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Yield response of maize to organic and inorganic fertilizer in Bauchi, Nigeria.

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Abstract
This research work was carried out at the Teaching and Research Farm of Abubakar Tafawa Balewa University, Gubi campus, Bauchi, Nigeria in 2013 and 2014 cropping season to ascertain the yield of hybrid maize (Zea mays L.) using cattle manure, poultry manure and inorganic fertilizer at three levels each. These were laid out in a randomized complete block design (RCBD) and replicated three times. The result obtained revealed that the number of days to first tasseling decrease as these treatment level increase. Poultry manure was found to have significant effect ($P \leq 0.05$) on all the parameters recorded and in both years of study. Cattle manure on the other hand did not have any significant effect on the crop throughout the sampling periods of study. Inorganic fertilizer was significant ($P \leq 0.05$) on number of days to first tasseling, leaf area index and cob weight in 2014 and on shoot weight in both years. The highest grain yield of 4.43t/ha and 5.97t/ha in 2013 and 2014 respectively was obtained when 10t/ha poultry manure level was applied, though it was statistically similar to when 5t/ha of the treatment was used. The least mean value for grain was found in the control. Based on results obtained from this study, 5t/ha poultry manure was recommended for optimum yield of hybrid maize in the study area.

Key Words: *Gubi, cattle manure, poultry manure, manure, N.P.K: 20: 10: 10., hybrid maize.*

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I. Introduction

Maize (*Zea mays L.*) is an important cereal ranks among the world's three most important cereals and a major staple food in many countries of the world (FAO, 2003). Maize is a major source of food for many people in the world and are also palatable livestock feeds (Agbato, 2003., Dutt, 2005), it can grow on a wide range of soils, however, optimum production can be obtain on a well drain loamy soil with a pH of 5.5 to 7.0 and rainfall between 500 to 800 mm per annum depending on the variety (FAO, 2012) because different cultivars have varying water requirement and crop water use efficiencies (Asare *et al.*, 2011). Hegde (1998) reported that locally available organic manures can be use to replace or minimized the use of costly chemical fertilizers in order to sustains the soil productivity or integrated use of organic and inorganic fertilizer to meet the nutritional needs of crops.

Akongwubel *et al*. (2012) observed an increased in the vegetative growth characteristics of maize in all plots receiving poultry manure application than the control treatment with the tallest plants obtained in plots treated with 20 t/ha of poultry manure. Similarly, in a field trial to determine the effect of poultry manure levels on the productivity of spring maize, results obtained revealed that 12t/ha level of poultry manure significantly produced highest grain yield (Farhad *et al.*, 2009; Boateng *et al.*, 2005).

Inorganic fertilizer on the other hand have high concentration of nutrients and readily available for plants in conventional agriculture but its use is limited for its high cost inaccessibility to majority of poor resource farmers in developing country like Nigeria (Webber *et al.*, 2001). In Nigeria, the guinea savannah ecological zone has been reported to have the greatest potential for maize cultivation but have been constraint by the inherent low fertility status of most soil where optimum production can only be obtain with adequate fertilizer application (Osundare, 2008). Tankou (2004) therefore suggested searching for soil fertility improvement techniques such as the use of organic and inorganic fertilizers. Hence, the need for this study.

II. Materials And Methods

Experimental Site

The experiments were conducted during the rainy seasons of 2013 nd 2014 at the teaching and research farm of the Faculty of Agriculture, Abubakar Tafawa Balewa University at Gubi campus, Ganjuwa Local Government area of Bauchi State, Bauchi Nigeria. Bauchi is found in the northern guinea savanna zone of Nigeria.

The total amount of rainfall in 2013 during the growing period of the maize plants from July to October was 1516.7 mm; while during the period in 2014 was 936.4 mm (Table 1). Furthermore, the rainfall in 2013 was not well spread because it rained from May to October but well spread in 2014 with rainfall from February to October (Table 1).

Physical and Chemical Properties of Soil, Cattle Manure and Poultry Manure

Soil samples were collected from the experimental sites at a depth of 0–15cm and 15–30 cm using a soil auger after ploughing the land. The soil samples were analyzed to determine soil type and fertility level of the soil (Table 2). Cattle and poultry manure used for the experiment were similar subjected to laboratory analysis to determine their elemental compositions (Table 3)

3.4 Treatments and Experimental Design

The experiment consisted of three factors: Cattle manure (CM), Poultry manure (PM) and Inorganic fertilizer (IF) each at three levels. Therefore, there was 3 x 3 x3=27 or 3^3 treatment combinations laid out in a randomized complete block design with three replications.

Cultural practices

The land was ploughed using a disc plough and harrowed manually to give a fine tilt before the seeds were sown on 13th July, 2013 and on 6th July, 2014. The ploughed land was demarcated into plots of 2.5m x 1.5m ($3.75m^2$) each using pegs. A discard of two metres was used to separate one block from the other while one metre discard was used to separate one plot from the other. The inter row spacing was 75cm while the intra row spacing was 25cm giving a population of 20 maize plants per plot or 53,333 plants per hectare. This spacing was based on the recommendation of Iken and Anusa (2004). Seeds were sown on the flat plot.

Weeding was done manually two times, at three and six weeks after sowing (WAS) harvesting was carried out on 20 November, 2013 and 14 November, 2014 (19 WAS) when the crops had reached physiological maturity. This was noticed when the point of attachment to the cobs showed black spots and shoots were fully dried.

Data Collection and Analysis

Data was recorded on the yield and yield components viz: number of days to first tasselling, leaf area index, shoot weight per plot, grain yield (weight of grains) in tonnes per hectare (t/ha), weight of 100 grains and weight of cobs per plant.

The data collected during the research were subjected to analysis of variance using minitabsoftware. Means that were statistically significant were separated using the least significant difference (LSD) as described by Steel and Torrie (1987).

III. Results

Physical and Chemical Properties of Soil at the Experimental Site in 2013 and 2014

Particle size distribution of the soil at the experimental site at 0–15 and 15–30 cm depths in 2013 and 2014 are presented in Table 2. The percentage of sand was higher at 0– 15 cm than at 15–30 cm depth in both years. Texture of the experimental sites was sandy clay.

The chemical properties of soil of the experimental site are also presented in Table 2. The pHw at 15–30 cm depth was lower than the pH at 0–15 cm depth. Organic carbon, total nitrogen, available phosphorus, calcium, magnesium, potassium, cation exchange capacity, copper, iron and manganese had lower values at 15–30 cm depth than at 0–15 cm depth. Sodium and zinc had higher values at 15–30 cm depth than at 0–15 cm depth in 2013. Organic carbon, total nitrogen, available phosphorus, calcium, magnesium, potassium, sodium, cation exchange capacity, zinc and copper had lower values at 15–30 cm depth than at 0–15 cm depth while iron and manganese had higher values at 15–30 cm depth in 2014 (Table 2).

Chemical Analysis of CM and PM used for the Study in 2013 and 2014

PM had higher values than the CM in 11 of the characters listed in Table 3 in both 2013 and 2014. PM had only slightly lower mean value in pH than that of CM in both years.

Days to first tasseling: CM had no significant effect ($P\leq0.05$) on number of days to first tasseling while PM had significant effect ($P\leq0.05$) on the number of days to first tasseling and in both years. IF had significant effect ($P\leq0.05$) on number of days to first tasseling and in 2014. The control tasseled late while those fertilized with treatments tasseled earlier (Table 4).

Leaf area index: CM had no significant effect ($P\leq0.05$) on leaf area index while PM had significant effect ($P\leq0.05$) on leaf area index, similarly, IF was significant on leaf area index in 2014. Leaf area index increase as the treatment level increase (Table 4). The highest value of leaf area index was obtained when optimal treatment levels were applied.

Shoot weight: PM and IF had significant effect (P≤0.05) on the shoot measured per plot while CM had no significant effect (P≤0.05). Shoot weight per plot increase as the treatment level increase. The highest mean value for shoot weight was obtained when 400kg/ha IF level was used (Table 4).

Grain yield: PM treatment was highly significant (P≤0.05) on grain yield and in both years of study while CM and IF had no significant effect (P≤0.05) on the crop. The highest grain yield of 4.43 t/ha and 5.97 t/ha was obtained in 2013 and 2014 respectively when 10t/ha PM level was applied. The least mean value was found in the control plot where no treatment was applied. The total grain yield increase as treatment level increase (Table 4).

100 grain weight: The same trend observed on gain yield was also observed on 100 grain weight except that PM had no significant effect (P≤0.05) on grain weight in 2014 (Table 4)

Cobs weight: CM had no significant effect (P≤0.05) on cob weight while PM had significant effect (P≤0.05) on cob weight throughout the sampling period. IF had significant effect (P≤0.05) on cobs weight only in 2014 (Table 4). Cob weight per plant increase as treatment level increase.

IV. Discussion

Days to first tasseling: treatments applied was found to decrease the number of days to first tasseling. This could be attributed to nutrients found in these treatments which enhanced early tasseling of the crop. The non-significant effect of CM on this parameter could be due to differences in the rate of mineralization and release of nutrients in CM as reported by Lekasi, *et al.* (2005). PM is most likely to mineralize quickly and release nutrients for plants than CM. Nutrients in PM are found to be the highest among different sources of organic manures and are supplied in readily available form (Omosore, *et al*., 2009). The nitrogen in IF have been reported to be readily available to plants than (Abiola and Aiyelaagbe, 2005) and this could probably be responsible for its significant effect in 2014.

An increase in leaf area index as treatment level increase is an indication of available nutrients found in the treatment applied. Leaf area index increased implies that the photosynthetic area of the leaf also increases. The significant increase due to application of PM or IF could be attributed to availability of nutrients in PM and IF as earlier advanced for days to first tasseling. This agreed with the work of Boateng *et al*. who discovered the highest leaf area index when 6t/ha poultry manure level was used.

Shoot weight: Among the different treatments applied, only PM was found to significantly influence the shoot of this crop throughout the sampling period. Shoot weight per plot increase the treatment level increase with the highest shoot weight obtained when the highest level of PM was used is an indication that nutrients in PM are readily available to the crop as reported by Omosore *et al.* (2009). An in shoot weight as PM treatment increase up to the highest level conformed to the work of Ayodele (1993) who reported that crop respond to fertilizer based on the quantity applied. The end product of physiological and morphological development in maize is the grain yield. The significant effect (P≤0.05) of grain yield due to application of PM is in harmony with the work of Tambone *et al.* (2007) which indicates that application of PM increase the growth and production of maize. Similar result reported by Lombin *et al.* (2009) states that among all organic manures, PM was found to have high nutrients and are readily available for plant use. The application of 5 or 10 t/ha PM was found to be statistically similar; this could be due to balance in nutrients supplied during the grain filling period. This implies that 5t/ha PM was better alternative than 10t/ha PM on maize probably due to decreasing returns.

The highest level of IF (400kg/ha) gave the highest mean value of cob weight which was significantly (P≤0.05) higher than the control but statistically the same as the use of 200kg/ha. Similar trend was also observed for PM. The significant effect (P≤0.05) observed with PM application throughout the sampling period could be attributed to the availability of nutrients found in PM analyzed before the start of this study.

significant interaction of CM x PM was observed on days to first tasseling and 100 grain weight in 2013 and on shoot weight and grain yield in both years and only on cob weight in 2014. PM x IF interaction was significant (P≤0.05) on days to first tasseling and grain yield in both years and on cob weight in 2014 only. CM x IF interaction was significant (P≤0.05) on leaf area index, grain yield and cob weight in 2014 is in conformity with similar work conducted by Ekesiobi *et al.* (2015) which revealed a significant growth and yield performance of maize with the application of 10t/ha poultry manure combined with 75kg/ha urea.

V. Conclusion

The result obtained in this study revealed several points of interest. Poultry manure was found to be the most valuable for optimum production of maize in this area. Poultry manure was significantly higher than the control and this was true throughout the sampling period. On the other hand, cattle manure was not significant on any of the parameters recorded and in both years. Inorganic fertilizer was significant on some of the parameters recorded and in 2014, it was only significant on shoot weight per plot in 2013. Based on the results obtained, 5t/ha poultry manure which was statistically similar to 10t/ha of the treatment was recommended for optimum growth of the crop in this ecological zone.

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Table 1: Meteorological data covering the experimental period in 2013 and 2014.

	2013			2014		
Month	mean Total Rainfall (mm)	mean monthly temperature (O^C)	monthly relative humidity (%)	mean Total rainfall (mm)	mean monthly temperature (O^C)	monthly relative humidity (%)
January	0.0	25.1	21	0.0	25.6	33
February	0.0	28.0	18	16.8	26.6	18.0
March	0.0	33.7	20	1.6	31.4	26.0
April	41.7	32.4	42	17.4	32.6	41.0

May	61.9	30.3	53	170.5	29.7	57.0
June	171.0	27.8	62	253.0	28.5	61.0
July	569.0	25.9	71	347.0	26.9	69
August	707.0	24.7	77	376.6	26.0	72
September	126.0	26.8	69	197.6	26.6	71
October	114.7	28.5	49	15.2	28.8	54
November	0.0	30.1	23	0.0	28.6	33
December	0.0	26.3	33	0.0	24.4	20

Source: Nigerian Meteorological Agency.

Table 1: Physical and chemical properties of soil at the experimental site in 2013 and 2014 cropping seasons.

Physical properties	**2013**		**2014**	
	Depth of soil sample		**Depth of soil sample**	
Distribution of particles	0 – 15cm	15 – 30cm	0 – 15cm	15 – 30cm
Sand %	62.40	60.40	64.40	62.40
Silt %	9.28	9.28	5.28	6.28
Clay %	28.32	30.32	30.32	31.33
Soil Texture	sandy clay	sandy clay	sandy clay	sandy clay
Chemical Properties				
pHw (1:1)	6.45	5.92	6.23	5.66
pHc (1:2)	5.25	5.06	5.17	4.59
Organic Carbon (gkg^{-1})	0.83	0.42	0.81	0.52
Total Nitrogen (gkg^{-1})	0.07	0.05	0.10	0.07
Available Phosphorus ($mgkg^{-1}$)	6.25	5.35	7.20	4.54
Calcium (cmol (+)kg^{-1})	2.98	2.16	2.59	2.03
Magnesium (cmol (+)kg^{-1})	0.75	0.55	0.83	0.53
Potassium (cmol (+)kg^{-1})	0.21	0.18	0.26	0.17
Sodium (cmol (+)kg^{-1})	0.19	0.20	0.16	0.20
Cation Exchangeable Capacity (cmol (+)kg^{-1})	4.63	4.06	4.06	3.64
Zinc ($mgkg^{-1}$)	0.21	0.23	0.18	0.09
Copper ($mgkg^{-1}$)	0.17	0.16	0.13	0.06
Iron ($mgkg^{-1}$)	9.26	7.88	7.68	9.68
Manganese ($mgkg^{-1}$)	13.84	17.25	18.11	21.06

Table 2: Chemical analysis of cattle manure and poultry manures used for this study in 2013 and 2014

Parameters	**2013**		**2014**	
(Chemical Properties)	**Cattle manure**	**Poultry manure**	**Cattle manure**	**Poultry manure**
pHw	7.13	6.84	7.42	6.75

Nitrogen (%)		1.65		3.82		1.73		3.41
Organic carbon (%)		28.16		30.25		28.94		31.09
Phosphorus (gkg^{-1})		10.74		12.92		11.44		12.86
Calcium (gkg^{-1})	3.24		28.01		3.75		29.13	
Magnesium (gkg^{-1})		0.34		0.87		0.53		1.06
Potassium (gkg^{-1})	0.74		1.84		0.62		1.75	
Sodium (gkg^{-1})	0.54		2.45		0.49		2.22	
Zinc ($mgkg^{-1}$)		32.80		78.11		31.42		69.57
Copper ($mgkg^{-1}$)	21.78		42.53		19.82		38.11	
Iron ($mgkg^{-1}$)		6.10		15.63		7.55		19.26
Manganese ($mgkg^{-1}$)		22		18.01		4.77		18.88

Table 49: Effect of Treatments and their Interaction for Days to First Tasselling, Leaf Area Index, GY/P= grain yield (t/ha); 100GW= 100 grains weight; CW/P=cobs weight per plant 2013 and 2014.

Treatments	DFT	LAI	ShW/pt	GY(t/ha)	100GW	CW/p
Cattle manure (t/ha)						
0	59.15(53.59)	0.18(0.27)	1.17(4.18)	3.46(5.12)	18.15(21.33)	17.85(36.65)
5	58.33(51.93)	0.19(0.31)	1.23(4.24)	4.05(5.65)	19.70(21.44)	18.92(38.78)
10	57.48(51.74)	0.20(0.30)	1.25(4.33)	3.81(5.12)	20.45(21.52)	19.84(35.48)
SE±	0.455(0.610)	0.004(0.009)	0.064(0.207)	0.147(0.193)	0.488(0.578)	0.814(1.744)
Poultry manure (t/ha)						
0	60.52(55.15)	0.17(0.25)	0.93(3.65)	2.95(4.21)	17.59(19.74)	15.25(31.05)
5	57.44(51.30)	0.20(0.31)	1.31(4.22)	3.93(5.70)	20.00(21.63)	19.45(39.46)
10	57.00(50.82)	0.20(0.32)	1.41(4.88)	4.43(5.97)	20.71(22.93)	21.70(40.41)
LSD (0.05)	1.191(1.889)	0.016(0.034)	0.195(0.512)	0.495(0.582)	1.775 –	2.678(4.017)
SE	– –	– –	– –	– –	–	(0.578) – –
Inorganic fertilizer (kg/ha)						
0	59.34(54.19)	0.18(0.27)	1.06(33.67)	3.68(4.96)	19.11(21.04)	17.93(32.58)
200	58.63(52.08)	0.19(0.30)	1.21(4.09)	3.81(5.33)	19.26(21.56)	17.81(37.56)
400	56.99(51.00)	0.20(0.31)	1.39(5.00)	3.83(5.60)	19.37(21.70)	20.67(40.78)
LSD (0.05)	– (1.889)	– (0.034)	0.195(0.515)	– –	– –	– (4.017)
SE±	0.455 –	0.004	– –	0.488(0.193)	0.814(0.578)	– –
Interaction						
CM x PM	*(NS)	NS(NS)	*(**)	*(***)	*(NS)	NS(**)
PM x IF	**(*)	NS(NS)	NS(NS)	*(***)	NS(NS)	NS(**)
CM x IF	NS(NS)	NS(*)	NS(NS)	NS(*)	NS(NS)	NS(***)
CM x PM x IF	NS(NS)	NS(NS)	NS(NS)	NS(NS)	NS(NS)	NS(NS)

DFT = number of days to first tasseling; LAI = leaf area index, ShW/pt= shoot weight per plot, GY/P= grain yield (t/ha); 100GW= 100 grains weight; CW/P=cobs weight per plant.