increase in yields, the average maize grain yield increased from less than one ton/ha in the last two decades to more than 1.7 t/ha in 2006. The estimated average annual growth rate in maize production over the last ten years was 5.46% which is about twice the projected 3.2% needed to meet our demands (Shaib *et al.* 2007). Federal Government approved the doubling maize production from 4.5 m tons to 9.0 metric tons (MT) in 2007. To satisfy maize demand, Nigeria needs to produce a minimum output of 10 MT annually (Aziz, 2008). Doubling maize committee estimates a total of 11.3 metric tons (MT) annually to meet the demands of human consumption (1 MT), livestock industry (8 MT), industrial use (2 MT), national food reserve (0.1 MT) and export to neighbouring countries (0.2 MT) (Anon, 2005). Nigerian Savanna is a heterogeneous ecological zone constituting more than 75% of the country's total area situated between latitude 07-13 ^{o}N and longitude 02-15 ^{o}E (Kowal and Knabe, 2011).

Effects of organic manure

Potential for maize production can only be fully realized with adequate fertilizer application (Norman *et al.* 2006) since most savannah soils are deficient of native soil nitrogen (Jones, 2003) and native phosphorus. Guinea savannah ecological zone has been reported to have the greatest potential for maize cultivation (Kassam and Kowal, 2001). Hegde (2008) reported that the use of costly chemical fertilizers can be minimized or replaced using locally available organic manures. Integrated use of organic and inorganic manures and or optimized fertilizer recommendation sustains the productivity of soil and crops in integrated cropping system. This approach restores and sustains soil health and productivity in the long run, besides meeting the nutritional needs of crops (Sultana *et al.* 2015; Satyajeet *et al.* 2007). Maintenance of high crop yields under intensive cultivation is possible only through the use of fertilizer. However, the use of inorganic fertilizers alone has not been helpful under intensive agriculture because it aggravates soil degradation (Sharma and Mittra, 2001). The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yields. Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Sharma and Mittra, 2001). Improvement of environmental conditions and public health concerns as well as the need to reduce cost of fertilizing crops are also important reasons for advocating increased use of organic materials (Seifritz, 2002). Application of organic manures also improves the soil physical and microbial properties (Belay *et al.* 2001). Nitrogen (N) is typically the nutrient of most concern because it has a strong influence on cereal crop yields (Havlin *et al.* 2005). Plants take up N in the form of ammonium (NH^{4+}), a result of mineralization and NO^{3-}, a result of nitrification. In manure, between 50 and 75 % of total N is organic (R-NH 2) and needs to undergo mineralization before it becomes available for plants. The remaining 25 to 50 % is NH^{4+}, which is highly susceptible to volatilization (Havlin *et al.* 2005). Mineralization and N recycling begin as soon as the manure is incorporated into the soil. Rate of mineralization varies among N sources but the rate is highest at application and decreases with time (Havlin *et al.* 2005). Application timing is a crucial component to maximizing N

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use efficiency in manures. Management of manure fertilizers is much more difficult than that of mineral fertilizers, primarily because manure and other organic fertilizers are affected by the handling during storage and application as well as the timing of incorporation and distribution (Thomsen, 2005). Autumn applications increase N loss through the soil system, in comparison with later applications that lead to increased crop utilization of N (Thomsen, 2005). Low soil fertility has been recognized as one of the major production constraints affecting agriculture in Sub–Sahara Africa. Soil fertility depletion in small holder farms is the fundamental cause of declining per capital food production (Sanchez *et al.* 2006). This depletion is mainly due to intensive and continuous cropping with low application of fertilizer, causing a negative balance between nutrition supply and extraction from the soil. The need to take appropriate measures to check this decline in soil productivity is urgent. The shortage and high cost of inorganic fertilizers have limited their use for crop production among the peasant farmers in Nigeria (Tanimu *et al.* 2007). Therefore the tendency for increased dependence on the use of organic waste such as farmyard manure, crop residues and poultry manure. Poultry manure has been adjudged to be the most valuable of all manures produced by livestock (Omisore *et al.* 2009). Nutrient contents of poultry manure are among the highest of all animal manures and the use of poultry manure as soil amendment for agricultural crops will provide appreciable quantities of all the major plant nutrients. It also improves biological activities, soil tilth and soil chemical properties (Michael and George, 2008). Superiority of poultry manure was also reported by (Chandrashekara *et al.* 2000). Saranappa (2002) showed 7.62 % increase in seed yield of maize with the application of poultry manure. Mehta and Shaktawat (2002) reported that application of farm yard manure at 10 t/ha recorded higher grain yield and was economical. In Nigeria, the shortage and high cost of inorganic fertilizer has put the commodity out of reach of most peasant farmers, leaving them with no other option than to look for cheaper alternatives of fertilizing their maize and other crops. The need for a cheap alternative to mineral fertilizer culminated in the choice of organic manure, such as poultry manure and cow dung for crop production.

II. Materials and Methods

This work was carried out in Allies Gardens and Landscaping, Gombe State, Nigeria. Gombe state is one of the states in the northern part of Nigeria that span two distinctive vegetation zones, namely, the Sudan savannah and the Sahel savannah. The Sudan savannah type of vegetation covers the southern part of the state. Here, the vegetation gets richer and richer towards the south, especially along water sources or rivers, but generally the vegetation is less uniform and grasses are shorter than what grows even farther south, that is, in the forest zone of the middle belt. Partially decomposed cattle dung was collected from Kasuwan Shanu Tashan Dukku motor pack, while poultry droppings were obtained from Poultry Farm Centre Tudun Wada. NPK 15:15:15 fertilizer was obtained from Gombe main Market. The seeds were collected in Gombe State Agricultural Development Programmed (GSADP). The variety of the maize seeds used during the experiment is Extra Early Variety Drought Resistant (EEVDT) TZ, Alheri, Premier, Samarz 18 and the control (Local variety). River soil and top soil were mixed for water circulation, in a ratio of three to six (3:6) using shovel. About 2kg of the mixture was put in each of the poly pots, three poly pots were used for every replication rate of all the treatments. Maize seeds were sown in March 27, 2017. Two seeds were sown in each poly pot. After germination, the young seedling was thinned out to avoid overcrowding; one seedling was left in each poly pot. The seedlings were watered after every two days up to six weeks after planting. The experimental plants were harvested at six weeks after planting.

Figure 01A and 01B. Maize cultivars at experimental site at six weeks after germination.

Organic manure was mixed with the soil and potted and watered for three days before the seeds were planted. NPK fertilizer was applied one week after the seed emergence from the soil. At two weeks after planting, all the 48 plants in every replication were selected for the measurement of growth characteristics at 2nd, 3rd and 4th weeks after planting respectively. All the data collected were statistically analyzed using the analysis of variance (ANOVA). Computer software used was Minitab(c) V. 17 (State College PA). A probability value of 0.05 was used as bench mark for significant differences between parameters.

III. Results and Discussion

Effect of treatment on measured parameters

The mean plant height increased with an increase in the number of weeks irrespective of the rate of poultry manure, cow dung, NPK and the control. Plant generally becomes taller. NPK and PM, CD rate have increased respectively. However, NPK has higher mean plant height followed by PM and CD. Whereas no significant differences were observed for biomass (g), leaf area (cm2) and root shoot ratios (Table 01).

Table 01. Mean plant height as influenced by poultry manure (PM), cow dung (CD), NPK, and control at week 1 to week 4

Parameter	Treatment				P value
	NPK	PM	CD	CTL	0.000
PH WK1	25.38^{A}±5.64	23.63^{A}±1.98	19.52^{B}±4.40	18.19^{B}±1.16	0.000
PH WK 2	32.46^{A}±5.81	32.31^{A}±4.23	25.38^{B}±6.20	22.16^{B}±2.98	0.000
PH WK 3	39.63^{A}±5.74	41.12^{A}±8.51	30.72^{B}±7.80	29.58^{B}±7.35	0.000
PH WK 4	47.22^{A}±6.70	43.25^{A}±9.82	39.32^{A}±10.57	38.18^{A}±7.60	0.004
LEAF AREA(cm)	529.5^{A}±262.1	506.3^{a}±95.9	471.2^{b}±180.2	413.1^{b}±176.7	0.465
BIOMASS (g)	88.4^{A}±77.2	88.1^{A}±64.0	87.7^{A}±91.7	85.6^{A}±64.0	0.880
ROOT TO SHOOT RATIO	3.75^{A}±5.06	2.88^{B}±5.20	1.64^{B}±1.33	0.98^{C}±0.82	0.276

*Means that do not share a letter are significantly different.PH WK=plant height/weeks

Effect of the treatments on the varieties

Significant differences were observed between the treatments for plant height (cm) from week 1 to week 4, leaf area (cm^2), and biomass (g). Root shoot ratios showed no significant difference between the varieties (Table 02).

Table 02. ANOVA analysis of measured parameters of the different maize varietyat week 1 to week 4

Parameter	Variety				P value
PARAMETER	ALHERI	PREMIER	SAMAZ 18	LOCAL	
PH WK 1	24.67^{A}±5.30	22.02^{B}±3.82	19.59^{B}±4.12	18.45^{C}±4.85	0.009
PH WK 2	33.02^{A}±6.12	30.55^{A}±6.82	26.54^{B}±4.08	22.56^{C}±5.35	0.000
PH WK 3	42.52^{A}±6.73	38.44^{B}±5.97	30.29^{BC}±9.67	29.81^{C}±5.82	0.000
PH WK 4	50.58^{A}±6.15	47.01^{B}±5.17	36.74^{C}±7.41	33.67^{C}±5.67	0.000
LEAF AREA(cm^2)	638.3^{AB}±191.0	472.2^{B}±171.1	449.0^{B}±103.0	360.6^{C}±17.8	0.001
BIOMASS (g)	159.0^{A}±75.8	119.9^{BC}±78.0	112.00^{C}±13.44	109.83^{C}±13.95	0.000
ROOT:SHOOT RATIO	2.64^{A}±5.26	2.48^{A}±5.26	2.08^{A}±1.25	2.05^{A}±1.72	0.977

*Means that do not share a letter are significantly different. PH WK=plant height/weeks

Discussion

Plant height increased with increasing levels of NPK, PM and CD. Plants were generally taller irrespective of the rate of NPK, PM and CD applied. Throughout the experimental weeks, the difference in plant height among the different rates of PM, CD and NPK were not significant. However, the mean plant height shows that plant varieties that had NPK were taller followed by those having PM, and CD but statistically there is no difference. Because nitrogen is present in high amount in the treatments

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which increases the growth of the maize seedling as reported by El-Sharkawy *et al*. (2004) and Ngamo *et al.* (2004). Nitrogen influences plant height by affecting cell size, leading to rapid elongation of the internodes and consequently, the final plant height. Leaves are the main photosynthetic organs of the plant, having less leaf number could result in the reduction of assimilates produced and partitioned to the grain (Johnson, 2008). Plant leave number in all the weeks increases irrespective of the rate of PM, CD and NPK. NPK has the highest leave number as observed in week 4 followed by PM, and CD which also explains the reason behind the significant difference in leave number among the treatments. PM and CD has higher leave number compared to the control in all the rates of the treatment. The mean biomass, root shoot, and leaf area also shows that plant varieties having NPK showed higher growth compared to PM and CD. However, plants having PM and CD showed higher biomass compared to the control of the local variety.

IV. Conclusion

Application of poultry manure and cow dog could resulted in an improved growth of maize. Poultry manure and cow dung can replace the use of NPK. The most effective growth parameter in measuring the growth maize is leave number and biomass. Poultry manure has more nitrogen content as compared to cow dung which is the reason behind the significant difference between the two treatments. Poultry manure and cow dung can be used for an improved maize production. The current study couldn't establish to suggest a preferable dosage or amount of either PM or CD that can be applied to replace NPK. However, it is suggested that it will be required in the future to determine the rate of poultry manure and cow dung that can replace the use of NPK by undertaking similar researches.

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Competing Interest

Authors have declared that no competing interests exist.

Author Contribution

AAZ, designed the experimental design, performed the statistical analysis and proof read the first draft. AAZ AND AAD wrote the manuscript draft and conducted the preliminary experiments in the field. All the authors contributed wholly to the achievement of the research study output.

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