Journal of
Journal of Advances in Agronomy and Crop Science

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Research Article Open Access

The growth of Maize (Zea mays L.) as Influence by Organic and Minerals Fertilizer in Bauchi, Nigeria

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Received Date: July 15, 2023 **Accepted Date:** **August 15,** 2023 **Published Date:** **August** 18, 2023

Citation: Damiyal DM, Sheriff HH, Ali S, Waziri A, Mamzing D (2023) The growth of Maize (Zea mays L.) as Influence by Organic and Minerals Fertilizer in Bauchi, Nigeria. J Adv Agron Crop Sci 2: 1-10

Abstract

The experiments were carried out 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. The experiments were conducted during the rainy seasons of 2013 and 2014 aimed at investigating the effect of cattle manure, poultry manure and inorganic fertilizer on the growth of hybrid maize. The objectives of this study have been achieved as significant differences were observed among the treatment applied. In 2013, the highest number of leaves per plant (13.05), taller plants (189.85cm) and thicker stems (3.44cm) were obtained when 10t/ha PM was used and these were significantly (P≤0.05) higher than the control. On the other hand, in 2014, inorganic fertilizer was found to produce higher leaf number (14.86) per plant, taller plants (219.27cm) per plant and thicker stem (2.96cm) per plant and were significantly (P≤0.05) higher than the control. It is of interest to discover that CM, PM and IF applied induce early tasseling in maize while the control plots tasseled late. The leaf index and first node with ear increase as the treatment level increased. It was therefore concluded 10t/hapoultrymanure or 400kg/ha inorganic fertilizer may be used for optimum vegetative growth of maize.

Keywords: Organic; Mineral Fertilizer; Maize

Introduction

Maize in a major staple crop that provides feeds for livestock and raw materials for industries. Maize is consumed in a variety of ways, it can be roasted, cooked, fried or grounded in flower [1]. In order to meet up this demand, maize production need to increase from year to year [2]. reported that maize production increase from 7.4 mollion tons in 2009 to 10.3 million tons in 2013. The inherent low fertility status of most tropical soils have posed a major constraint to the production of crops particularly maize which is a heavy feeder crop [3]. The guinea savannah ecological zone in Nigeria have the greater potential for maize production, unfortunately, these areas have been reported to be deficient in native nitrogen and available phosphorus, thus, this have necessitated the need for fertilizer sources to sustain the productivity of crop in this region [4]. The steady increase in the price of inorganic fertilizer every season makes the product unaffordable to peasant farmers in sub-saharan Africa. Therefore, they resorted to organic manure as a means of fertilizing their crop. This study was conducted with a view to ascertain the manure rate as an alternative for inorganic fertilizer in order to enhance productivity of maize in the study area.

Materials and Methods

Experimental Site: The experiments were carried out 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. The experiments were conducted during the rainy seasons of 2013 and 2014. The experimental site is located at Latitude 10o281 North and Longitude 09o491 East and situated at 600 metres above sea level. Bauchi is found in the northern guinea savanna zone of Nigeria.

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. Cattle and poultry manure used for the experiment were similarly subjected to laboratory analysis to determine their elemental compositions. The following physical and chemical properties were determined in the laboratory: percentage of sand, silt and clay; pHw, pHc, Organic carbon, total nitrogen, available phosphorus, calcium, magnesium, potassium, sodium, cation exchange capacity, zinc, copper, iron and manganese.

Experimental Materials: Three experimental materials: Cattle manure (CM), Poultry manure (PM) and Inorganic fertilizer (IF) were used for the research. Cattle and poultry manure were obtained from the Abubakar Tafawa Balewa University farm while the inorganic fertilizer NPK (20:10:10) was bought from Bauchi market and seeds of hybrid maize (Oba Super 2) obtained from premier seed company of Nigeria. were used.

Treatments and Experimental Design: Three experimental materials: Cattle manure (CM), Poultry manure (PM) and Inorganic fertilizer (IF) each with three levels were used for the research. Therefore, there was 3 x 3 x3=27 or 33 treatment combinations. These were laid out in a randomized complete block design with three replications.

Land Preparation and Planting: 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 (3.75m2) 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 [17]. Seeds were sown on the flat plot.

Treatment application: The treatments were measured in grammes (g) using a weighing scale, then thoroughly mixed and broadcast on the flat plot where it was mixed with the soil and left for three days before sowing.

Weeding

Weeding was done manually two times, at three and six weeks after sowing (WAS).

Harvesting

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

Growth parameters were taken on number of leaves, plant height and stem diameter per plant at 2, 4, 6, 8, and 10 weeks after sowing (WAS), similarly, leaf area was also measured and leaf area index calculated. First node with ear, number of days to

first tasselling and the number of days to 50% tasselling were also ascertain as yield attributes.

Data Analysis

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 [18].

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 1. 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 1. 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 1).

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

Physical properties	**2013**		**2014**	
	Depth of soil sample		Depth of soil sample	
Particle distribution	0 -15 cm	15 – 30 cm	0 -15 cm	15 – 30 cm
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 exchange 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 and poultry manure 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

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 2 in both 2013 and 2014. PM had only slightly lower mean value in pH than that of CM in both years.

Effect of Treatments on Number of Leaves per Plant at 2, 4, 6, 8 and 10 WAS in 2013 and 2014

There was significant difference (P≤0.05) among the means of CM levels in number of leaves per plant at 4, 6, 8 and 10WAS only in 2014 but significant differences (P≤0.05) were observed among the PM level means throughout the sampling period and in both years. There were no significant differences in number of leaves per plant among the IF levels except at 2 and 8WAS in 2013 but Significant differences (P≤0.05) in mean number of leaves among IF levels were observed throughout the sampling period in 2014 (Table 3). Leaf number per plant increased as treatment level increase. In 2013, the highest number of leaves per plant (13.05) was obtained when 10t/ha PM was used and these were significantly (P≤0.05) higher than the control and when 5t/ha PM applied. In 2014, 400kg/ha IF gave the highest leaf number (14.86) per plant (Table 3).

Table 3: Effect of treatment on number of leaves per plant at 2,4, 6, 8 and 10 weeks after sowing (WAS)

		Weeks After Sowing (WAS)				
Treatment	**Levels**	**2**	**4**	**6**	**8**	**10**
CM	0 t/ha	4.30 (4.66)	6.60 (8.78)	9.07 (11.74)	12.12 (13.76)	10.46 (12.55)
	5 t/ha	4.30 (4.68)	6.75 (9.39)	9.54 (12.36)	12.32 (14.77)	10.71 (12.83)
	10 t/ha	4.32 (4.72)	6.76 (9.15)	9.42 (12.00)	12.22 (14.24)	10.61 (12.65)
	LSD P≤ 0.05	NS (NS)	NS (0.320)	NS (0.452)	NS (0.481)	NS (NS)
PM	0 t/ha	4.18 (4.62)	6.29 (8.70)	8.84 (11.14)	11.21 (13.28)	10.09 (12.16)
	5 t/ha	4.34 (4.80)	6.92 (9.35)	9.51 (12.55)	12.40 (14.74)	10.62 (12.96)
	10 t/ha	4.40 (4.65)	6.91 (9.27)	9.67 (12.42)	13.05 (14.74)	11.22 (12.01)
	LSD P≤ 0.05	0.118 (0.152)	0.265 (0.320)	0.380 (0.452)	0.501 (0.481)	0.345 (0.345)
IF	0 kg/ha	4.19 (4.57)	6.60 (8.37)	9.10 (10.91)	11.94 (13.16)	9.88 (12.10)
	200/kg ha	4.26 (4.74)	6.65 (9.50)	9.36 (12.53)	12.07 (14.74)	10.88 (12.55)
	400/kg ha	4.47 (4.75)	6.68 (9.45)	9.56 (12.67)	12.65 (14.86)	11.17 (13.38)
	LSD P≤ 0.05	0.118 (0.152)	NS (0.320)	NS (0.452)	0.501 (0.481)	0.345 (0.345)

Effect of Treatments on Plant Height (cm) per Plant at 2, 4, 6, 8 and 10WAS in 2013 and 2014

Significant differences (P≤0.05) among the CM level means for plant height was detected only at 8 and 10WAS in 2014 while significant difference (P≤0.05) was observed among the PM level means throughout the sampling period and in both years with 5 and 10t/ha giving significantly (P≤0.05) taller plants than the 0t/ha application. Also, there were significant differences (P≤0.05) among the IF level means for plant height throughout the sampling period and in the two years of study except at 2 WAS in 2014 (Table 4). Taller plants (189.85cm) was obtained when 10t/ha PM was used and this significantly (P≤0.05) higher than the control in 2013 while in 2014, IF was found to produced taller plants (219.27cm) and were significantly (P≤0.05) higher than the control (Table 4).

Table 4: Effect of treatment on plant height per plant at 2,4, 6, 8 and 10 weeks after sowing (WAS)

		Weeks After Sowing (WAS)				
Treatment	**Levels**	**2**	**4**	**6**	**8**	**10**
CM	0 t/ha	8.26(8.25)	19.84(29.17)	47.51(65.63)	104.67 (151.22)	162.67 (199.09)
	5 t/ha	8.61(8.45)	20.97(30.77)	50.84(72.02)	111.99 (171.61)	181.12 (213.34)
	10 t/ha	8.61(8.31)	20.71(30.21)	50.56(70.66)	117.83 (165.74)	173.43 (209.09)
	LSD P≤ 0.05	NS(NS)	NS (NS)	NS (NS)	NS (14.548)	NS (10.068)
PM	0 t/ha	7.77(7.84)	17.23(27.34)	41.49(61.62)	96.69 (138.96)	148.85 (191.46)
	5 t/ha	8.74(8.68)	22.10(31.82)	52.64(73.81)	115.42 (173.64)	178.52 (213.41)
	10 t/ha	8.97(8.48)	22.19(30.90)	54.78(72.88)	122.39 (175.96)	189.85 (215.65)
	LSD P≤ 0.05	0.595(0.396)	1.824(2.844)	4.447(6.009)	13.122 (14.548)	22.685 (10.068)
IF	0 kg/ha	7.96(7.95)	20.15(24.90)	48.65(60.18)	108.41 (146.61)	166.85 (190.16)
	200kg/ha	8.48(8.54)	20.18(32.27)	48.84(72.48)	110.25 (165.89)	173.08 (211.09)
	400kg/ha	9.04(8.52)	21.20(32.90)	51.41(75.67)	115.84 (176.05)	177.28 (219.27)
	LSD P≤ 0.05	0.595(NS)	1.824(2.844)	NS (6.009)	NS (14.548)	NS (10.068)

Figures in bracket are for 2014; NS= not significant

Table 5: Effect of treatment on stem diameter per plant at 2,4, 6, 8 and 10 weeks after sowing (WAS)

		Weeks After Sowing (WAS)				
Treatment	**Levels**	**2**	**4**	**6**	**8**	**10**
CM	0 t/ha	0.69 (0.71)	1.41 (1.96)	2.38 (3.18)	3.07 (3.58)	2.74 (2.74)
	5 t/ha	0.75 (0.75)	1.46 (2.23)	2.59 (3.27)	3.20 (3.60)	2.83 (2.85)
	10 t/ha	0.71 (0.73)	1.48 (2.12)	2.49 (3.29)	3.21 (3.73)	2.84 (2.81)
	LSD P≤ 0.05	NS (NS)	NS (0.191)	NS (NS)	NS (NS)	NS (0.229)
PM	0 t/ha	0.65 (0.69)	1.19 (1.91)	2.09 (2.91)	2.84 (3.19)	2.62 (22.62)
	5 t/ha	0.76 (0.76)	1.57 (2.24)	2.54 (3.41)	3.20 (3.78)	2.85 (2.88)
	10 t/ha	0.73 (0.75)	1.60 (2.16)	2.83 (3.42)	3.44 (3.94)	2.94 (2.89)
	LSD P≤ 0.05	0.076(0.051)	0.125(0.191)	0.232(0.192)	0.151(0.265)	0.110(0.229)
IF	0 kg/ha	0.69 (0.72)	1.43 (1.63)	2.40 (2.80)	3.04 (3.18)	2.68 (2.61)
	200 kg/ha	0.72 (0.73)	1.43 (2.24)	2.51 (3.43)	3.12 (3.74)	2.76 (2.82)
	400 kg/ha	0.73 (0.75)	1.50 (2.44)	2.56 (3.51)	3.33 (3.98)	2.97 (2.96)
	LSD P≤ 0.05	NS (0.051)	NS (0.191)	NS (0.192)	0.151(0.265)	0.110(0.229)

Figures in bracket are for 2014; NS= not significant

Effect of Treatments and their Interaction on Stem Diameter (cm) per Plant at 2, 4, 6, 8 and 10 WAS in 2013 and 2014

There was no significant difference (P≤0.05) among the means of CM levels for stem diameter at 2 and 10WAS in 2013 and at 4 and 10WAS in 2014. There were significant differences (P≤0.05) among the means of the PM levels throughout the sampling period. Significant differences (P≤0.05) among the means of the IF level in stem diameter were observed only at 8 and 10 WAS in 2013. IF levels had significant differences (P≤0.05) throughout the sampling period except at 2 WAS in 2014 (Table 5). The result for stem diameter followed similar trend for leave number and plant height whereas thicker stems (3.44cm) was obtained when 10t/ha PM was used in 2013 while thicker stem (2.96cm) in 2014 per plant and were significantly (P≤0.05) higher than the control (Table 5).

Effect of Treatments and their Interaction for Leaf Area Index, First Node with Ear, number of Days to First and 50% Tasselling in 2013 and 2014

CM had no significant effect (P≤0.05) on all the four parameters but PM had significant effect (P≤0.05) on all of these characters, whereas PM level increase, leaf area index, first node with ear per plot in 2013 increased while number of days to first tasselling, and 50% tasselling decreased (Table 6). There were no significant differences among the three CM level means in leaf area index, first node with ear, days to first tasselling and days to 50% tasselling, but there were significant differences among the PM level for all of the above characters (Table 6). IF had signifi cant effect (P≤0.05) only on first node with ear in 2013 but was significant throughout the sampling period in 2014 for the four parameters. In all, IF was found to induced early tasseling in number days to both first and 50% tasseling and this was true in both years (Table 6).

Table 6: Effect of treatment on leaf area index, number of node with ear, number of days to first and 50% tasseling

Treatment	Levels	Leaf area index	first node with ear	number of days to first tasseling	number of days to 50% tasseling
CM	0 t/ha	0.18 (0.27)	6.62 (7.68)	59.15 (53.59)	66.41 (59.63)
	5 t/ha	0.19 (0.31)	6.85 (7.92)	58.33 (51.93)	65.52 (57.85)
	10 t/ha	0.20 (0.30)	6.87 (7.97)	57.48 (51.74)	65.00 (57.56)
	LSD P≤ 0.05	NS (NS)	NS (NS)	NS (NS)	NS (NS)
PM	0 t/ha	0.17 (0.25)	6.22 (7.17)	60.52 (55.15)	67.00 (61.11)
	5 t/ha	0.20 (0.31)	6.90 (8.04)	57.44 (51.30)	65.04 (57.34)
	10 t/ha	0.20 (0.32)	7.22 (8.36)	57.00 (50.82)	64.89 (56.59)
	LSD P≤ 0.05	0.016 (0.034)	0.225 (0.451)	1.191 (1.889)	1.377 (1.468)
IF	0 kg/ha	0.18 (0.27)	6.53 (7.07)	59.34 (54.19)	67.11 (60.30)
	200 kg/ ha	0.19 (0.30)	6.80 (8.17)	58.63 (52.08)	65.85 (58.04)
	400 kg/ha	0.20 (0.31)	7.00 (8.33)	56.99 (51.00)	63.96 (56.70)
	LSD P≤ 0.05	NS (0.034)	0.225 (0.461)	NS (1.889)	NS (1.468)

Figures in bracket are for 2014; NS= not significant

Discussion

Physical and chemical properties of the soil at the experimental site

The soil texture of the experimental site was sandy clay. The high sand content of the soil was probably due to high content of quartz in the material [5]. Also, the soil was weakly acidic. All chemical properties have higher mean values at 0 – 15cm depth than at 15 – 30 cm except in sodium and manganese and this was observed in both years. This is an advantage because most roots of the maize plants are in the 0 – 15 cm depth.

Chemical analysis of the cattle and poultry manures used in this study

Nutrient content of the poultry manure was by far higher than that of the cattle manure in all of the 11 nutrients recorded. Again this was true in 2013 and 2014. Variation in nutrient contents of manures might probably be attributed to the different source of their feeds as feed source for poultry is different from cattle. The poultry manure is most likely to mineralize quickly and release nutrients for plants than the cattle manure. This result appears to agree with the results of [6]. who reported that nutrient content of poultry manure is among the highest of all manures [7]. Effect of Treatments on Number of Leaves per Plant at 2, 4, 6, 8 and 10 Weeks after Sowing The reason for this significant effect of poultry manure than the cattle manure and inorganic fertilizer was probably because PM had more nutritional values in all of the elements than CM. This agreed with the results of [8]. who reported that PM was rated as the best among difference sources of organic manure because its nutrient content is more concentrated and supplied in readily absorbable form [9]. similarly discovered that cattle slurry had no significant effect on leaves of maize. The increased in leaf number by IF could be probably due to the availability of the nutrient elements in absorbable form by plants [10]. similarly re ported that high nitrogen content of any treatment at the time of field application will enhanced the vegetative growth of maize. [11] similarly discovered that the application of poultry manure at 15t/ha increased leaf number in hybrid maize and was similar with10t/ha application rate. The reduction in leaf number with advancing plant age was due to senescence.

Effect of Treatments on Plant Height at 2, 4, 6, 8 and 10 Weeks after Sowing

The taller plants obtained when 10t/ha poultry manure was applied on the hybrid maize was an indication that poultry manure had abundant plant nutrients and is directly correlated with growth. The result is in agreement with the work of [11]. who discovered that 10t/ha poultry manure applied on hybrid maize gave taller plants and thick stem diameter [12]. observed an increased in the vegetative growth characteristics of maize measured at 8 and 16 weeks after planting in all plots receiving poultry manure application than the control treatment where poultry manure was not applied in two seasons of their study. The tallest plants were obtained in plots treated with 20 t/ha of poultry manure. Similarly, [13], also reported that the positive effect of changes in K, Ca and Mg levels upon application of poultry manure had improve maize growth in height, leaf length and number of leaves.

Effect of Treatments on Stem Diameter at 2, 4, 6, 8 and 10 Weeks after sowing

The significant effect of poultry manure on the hybrid maize might be attributed to the high nutrient content in the manure which is readily available for plant uptake as stated by [7], Thick stem diameter obtained in this study agreed with the work of [14]. who revealed that nitrogen is involved with the vegetative growth as well as increasing stem diameter [15]. reported that nitrogen in IF are readily available to plant than organic source of fertilizer. High doses of nitrogen fertilizer increase yield and yield related components of maize [10,11] similarly reported that 10t/ha poultry manure applied on maize gave significantly thick stem diameter at two, four and six weeks after sowing. The reduction in stem girth and leaf sheath as the plants advances in age was attributed to reallocation of the dry matter to the ear of the maize.

Effect of Treatments on Leaf area index, First node with Ear, number of days to First and 50% tasseling

The reason for higher leaf area which might have provided larger area for photosynthesis higher node number with ear decreased in number of days to first and 50% tasselling as treatment level increase may be attributed to the high nitrogen concentration provided by the poultry manure or inorganic fertilizer. Similar reports have shown that poultry manure contain high nitrogen content which led to increase maize performance [16]. reported that higher doses of nitrogen fertilizer increase yield and yield related components of maize.

Summary, Conclusion and Recommendations

Treatments applied in this study were found to significantly influence the growth of maize. The leave number per plant increase as treatment level increased and this was true for the growth parameters studied and in both years except on the number of days to first and 50% tasseling where an increase in treatment level induce early tasseling while the control tasseled late. Result obtained in 2013 revealed that PM applied at 10t/ha gave the highest number of leaves per plant (13.05), taller plants (189.85cm) and thicker stems (3.44cm) and were significantly ($P \leq 0.05$) higher than the control. On the other hand, in 2014, highest leaf number (14.86) per plant, taller plants (219.27cm) per plant and thicker stem (2.96cm) per plant were obtained when 400kg/ha IF was used and were significantly ($P \leq 0.05$) higher than the control. Based on the result obtained in this study, 10t/ha PM or 400kg/ha IF whichever is available was recommended for optimum maize production in the study area.

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