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Combined Effects of Poultry Manure and NPK Fertilizer on Maize (*Zea mays* L.) Performance in Maiduguri Northern Guinea Savannah of Nigeria

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Abstract: *A pot experiment was conducted in the year 2018 dry season at the Ramat polytechnic Teaching and Research Farm Maiduguri, Nigeria, located within the Northern Guinea Savannah zone of Northeastern Nigeria to determine the effects of poultry manure and NPK fertilizer on the performance of maize (Zea mays L.). The experiment consists of fourteen (14) treatment combinations replicated three (3) times laid out in a Completely Randomized Design (CRD). A surface (0 – 20 cm) soil sample was collected from the University of Maiduguri Teaching and Research Farm and thoroughly mixed the sample for analysis was air-dried and passed through a 2 mm sieve and stored for analysis. Soil physicochemical properties were determined using standard methods. Agronomic data were collected. Data collected were subjected to statistical analysis using Analysis of Variance (ANOVA). The study revealed that application of poultry manure alone was less in maize performance when compared to NPK fertilizer application.*

Keywords: *NPK, Poultry Manure, Maize*

INTRODUCTION

Maize (*Zea mays* L.) is an essential staple food crop that is being competed for by both livestock and man. It provides the bulk of raw materials used for the animal feed and many agro-allied industries in the world (Randjelovic *et al*., 2011). It is estimated that in 2012, the total world production of maize was 875,226,630 tons (FAOSTAT, 2014) with the United States, China, and Brazil harvesting 31%, 24%, and 8% of the production figure, respectively. In Nigeria, maize is cultivated on more than 6 million hectares' maize production spread across Nigeria with an annual production of 26 million tonnes from 3,845,000 hectares (FAO, 2009). However, most of the production aims to meet domestic needs, since a negligible part of the output is formally exported (FAOSTAT, 2012).

The yield increases recoded from most crops in the last 60 years are results of two main factors, including progress in plant breeding and fertilizer use (Grzebisz and Diatta, 2012). Maize is, on average, the 5th most produced agricultural commodity between the period of 2005-2010, which becomes the 3rd most produced crop in Nigeria during 2009. The spread of maize can also be recognized to its adaptability to a wide range of soils and climatic conditions (FAO, 2006).

Maize is a very high nutrient-demanding crop, which requires adequate nutrition for maximum performance (Rashid and Ryan, 2004). Among several other factors which cause a decline in maize yield is soil degradation for intensive cultivation and continuous application of NPK fertilizers which may cause nutrient imbalance and limit the uptake of other essential nutrients, thus limiting the crop performance (Chukwu *et al*., 2012).

Integrated application of organic and inorganic fertilizer improves soil fertility and crop yield (Fereidooni *et al*., 2013). Well planned usage of organic manure and inorganic fertilizers are essential to increase productivity, input use efficiency, and safeguard soil health (Bandyopadhyay *et al*., 2010). The highest productivity of crops in a sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying an appropriate combination of different organic manures and inorganic fertilizers (Chandrashekara *et al.*, 2000). It is essential to identify the best type of available organic resources, which can be used as fertilizers and their best combination with an appropriate proportion of inorganic fertilizers. The use of both organic and inorganic fertilizers by farmers has been reported to increase yield and sustain soil productivity (Chukwu *et al.,* 2012).
The application of organic fertilizers has been positively shown to affect the structure of the microbial community differently than an application of sole mineral fertilizers (Wu *et al*., 2012). Proper application of organic and inorganic fertilizers can increase the activities of soil microorganisms and enzymes and soil nutrient contents (Saha *et al*., 2008). Furthermore, the application of organic manure mixed up with chemical fertilizer can prove to be an excellent procedure in maintaining and improving fertility and increasing fertilizer use efficiency.

Declining soil fertility in Nigeria has caused some of the problems faced by smallholder farmers today, especially among maize producers. High cost of chemical fertilizers has become a problem, and total dependence on organic manure is not feasible due to its bulkiness and transportation cost. Therefore combining chemical fertilizers and organic manure has proved to be essential for enhanced nutrient release, crops nutrient uptake and the optimum production of maize by the smallholder farmers thus the objective of this study was to determine the effects of sole poultry manure application, N.P.K., and their combinations on maize performance.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted during the dry season of 2018 at Ramat polytechnic Maiduguri, Nigeria, located within the Sudan savanna zone of Nigeria. It lies approximately between latitude 11^{o} 5' and 11.83°' N and longitude 13°09' and 13.50°'E at about 350 m (1161 ft) above sea level. The climate is hot and dry for a greater part of the year, with a rainy season from June to September, with mean annual rainfall and temperature of about 600 mm and 32 ^{o}C, respectively. The mean relative humidity ranges between 30 to 50% usually the lowest in February and March and the maximum in August.

Treatments and Experimental Design

The experiment consists of fourteen (14) treatment combinations, T1=0 PM + 0 NPK (Control), T2=100% PM (8t/ha), T3 =75% PM (6t/ha), T4=50% PM (4t/ha), T5=25% PM (2t/ha),T6=100% NPK(120-60-30 kg/ha), T7=75% NPK (90-45-22.5 kg/ha), T8=50% NPK(60-30-15 kg/ha) T9= 25% NPK(30-15-7.5 kg/ha), T10=100% PM +100% NPK (8 t/ha+120-60-30 kg/ha), T11=75% PM + 75% NPK (6 t/ha +90-45-22.5 kg/ha), T12=75%PM +25 NPK(6 t/ha + 30-15-7.5 kg/ha), T13=25%PM

+75%NPK (2 t/ha +90-45-22.5 kg/ha), T14=50%PM + 50%NPK(4 t/ha +60-30-15 kg/ha) replicated three (3) times laid out in a completely randomized design.

Plant growth parameters

Plant height (cm)

Plant height was measured in centimeter (cm) using a measuring tape from soil surface to the top of tagged plant at 2, 4, 6, 8, and 10 weeks after sowing (WAS).

Total fresh and dry shoot biomass weight (g)

Biomass (shoot) fresh weight per plant (g) was determined by harvesting the stalk at 10 week after sowing (WAS). It was oven dried at 70 ^{0}C for 24 hours and weighed using electronic sensitive balance model MP10001 and recorded.

Total fresh and dry root biomass weight (g)

At harvest, maize crop was carefully removed and washed off to remove soils from the roots. The roots were separated from the shoots, placed in separate envelopes and the weight recorded. It was oven-dried at a temperature of 70 ^{o}C for 48 hours for determination of dry root biomass (Copeland, 1976).

Number of leaves per plant (cm)

Number of leaves were counted in each pot using the tagged maize stands for data collection and recorded at 2, 4, 6, 8 and 10 WAS.

Leaf area per plant (cm^2)

Leaf area was taken at 2, 4, 6, 8 and 10 WAS from each pot (tagged plants). It was measured using grid method by taking two leaves at random from each pot and leaves were placed on a graph paper and traced using pencil. The number of full and half squares covered by each leave were counted and their average taken as leaf area per plant (Pal and Murari, 1985).

Results

Physical and Chemical Characteristics of Experimental Soil

Table 1 shows the result of the initial soil analysis which was carried out to assess the soil fertility status of the soil before the experiment. The result obtained showed that the soil was sandy loam in texture,

neutral in pH with a value of 7.2. The EC of the soil was 0.05 dSm^{-1} which was low. The OC and N content of the soil were 2.30 and 0.03% which were low. Available phosphoru (8.05 mg/kg) was moderate in content. Exchangeable K (0.09 Cmol/kg), Ca (1.40 Cmol/kg), Na (0.12 Cmol/kg) were all low in concentration while Mg (2.20 cmol/kg) was moderate in concentration. CEC (3.81cmol/kg) was very low but BS was very high with value of 92.70%.

The details of the chemical properties of the manure used for the experiment is presented in Table 2. The poultry manure was high in N (3.05 %) and in P (0.44%) and moderate in K (1.80 %), low in Ca (0.80 %) and moderate in Mg (0.55 %).

Table 1: The initial physical and chemical characteristics of the soil of the Study Area

Property	Value
Particle size distribution(g/kg)	
Sand	578.0
Silt	325.0
Clay	097.0
Soil textural class	Sandy loam
Chemical properties	
pH(H_2O)	7.2
Organic Carbon (g/kg)	2.30
Total N(g/kg)	0.30
Available P(mg kg^{-1})	8.05
E.C (dSm^{-1})	0.05
C:N	7.67
Exchangeable Bases ($Cmolkg^{-1}$)	B
Ca	1.40
Mg	2.20
K	0.09
Na	0.12
Exchangeable Acidity (E.A) ($Cmolkg^{-1}$)	0.30
CEC ($Cmolkg^{-1}$)	3.81
ECEC ($Cmolkg^{-1}$)	4.11
Base Saturation (%)	92.70
Initial microbial count (Cfu/ml)	

Table 2: Chemical Composition of the Poultry Manure Used

Parameter (%)	Value
Nitrogen	3.05
Phosphorus	0.44
Potassium	1.80
Ca^{2+}	0.80
Mg^{2+}	0.55

Effect of Poultry Manure and NPK Fertilizer on Maize Plant Height

The Combined effects of Poultry manure and NPK fertilizer on plant height of Maize is shown in Table 3. At 2 WAS, shortest maize height was 9.31 cm by application of 25% NPK and tallest height was by 75% PM + 75% NPK. Significant difference existed among the treatments. At 4 WAS there were significant ($P<0.05$) difference amount the treatments. Tallest maize height of 39.6cm was by application of 75% PM + 75% NPK and shortest value was obtained in the control. Similarly, at 6 WAS, significant difference was observed with PM and NPK fertilizer application. Tallest maize height of 71.26 cm was by application of 100% PM + 100% NPK and shortest in the control. At 8 WAS, shortest maize height was 50.35 cm recorded with the control and tallest height was recorded with 100% PM + 100% NPK. Significant difference existed among the treatments. At 10 WAS, tallest (134 cm) maize height was recorded with the application of 100% PM + 100% NPK and shortest (59.60 cm) maize plant height was recorded with control.

Table 3. Effects of combined poultry manure and NPK fertilizer application on maize plant height in Maiduguri, 2018.

Mean(s) followed by same letter(s) within a column are significantly not different according to Duncan Multiple Range Test (DMRT) at 5% level of probability

4.4 Effect of Poultry Manure and NPK Fertilizer on Number of Leaves per Plant

The mean effect of number of leaves as affected by application of PM and NPK fertilizers is presented in Table 4. At 2 WAS, significant difference ($P< 0.05$) was observed between control and 75% PM + 25% NPK only and the highest number of leaveswas observed with 75 % PM + 25% NPK while the lowest number of leaveswas observed with the control. At 4 WAS, significant ($P<0.05$) difference also exist between the treatments with the highest leaf number (7.66) observed with 100% NPK and lowest (5.00) with the control. At 6 WAS, significant difference was observed between control and the treatments. The highest number of leaves of 9.16 and the lowest number (6.16) were given by 100% NPK and control. At 8 WAS, significant difference was observed among the treatments. The highest leaf number of 10.66 was obtained with the application of 100% NPK while the lowest with value of 8.00 was recorded with the control. At 10 WAS, significant difference was also observed between control and some treatments. 100% PM +100 % NPK gave the highest number while the lowest (10.40) was observed with the control.

.Table 4. Effect of combined poultry manure and NPK fertilizer on number of leaves of maize plant in

Treatment	Plant height (cm) at				
	2 WAS	4WAS	6 WAS	8 WAS	10 WAS
Control	10.41^{cd}	18.28^{d}	23.36^{e}	50.35^{d}	59.60^{f}
100% PM	17.91^{a-c}	32.92^{a}	63.68^{ab}	96.98^{a}	126.07^{ab}
75% PM	14.80^{a-d}	24.28^{b-d}	43.78^{cd}	69.93^{b-d}	100.92^{c-e}
50% PM	14.51^{a-d}	23.95^{b-d}	46.83^{b-d}	69.37^{b-d}	100.38^{c-e}
25% PM	15.65^{a-d}	24.60^{b-d}	42.75^{cd}	66.50^{cd}	96.57^{de}
100% NPK	15.95^{a-d}	28.00^{bc}	56.85^{a-d}	84.80^{a-c}	116.50^{a-d}
75% NPK	15.51^{a-d}	27.91^{bc}	51.36^{b-d}	84.18^{a-c}	116.25^{a-d}
50% NPK	11.48^{b-d}	26.73^{b-d}	55.48^{a-d}	81.98^{a-c}	116.42^{a-d}
25% NPK	9.31^{d}	23.06^{cd}	44.66^{cd}	70.88^{b-d}	104.57^{b-e}
100% PM +100% NPK	19.41^{ab}	37.71^{a}	71.26^{a}	103.88^{a}	134.00^{a}
75% PM + 75% NPK	22.33^{a}	39.60^{a}	70.65^{a}	101.08^{a}	133.78^{a}
75%PM +25 %NPK	16.51^{a-d}	25.45^{b-d}	41.78^{c-e}	65.93^{cd}	95.97^{de}
25%PM +75%NPK	16.16^{a-d}	32.75^{ab}	60.13^{a-c}	90.50^{ab}	119.83^{a-c}
50%PM +50%NPK	10.33^{cd}	21.36^{cd}	39.18^{de}	61.13^{cd}	91.38^{e}
S. E ±	4.05	4.60	9.07	11.66	10.56

Maiduguri, 2018.

Mean(s) followed by same letter(s) within a column are significantly not different according to Duncan Multiple Range Test (DMRT) at 5% level of probability

Effect of combined application of poultry manure and NPK fertilizer on Leaf Area per Plant

The effects of PM and NPK fertilizer on leaf area of maize is presented in Table 5. Leaf area varied significantly (P<0.05) with different treatments applied. At 2 WAS, largest leaf area was 69.13 cm2 obtained with 100%PM + 100% NPK while the smallest leaf area was 17.33 cm2 obtained with the control. Highest leaf area was also recorded with 100% PM + 100% NPK and lowest observed with the control with values 38.00 and 126.70 cm2 respectively at 4 WAS. Significant difference was observed among the treatments. At 6 WAS, PM and NPK fertilizer applied significantly affected maize leaf area. Application of PM and NPK at 100% PM and 100 % NPK gave the highest leaf area of 253.40 cm2 while the lowest leaf area of 72.67 was obtained with the control. Treatments effect also varied significantly with applied rates of PM and NPK in sole and in combination on leaf area at 8 WAS with highest (506.67 cm2) leaf area observed with 100 % PM + 100 % NPK and the lowest (152.00 cm2) with the control. Maximum maize leaf area was recorded at 10 WAS where the highest leaf area was 1013.3 cm2 and the lowest was 304.00 cm2 recorded with 100 % PM + 100 % NPK and with the control treatments respectively.

Treatment	Number **of** leaves/ plant at				
	2 WAS	4WAS	6 WAS	8 WAS	10 WAS
Control	3.00^{b}	5.00^{c}	6.16^{c}	8.00^{b}	10.50^{c}
100% PM	3.83^{ab}	7.00^{ab}	8.50^{ab}	10.33^{a}	12.00^{ab}
75% PM	4.16^{ab}	7.16^{ab}	8.50^{ab}	9.83^{a}	11.83^{ab}
50% PM	3.83^{ab}	6.50^{b}	8.16^{ab}	10.00^{a}	12.33^{ab}
25% PM	4.00^{ab}	7.00^{ab}	8.50^{ab}	10.00^{a}	12.00^{ab}
100% NPK	4.33^{ab}	7.66^{a}	9.16^{a}	10.66^{a}	12.16^{ab}
75% NPK	4.16^{ab}	6.66^{ab}	8.33^{ab}	10.33^{a}	12.33^{ab}
50% NPK	2.83^{b}	6.16^{b}	8.16^{ab}	10.00^{a}	11.66^{a-c}
25% NPK	3.00^{b}	6.33^{b}	8.16^{ab}	9.66^{a}	11.16^{bc}
100% PM +100% NPK	4.33^{ab}	6.83^{ab}	8.66^{ab}	10.50^{a}	12.50^{a}
75% PM + 75% NPK	4.00^{ab}	7.16^{ab}	8.50^{ab}	10.33^{a}	11.83^{ab}
75%PM +25 %NPK	5.00^{a}	6.33^{b}	8.33^{ab}	9.83^{a}	11.33^{a-c}
25%PM +75%NPK	3.16^{ab}	6.33^{b}	7.66^{b}	9.83^{a}	11.66^{a-c}
50%PM + 50%NPK	3.16^{ab}	6.66^{ab}	8.00^{ab}	9.66^{a}	11.16^{bc}
S. E ±	0.93	0.50	0.61	0.67	0.62

Treatment	Leaf Area (cm^2)				
	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
0 % PM + 0 % NPK	17.333^{f}	38.000^{i}	72.667^{h}	152.00^{g}	304.00^{k}
100% PM	42.000^{cd}	79.300^{e}	184.00^{cd}	336.00^{d}	762.67^{de}
75% PM	37.500^{de}	74.667^{ef}	149.33^{f}	298.67^{e}	597.33^{gh}
50% PM	32.000^{e}	64.000^{g}	128.00^{g}	256.00^{f}	512.00^{i}
25% PM	18.333f	47.033^{h}	86.667^{h}	176.00^{g}	346.67^{j}
100% NPK	32.667e	72.000^{f}	151.33^{ef}	288.00^{e}	576.00^{h}
75% NPK	46.667^{bc}	92.000^{d}	168.00^{de}	371.33^{c}	736.00^{e}
50% NPK	38.667^{d}	77.333^{ef}	154.67^{ef}	309.57^{de}	618.67^{g}
25% NPK	19.000^{f}	38.000^{i}	76.000^{h}	152.00^{g}	304.00^{k}
100% PM +100% NPK	60.133^{a}	126.70^{a}	253.40^{a}	506.67^{a}	1013.3^{a}
75% PM + 75% NPK	58.667^{a}	117.53^{b}	234.67^{b}	442.67^{b}	938.67^{b}
75%PM +25 %NPK	56.000^{a}	111.82^{b}	238.00^{ab}	429.50^{b}	885.33^{c}
25%PM +75%NPK	48.667^{b}	97.333^{cd}	194.67^{c}	372.67^{c}	778.67^{d}
50%PM + 50%NPK	49.000^{b}	98.333^{c}	190.67^{c}	381.53^{c}	672.00^{f}
S. E ±	2.8655	3.0674	8.6337	14.212	20.557

Table 5. Effects of combined application of poultry manure and NPK fertilizer on leaf area of Maize in Maiduguri, 2018

Treatment	Fresh Root and Straw (g)		Dry Root and Straw (g)	
	Root	Straw	Root	Straw
Control	8.13[f]	49.93[f]	5.30[d]	13.66[b]
100% PM	61.30[a]	105.23[ab]	33.00[a]	21.26[ab]
75% PM	47.20[ab]	96.50[a-c]	23.13[a-c]	16.70[b]
50% PM	41.80[a-c]	87.90[a-d]	18.30[a-d]	21.00[ab]
25% PM	26.16[b-f]	84.73[a-d]	15.93[b-d]	19.66[ab]
100% NPK	25.90[b-f]	81.13[a-d]	15.26[b-d]	26.43[a]
75% NPK	22.86[c-f]	75.86[a-d]	14.23[b-d]	19.73[ab]
50% NPK	20.40[c-f]	74.76[a-d]	13.53[b-d]	16.23[b]
25% NPK	32.40[b-e]	68.43[a-d]	09.20[cd]	21.93[ab]
100% PM +100% NPK	62.50[a]	106.37a	33.53[a]	27.63[a]
75% PM + 75% NPK	37.96[b-d]	88.00[a-d]	19.30[a-d]	22.70[ab]
75%PM +25 %NPK	48.20[ab]	96.73[a-c]	26.26[ab]	26.50[a]
25%PM +75%NPK	15.86[d-f]	65.66[b-d]	7.93[cd]	21.06[ab]
50%PM + 50%NPK	11.96[ef]	62.03[cd]	6.33[d]	14.80[b]
S. E ±	11.31	19.69	7.99	4.73

Table 6: Effect of combined poultry manure and NPK fertilizer application on maize fresh and dry root and straw weight in Maiduguri, 2018.

Mean(s) followed by same letter(s) within a column are significantly not different according to Duncan Multiple Range Test (DMRT) at 5% level of probability

Effect of Poultry Manure and NPK Fertilizer application on Fresh and Dry Root and Straw Weight of Maize

The effects of PM and NPK fertilizer application on fresh and dry root and straw weight of maize is presented in Table 6. The weight of fresh and dry roots and straw were significantly ($P<0.05$) affected by combined PM and NPK fertilizer application. The highest fresh root weight was 61.30g obtained with 100% PM while the lowest fresh root weight was 8.13g recorded with the control. Significant difference was observed among the treatments with fresh straw weight. The highest fresh straw weight was obtained with application of 100% PM + 100% NPK with value of 106.37g and the lowest value of 49.93g in the control.

Dry root and straw weight was significantly ($P<0.05$) affected by PM and NPK fertilizer application. The highest dry root weight was observed with 100 % PM + 100 % NPK application with value of 33.53 g while the lowest dry root weight was recorded with the control with a value of 5.30 g. Highest dry straw weight was obtained with application of PM and NPK fertilizer at 100% PM + 100% NPK with a value of 27.63g while the lowest was recorded with the control (13.66g).

5.2 Effect of Poultry Manure and NPK Fertilizer on Plant Height, Number of Leaves and Fresh and Dry Matter Weight

Short plant height in the control plots were due to the depletion of nutrients over time; hence, plants exhibited stunted growth due to an inadequate supply of nutrients. The relatively taller plant height might be attributed to the gradual release of essential nutrients from the inorganic and PM fertilizers as needed by the maize plant. The results of this experiment confirms the findings of Saleem (2010) and Gonzalez *et al*., 2001 who reported that chemical fertilizer and organic manure, which were supplied as essential nutrients at the initial establishment stage, produced the best results for the measured parameters, such as plant height. Increase in plant height in response to applications of combined fertilizer is attributed to availability of N from both NPK and manure throughout the growing season. These results are in agreement with the findings reported by, who observed that, compared with control treatments, 50% poultry manure+50% chemical treatments resulted in the tallest corn plants in corn-legume cropping systems. The findings agrees with the result of Neni *et al*. (2016) who reported that treatment of 75 % inorganic fertilizer + 5 ton ha^{-1} organic fertilizer with magnitude of 217.60 cm and 17.24 sheets, respectively; whereas the lowest value of average crop height and the lowest leaf numbers was found on treatment of 0 % inorganic fertilizer + 5 ton ha^{-1} organic fertilizer with magnitude of 209.08 cm and 17.08 sheets, respectively. The results showed that combination of organic and inorganic fertilizers significantly increased the plant height than sole use of inorganic fertilizer and then that of organic manure. Combination of organic and inorganic fertilizers was found better by Meelu *et al*. (1991) in upland rice and Channabasavanna (2003) in wetland rice than only inorganic fertilizers. Biomass accumulation was increased significantly by using the poultry manure with the combination of NPK fertilizer. These findings are in line with Asai *et al*. (2009) who obseved that amendments of organic nature could help in improving the porosity and soil's water holding capacity which results in more root growth, this, in turn, enhances the nutrient uptake from soil and as a consequence enhance biomass production. These consequences are in agreement with those reported by Hardy *et al*. (2001) and El- Ghadban *et al*. (2002) on lemongrass. In this respect, it is possible that the favorable effect of PM on growth characteristics may be because of their capability to enhance soil physicochemical as well as microbiological characteristics of the soil.

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