



Response of maize (*Zea mays* L.) To organic and inorganic fertilization at Jega, Sudan Savanna, Nigeria

SA Abubakar¹, A Muhammad², H Yusuf³, ZG Ibrahim^{4*}

^{1,2}Department of Crop Science, Kebbi State University of Science and Technology, Aliero, Nigeria

³Department of Preliminary Studies, College of Science and Technology, Waziri Umaru Federal Polytechnic, Birnin-Kebbi, Kebbi State, Nigeria

⁴Department of Agricultural Science, Shehu Shagari College of Education Sokoto, PMB 2129, Sokoto State, Nigeria

Abstract

Field experiments were carried out during the 2015/2016 dry season at the Teaching and Research (*fadama*) farm of Kebbi State University of Science and Technology, Aliero, to study the effects of organic and inorganic fertilization on the performance of maize (*Zea mays* L.) at Jega, Sudan Savanna of Nigeria. Treatments consisted of six (6) soil amendments, each designed to supply the recommended dose of 120 kg N ha⁻¹ using a compound fertilizer NPK [15:15:15], farm yard manure (FYM) and six-month old poultry manure (PM) from an automated battery cage system. Result shows that plant height at 10 WAP, number of leaves, Leaf area index (LAI), Mean cob weight, grain weight per cob, 100-seed weight and Total yield were significantly increased when the recommended nitrogen dose of 120 kg N ha⁻¹ was applied using 100% NPK (800 kg NPK [15:15:15] ha⁻¹) or a combination of NPK and PM at 50:50 ratio. Based on the results of this study, it was concluded that the integration of organic and inorganic soil amendments in form of NPK compound fertilizer and poultry manure at 50:50 ratio could be adopted for higher Maize yield, considering the complimentary role of poultry manure in improving the physical quality of the soil.

Keywords: NPK fertilizer, poultry manure, farm yard manure, maize yield

1. Introduction

Maize (*Zea mays* L.) is one of the main cereal crops of West Africa. It ranks third after wheat and rice in terms of global importance [1]. It belongs to the family Poaceae (Graminae), commonly known as the grass family. It is a tall, monoecious annual grass with overlapping sheaths and broad conspicuously distichous blades [2]. Global production of maize is 785 million tons, with the largest producer the United States, producing 42%. Africa accounts for 6.5% of the global production. Nigeria is largest maize producer in Africa accounting for 15.68% of Africa's production. African imports 28% of their required maize from outside the continent [3]. The yield of maize however, varies from variety to variety, location to location and also depends on the availability of essential factors such as soil fertility status [4, 5]. About 80% of maize is consumed locally as food in various delicacies and as livestock meals. The remaining 20% is utilized industrially in the production of starch, oil, high fructose, corn sweetener and ethanol. Maize consist of 71% starch, 9% protein and 4% oil on a dry weight basis [6]. Among the major causes of low maize yield is low soil fertility and maize is termed as *heavy feeder* crop. Therefore, strategy toward improving soil fertility should be put in place for a successful maize production. This could be achieved through appropriate fertilizer scheduling and management [7]. Organic manure helps to improve soil structure, soil aeration, nutrient retention, water holding capacity and water infiltration [8, 9]. Nutrients contained in organic manures are released more slowly and are stored for longer period in the soil thereby ensuring long residual effect [10]. This slow nutrient release pattern by organic manures could be

complemented by mixing them with inorganic nutrients that ensures fast nutrient release to crops at the early stage before mineralization of organic manure [11]. This combination is termed organo-mineral fertilizer and has been utilized in the production of maize [2]. The integration of organic and inorganic sources of fertilizer not only supply essential nutrients but also have some positive interactions to increase efficiency and reduce environmental hazards [13, 11, 14].

Reports on the application of organo-mineral fertilizers to crop indicated a significant increase in yield [15, 16, 17]. Considering the cost, unavailability at the time needed and environmental effects of inorganic fertilizers in Nigeria, organic materials such as bio-digested slurry, poultry manure, green and farm yard manures were identified with the ability to enhance soil fertility as well as improve crop productivity and environmental quality [18].

This study was designed to determine the performance of maize in response to application of different combinations of organic and inorganic fertilizers.

2. Materials and methods

The experiment was conducted at the Fadama Teaching and Research Farm of the Kebbi State University of Science and Technology Aliero located in Jega (lat. 12° N 11' N; long. 4° 16' E) during the 2015/2016 dry season. The area lies within the Sudan Savanna agro-ecological zone of Nigeria. It is characterized with erratic and scanty rainfall that last for about 5 months (May-September) and a long dry period (October-April). The climate of the area is semi-arid with average rainfall of about 550-650mm per annum. The relative humidity ranges from 21- 47% and 51-79% during the dry and

rainy seasons, respectively. Temperatures average between 14 - 30°C during the dry season and 27 - 41°C during the rainy season [19].

The treatments consisted of six [6] soil amendments, each designed to supply the recommended dosage of 120 kg N_{ha}⁻¹ using NPK [15:15:15], FYM and six-month old PM from an automated battery cage system. Treatments consisted of 0 kg NPK ha⁻¹, 800 kg NPK (15:15:15) ha⁻¹, 100% FYM equivalent to 5 t ha⁻¹, 100% PM equivalent to 1 t ha⁻¹, 50% FYM plus 50% PM (2.5 t of FYM and 0.5 t of PM ha⁻¹), 50% NPK plus 50% FYM [400 kg NPK (15:15:15) ha⁻¹ and 2.5 t of FYM ha⁻¹], 50% NPK ha⁻¹ plus 50% PM [400 kg NPK (15:15:15) ha⁻¹ and 0.5 t of PM ha⁻¹], denoted as T0, T1, T2, T3, T4, T5 and T6, respectively. Compound fertilizer NPK [15:15:15] was used to supply the inorganic soil amendment.

The plot size was 3m x 4m (12m²). The soil and manure analysis results are presented in Tables 1 and 2, respectively. Manure result indicated that FYM contained about five times (14.98%) as much organic carbon as PM (3.99%), while nitrogen content of PM (7.08%) was about four times more than FYM (1.53%). P and K contents were relatively similar between the two manure types. In the field, manure was applied during land preparation (2 weeks before planting) according to treatments, after which the maize seeds were planted by direct sowing in the field at a spacing of 25 x 60 cm. Irrigation was done by surface irrigation method, where water was drawn from a tube-well using water pump machine and conveyed through the irrigation channels and distributed to the plots. Irrigation was carried out at 3 days interval. Weeding was done manually using hoe as at when necessary. The crop was harvested 90 days after planting when the cobs matured.

Data were collected on plants height, number of leaves per plant, number of cobs per plant and grain yield per plot, which was converted to per hectare. The data generated were subjected to analysis of variance (ANOVA) in accordance with [20]. The treatment means were separated using Least Significant Difference test at 5% level of significance.

3. Results and Discussion

Plant height

Plant height at 8 and 10 weeks after planting (WAP) showed a significant response to fertilizer application. However, fertilizer application did not affect plant height at 6 WAP significantly. At 8 and 10 WAP, PM produced the tallest plants (126.43 and 127cm, respectively) (Table 3). At 10 WAP, 100% NPK, 100%FYM, 100% PM and 50%NPK+50%PM produced 114.13, 105.98, 127.23 and 108.28 cm, respectively, which were significantly highest. Combination of NPK and FYM at 50:50 produced shorter plants though greater than the untreated control, which produced the least (68.83cm) plant height. The trend may be because of the high content of Nitrogen found in poultry manure, which increases in the course of meeting up with the required quantity of P and K. This is in line with (21), who noted a significant increase in average maize height upon increase in the application of manure.

Leaf Number

Treatments did not affect the number of leaves at 6 WAP (Table 3). However, at 8 and 10 WAP there was significant treatment effect on number of leaves. The highest number of leaves was recorded by treatments with 100% NPK, 100% PM and 50%NPK+50%PM followed by 100%FYM and 50%NPK+50%FYM; and the least number of leaves was in the untreated control. This could be viewed as a typical *genotype x environment* interaction whereby the control treatment missed the fertility environment and therefore produced the least leaf number. As reported by [22] that plots treated with inorganic fertilizers produced the highest amount of leaves due to quick release and availability of plant nutrients especially nitrogen.

Leaf Area Index (LAI)

Leaf Area Index (LAI) defined as the ratio of the total leaf area to the soil area occupied per plant is presented in Table 4. At 6 WAP, treatments with 100%PM and 100%FYM produced higher LAI than 50%NPK+50%FYM but at par with 100%NPK. The lowest LAI was produced by the untreated control. At 8WAP, all fertilizer and manure combinations gave similar LAI which was significantly greater than the untreated control. At 10WAP, 100%PM produced significantly the highest LAI than only 50%NPK+50%FYM, which was in turn higher than the untreated control. The high LAI recorded by PM could be attributed to its high nitrogen content, which resulted in increased vegetative growth and consequently produce more leaves. As reported by [23], that poultry manure played an important role in increasing LAI.

Mean cob weight (g)

PM produced the higher mean cob weight than all other treatments except 100%NPK. Which were at par. However, the untreated control gave the lowest mean cob weight than all the treatments. The trend may be because PM is capable of supplying macro and micronutrients such as N, P, K, S, Ca, Mg, Cu, Mn, Zn, Bo and Fe that are essential for growth and yield than the NPK fertilizer alone [24][25][26].

Grain weight per cob (g)

The highest grain weight per cob was produced by 100%NPK, 100%PM and 50%NPK+50%FYM, followed by 100%FYM and the untreated control (Table 5). This may be because of the ability of the plant to utilize fully the nutrients in their inorganic form while in the organic form the amount will take more time to mineralize and become available for utilization. According to [22] who reported a decrease in cob weight of maize obtained in the organic fertilizers compared with inorganic fertilizers and later showed increase depending on the rate of the fertilizer applied.

100-seed weight (g)

Treatments had significant effect on 100-grain weight (Table 5), where 100%PM produced the highest 100-grain weight, though at par with 100%FYM and 50%NPK+50%FYM, followed by 100%NPK and 50%NPK+50%PM. The least

100-grain weight was by the untreated control. The poultry manure as reported by (23) may also be because of the macro and micronutrient supply the trend.

Yield (t ha⁻¹)

According to result (Table 5) 100%NPK produced the highest yield which was statistically similar to 100%PM. This was followed by 50%NPK+50%FYM and 100%FYM. The least maize grain yield was obtained in the untreated control. This is in line with (25) who reported that yield of maize increases as NPK fertilizer was applied.

Table 1: Physical and chemical properties of soil at the experimental site during 2011/2012 dry season

Soil properties	2011/12
Ph	5.20
Organic C (%)	0.50
Total N (%)	0.07
P(mgkg ⁻¹)	0.57
Exchangeable cation Cmolkg⁻¹	
Ca	1.00
Mg	0.40
Na	1.04
K	0.77
Particles sizes (%)	
Sand	68.6
Silt	17.5
Clay	13.5
CEC (mol/kg)	4.48

Table 2: Results of chemical analysis of the manures Used during the experiment

Nutrient	Manure type	
	Farm yard manure	Poultry manure
Organic carbon (%)	14.98	3.99
N (%)	1.53	7.08
P (%)	0.27	0.46
K (mg/kg)	325.33	250.67
C:N	9.79	0.56
C:P	55.48	8.67

Table 3: Plant Height (cm) as affected by organic and inorganic fertilization during the 2011/12 dry season at Jega, Sudan savannah

Treatment	Plant height (cm)		
	6 WAP	8 WAP	10 WAP
Control	65.68	67.88 ^d	68.83 ^c
800kg NPK (15:15:15) ha ⁻¹	105.33	112.88 ^b	114.13 ^a
100% FYM	102.88	105.00 ^c	105.98 ^a
100% PM	124.33	126.43 ^a	127.23 ^a
50% NPK+50%FYM	93.90	98.33 ^c	99.50 ^b
50%NPK+50%PM	105.10	107.23 ^{bc}	108.28 ^a
LSD 0.05	Ns	6.96	22.70
CV (%)	-	14.67	14.50

Means followed by same letter(s) within the same treatment group are not significantly different at the 5%

Table 4: Leaf Number as affected by organic and inorganic fertilization during the 2011/12 dry season at Jega, Sudan savanna

Treatment	Leaf Number		
	6 WAP	8 WAP	10 WAP
Control	9.75	10.75 ^c	12.25 ^c
800kg NPK(15:15:15)/ha	11.75	14.25 ^a	15.75 ^a
100% FYM	11.25	12.00 ^b	13.00 ^b
100% PM	11.75	13.75 ^{ab}	14.75 ^{ab}
50% NPK+50%FYM	11.25	12.00 ^b	13.00 ^{bc}
50%NPK+50%PM	11.00	13.25 ^{ab}	14.75 ^{ab}
LSD 0.05	1.88	2.24	2.09
CV (%)	6.85	5.30	5.36

Means followed by same letter(s) within the same treatment group are not significantly different at the 5%

Table 5: Leaf Area index (LAI) as affected by organic and inorganic fertilization during the 2011/12 dry season at Jega, Sudan Savannah

Treatment	Leaf Area Index (LAI)		
	6 WAP	8 WAP	10 WAP
Control	1.56 ^c	1.80 ^b	2.01 ^c
800kg NPK(15:15:15)/ha	2.23 ^{ab}	2.81 ^a	3.10 ^{ab}
100% FYM	2.89 ^a	2.31 ^b	2.67 ^{bc}
100% PM	2.89 ^a	3.39 ^a	3.65 ^a
50% NPK+50%FYM	2.06 ^b	2.61 ^a	2.88 ^b
50%NPK+50%PM	2.32 ^{ab}	2.92 ^a	3.40 ^{ab}
LSD 0.05	0.66	0.80	0.60
CV (%)	19.81	20.04	13.56

Means followed by same letter(s) within the same treatment group are not significantly different at the 5%

Table 6: Mean cob weight, grain weight, 100 seed weight and total yield of maize as affected by organic and inorganic fertilization during the 2011/12 dry season at Jega, Sudan savannah

Treatment	Mean cob weight (g)	Grain weight per cob (g)	100-seed weight (g)	Yield (tha ⁻¹)
Control	26.25 ^c	12.28 ^c	15.10 ^c	0.78 ^c
800kg NPK(15:15:15)/ha	59.00 ^{ab}	30.98 ^a	16.40 ^{bc}	1.99 ^a
100% FYM	52.25 ^b	20.70 ^{bc}	17.10 ^{ab}	1.26 ^{bc}
100% PM	66.75 ^a	29.95 ^a	18.90 ^a	1.84 ^{ab}
50%NPK+50%FYM	52.25 ^b	22.62 ^{ab}	17.90 ^{ab}	1.39 ^b
50%NPK+50%PM	54.00 ^b	25.71 ^a	16.60 ^{bc}	1.58 ^{ab}
LSD 0.05	12.13	9.70	2.14	0.60
CV (%)	15.54	27.08	8.34	27.02

Means followed by same letter(s) within the same treatment group are not significantly different at the 5%

4. Conclusion

Inorganic (NPK) fertilizer treatment produced the highest yield in tons per hectare which was comparable to poultry manure and the combination of both poultry manure and the NPK fertilizer. Similarly, NPK fertilizer produced the highest leaf number and grain weight per cob (g), while poultry manure produced the tallest plants and leaf area index (LAI). Based on findings of this study, it could be concluded that the use of poultry manure or NPK fertilizer alone or the combination of both could increase maize production.

5. Recommendation

Based on the results of this experiment, it is recommended

that, farmers in the study could combine NPK and PM at 400 kg NPK (15:15:15) ha⁻¹ and 0.5 t of PM ha⁻¹ for high maize yield. This combination, in addition to increasing yield, it improves the soil physical properties such as soil structure and water holding capacity, as well as reduces production cost by reducing the use of expensive inorganic fertilizer with the additional advantage of ensuring environmental health.

6. References

- Rouannent G. The tropical Agriculturist Ed: Rent caste, Macmillan Publisher Ltd, Malaysia, 1987, 102.
- Destovic D. Cereal crops in tropical regions of the third world, 2001, 23-45.
- IITA. Cereals Crops in Tropical Africa. International Institute of Tropical Agriculture Manual Series No. 7 Ibadan, Nigeria, 2012.
- Adediran JA, Banjoko VA. Response of Maize to Nitrogen, Phosphorus and Potassium fertilizers in the savannah zone of Nigeria. *Commun. Soil Sci. Plant Anal.* 1995; 26:593-606.
- Shanti KVP, Rao MR, Reddy MS, Sarma RS. Response of Maize (*Zea mays* L.) hybrid and composite to different levels of Nitrogen. *Indian J Agric. Sci.* 1997; 67:424-425.
- Onuk EJ. Introduction to *Zea mays* L, 2010, 12-15.
- Buresh RJ, Sanchez PA, Calhoun F. Replenishing soil fertility Africa. SSSA Spec. Publ. 51. SSSA and ASA, Madison, WI, 1997.
- Akinrinde EA, Olubakin DA, Omoloso SO and Ahmed AA *Agric J*, 2006; 1(2):96-103.
- Deksissa T, Short I, Allen J. In: Proceeding of the UCOWR/NIWA Annual Conf: Int'l Water Resources Education; Durham, NC, 2008.
- Sharma AR, Mitra BN. Effect of different rates of application of organic and nitrogen fertilizers in rice-based cropping system. *Journal of Agricultural Science (Cambridge)*. 1991; 117:313-318.
- Khaliq T, Mahmmod T, Kamel J, Masood A. *Int'l. J. Agric. Biol.* 2004; 6(2):260-263.
- Srihar MKC, Adeoye GO. Organomineral fertilizers effects on the performance of sweet maize (*Zea mays* L. *saccharata* strut.) in south eastern rainforest zone of Nigeria, 2003, 54-61.
- Ahmad N, Rashid M, Vaes AG. NFDC. 1996, 142-149.
- Uwah DF, Eneji AE, Eshiet UJ. Organic and mineral fertilizers effects on the performance of sweet maize (*Zea mays* L. *saccharata* strut.) in the South-eastern rainforest zone of Nigeria, 2011, 54-61.
- Ahmed S, Naz SY, Raja MR. Effects of farm yard manure, crop residues and mineral fertilizers on wheat yield under rainfed conditions. *Pakistan Journal of Soil Science.* 1998; 1:1-2.
- Jardoon MA, Bhatti AK, Khan F and Sahibzada QA. Effects of farm yard, manure and soil physical properties. *Pakistan Journal of Soil Science.* 2003; 22:47-55,
- Kiani MJ, Abbas M, Rahim N. Use of organic manure with mineral N fertilizer increases wheat yield at Rawakalot Azad jammu and kashim. *Archives of Agronomy and Soil science.* 2004; 51:299-309.
- Santhi R, Natesan R, Selvakumari G. *Indian Journal of Agricultural Research.* 2005; 39(3):213-216.
- Nigerian national news. A new report by Nigerian national news (NNN). nnn.com.ng, 2012.
- Gomez KA, Gomez AA. *Agriculture research* (2nd Edition). John Willey and sons, New York, 1984, 680.
- Obi ME, Ebo PO. *Bioresource technol.* 1994; 51(2-3):117-123.
- Hussain IT, Mahmood A, Ullah A and Ali A. Effects of nitrogen and sulphur on growth, yield and quality of hybrid maize. *Zea mays* L. *Pakistan J. Biol. Sci. (PJBS)*. 1999; 2(3):637-638.
- Agyenim SB, Zickermann J, Kornahrens M. Poultry Manure effect on Growth and yield of maize. *West Africa Journal of Applied Ecology*, 2006, 12-18.
- Stephenson AH, McCaskey TA, Ruffin BG. A survey of broiler litter composition and potential value as a nutrient resource. *Biological wastes.* 1990; 34:1-9.
- Oladotun AO. *Managing Manure as a fertilizer*, Saskatchewan, Agriculture, food and Rural Revitalization, 2002, 5.
- Agele SO. Growth and yield of tomato grown on degraded soil amended with organic wastes. *Proceedings of the 35th Conference of the Agricultural Society of Nigeria.* Sept. 16-21 University of Agric. Abeokuta, Nigeria, 2001, 159-164.