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RESEARCH ARTICLE

COMPARATIVE EFFECTS OF COMPOST – MINERAL, NPK AND UREA FERTILIZER AND TIME OF APPLICATION OF COMPOST - MINERAL FERTILIZER ON THE YIELD OF MAIZE

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ABSTRACT

The evaluation of the application compost – mineral fertilizer on maize was carried out in two locations (Ujemen and Emaudo) of the Teaching and Research Farm, Ambrose Alli University, Ekpoma, Nigeria. The experiment was laid out in a Randomised Complete Block Design (RCBD) with seven treatments, replicated thrice. The treatments were: 2, 4, 6 and 8 t ha^{-1} of compost mineral fertilizer, 300 kg ha^{-1}NPK 15: 15: 15, Urea (200 kg ha^{-1}) and the control. Growth parameters such as plant height, stem girth and leaf area were measured at 4, 5 and 6 weeks after planting, dry matter yield (DMY) and grain weight were taken at harvest. Data collected were statistically analysed using Genstat statistical package. In both locations, compost-mineral fertilizer applied at the rate of 6 and 8 t ha^{-1} significantly ($p \leq 0.05$) increased the growth, dry matter and grain yield of maize but not significantly different from each other. The application of compost – mineral fertilizer two weeks after planting significantly ($p \leq 0.05$) increased the yield of maize with yield value of 5. 65 t ha^{-1} compared to other application time. The grain yield values of 5.49 and 5.56 t ha^{-1} was obtained at Emaudo location and 5.69 and 5.78 t ha^{-1} at Ujemen with the application of 6 and 8 t ha^{-1} compost-mineral respectively. The application of compost - mineral fertilizer at the rate of 6 t ha^{-1}. improved the soil fertility resulting to higher yield of maize.

KEYWORDS

Compost-Mineral Fertilizer, Maize, NPK, Period of Application, Urea

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the world's most consumed cereal crops both as food for human and as feed for animals and it is widely cultivated globally (Shinde *et al*., 2014; Onuk *et al.,* 2010). Maize is an important cash crop among different income generating crops and is a major source of calories with the potential to mitigate the present food security and alleviate poverty (Oyelade and Awanane, 2013). In sub-Saharan Africa, absence or shortage of maize will invariably leads to famine and starvation. It was also estimated that by 2025, maize would have become the crop with the greatest production in developing countries and the world, and by 2050, the demand for maize in developing countries will double (CIMMYT and IITA, 2010).

However, the low yield of maize despite the large, cultivated hectares to meet the high demand is a major problem to farmers. This results from inadequate availability of farm input such as fertilizer and improved seeds for planting. Fertilizer either organic or inorganic and both are important farm input that significantly increase the yield and production of maize per hectare. In the tropics, soil fertility management has become a major concern of smallholder farmers to sustain their agricultural production (FAO, 2001). Thus, adopting context-specific soil management practices is crucial for sustainable agricultural productivities and environmental quality.

Among cereals, maize requires an adequate amount of nutrients, particularly N for optimum growth and yield (Agba and Long, 2005). Limited nitrogen could exert a substantial effect on maize crop yield and yield components as the plant stunted and leaves turn yellowish (Kogbe and Adediran, 2003). Previous studies have indicated that maize grain yield significantly increased by about 43–68%, due to the application of nitrogen fertilizer (Ogola et al., 2002). Therefore, nitrogen fertilizer management in the maize cultivation system is one of the major concerns and the most yield-limiting element (Baral and Adhikari, 2015). Cultivation through excessive use of chemical fertilizers is a major concern which has resulted to several soil fertility problems, including soil acidity, decline of soil structure and organic matter (Sheng et al., 2016; Feng and Zhu, 2017). The destructive effects of chemical fertilizers, high-cost price and unavailability have led to use of organic base fertilizer as a source of nutrients (Agegnehu and Amede, 2017). Most importantly, application of organic base fertilizer helps in improving soil texture, structure, reduce acidity and enhance the organic matter content of the soil (Abam et al., 2006).

Balanced and careful uses of external inputs which are ecologically and environmentally friendly are essential for a sustainable agricultural production (Kumar et al., 2015). Soils amended with organic fertilizers have positive effects on the soil productivity and quality (Agegnehu and Amede, 2017). A group researchers observed that the addition of organic inputs improved the soil physical properties, which led to a better environment for root development, water retention, nutrient exchange, and soil health (Fereidooni et al., 2013). Hence, the usage of locally available organic resources in agricultural soil is crucial to improve and sustain crop productivity. However, the use of organic inputs solely as a substitute for inorganic fertilizer cannot sufficiently increase crop yields and satisfy the food needs. Organic fertilizers slowly release nutrients,

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deficient in some nutrient elements and required in large quantities to satisfied the plant requirements (Salim and Mahmoodul, 2001). Hence, the integrated application of organic and inorganic fertilizer is the most convenient nutrient management method to improve soil nutrient and crop yield (Kramer et al., 2002). The combined application of organic and inorganic fertilizer is important to improve soil fertility, crop productivity, nutrient use efficiency, and protect soil health (Agegnehu and Amede, 2017).

The positive effect of the integrated application of organic and inorganic fertilizer in improving the growth and yield of maize has been confirmed (Amoah et al., 2012; Solomon and Jafer, 2015). According to the combined application of mineral fertilizer and compost significantly ($p \leq 0.05$) increased the growth and yield of rice compared to either mineral or compost application alone (Dania et al., 2021). Therefore, the combined application of organic and synthetic fertilizers has considerably improved soil fertility for sustainable crop productivity and economic viability. Also, it is widely agreed that the application of fertilizers is very essential in the cultivation and production of crops, however, farmers apply fertilizer with no time specification, hence, this experiment was carried out to recommend the actual time of fertilizer application to maize. Therefore, this experiment was carried out to assess the effective time of application and the comparative effects of compost-mineral and mineral fertilizer on the growth and yield of maize.

2. Materials and Methods

The study was carried out in two locations (Ujemen and Emaudo) of the Teaching and Research Farm, Ambrose Alli University, Ekpoma, Nigeria. Emaudo lies between Latitude North 6 degrees, 45 minutes, 34 seconds (6° 45' 34") and longitude East 6 degrees, 8 minutes 27 seconds (6° 8' 27" East) and Ujemen lies between Latitude 6°44′16.18″N, Longitude 6°4′46.4″E of the equator average annual rainfall of about 1500mm and temperature of about 15°C – 34°C (Uweni and Dania, 2008). Composite soil samples were collected at the depth of 0-15 cm from the experimental sites before planting to ascertain the p^H and nutrient status of the soil. The soils were air-dried, sieved and analysed for physical and chemical properties. Particle size distribution was determined by the hydrometer method, pH was measured in a 1:1 (soil-water) mixture by glass electrode pH meter, organic carbon was determined by the wet-dichromate acid oxidation method, available phosphorus was by the Bray-1 extraction method (Bouyoucos, 1962; Maclean, 1982; Bray and Kurtz, 1985; Bremmer and Mulvaney, 1982). Calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) were extracted with NH_4OAC pH 7.0 (Ammonium acetate). Potassium and Sodium were determined with a flame emission photometer, while calcium (Ca) and magnesium (Mg) were determined by the atomic absorption spectrophotometer (IITA 1979). Al^{3+} and H^+ were extracted with KCL (Thomas, 1982). ECEC was calculated by the summation of exchangeable bases and exchangeable acid (Anderson and Ingram, 1989).

2.1 Composting and Compounding of Compost – Mineral Fertilizer

The various organic materials such as pig dung, poultry manure, sawdust, and rice bran were composted for twelve weeks. After curing, the compost was air dried and fortified with NPK (ratio 20: 3: 1: 1 (25kg), Compost: N: P: K).

2.2 Management Practices

The sites were cleared, packed, tilled and marked into plot sizes of 2m x 2m with 1m walkways. Two seeds of SWAN-1- SR maize variety were planted at a spacing of 25cm x 75cm and later thinned to one seedling per stand two weeks after planting (WAP). The experiment was laid out in a Randomised Complete Block Design (RCBD) in the two locations. The experiment consisted of seven treatments; 2, 4, 6 and 8 tons/ha compost-mineral fertilizer, 300 kg/ha of NPK, 200 kg / ha of Urea fertilizers and the control replicated three times. The fertilizers were applied at two weeks after planting. Manual weeding was carried out twice before harvest. The following growth parameters were taken; plant height, stem girth and leaf area at 4, 5 and 6 WAP while grain weight and dry matter yield were determined after harvest. Data collected were analysed statistically using Analysis of Variance (ANOVA) and least significant difference (LSD) was used to compare means at 5% level of significance (SAS, 2005).

3. Results and Discussion

3.1 Soil Physical and Chemical Properties

The results of the physical and chemical properties of the soil from the two locations are shown in Table1. The soils of both locations were classified as sandy loam in texture, had moderate pH, organic carbon and nitrogen content, phosphorus content and ECEC were low (Enwezor et al., 1989). The nutrients content of the soil was low; hence, it was imperative to apply fertilizer. The nutrient content of compost and compost – mineral fertilizer is very adequate to sustain crop production (Table 1).

Table 1: Physical and Chemical Properties of The Soil at The Emaudo and Ujemen Experimental Sites with Compost and Compost – Mineral Fertilizer

Parameters	Ujemen	Emaudo	CMF	Compost
pH (H2O)	5.76	5.68	8.13	8.18
Organic Carbon (g/kg)	12.33	11.56	37.23	47.18
Total N (g/kg)	1.13	1.09	2.01	4.16
Available P (mg/kg)	9.67	9.55	25.35	38.37
Exchangeable Cations	(Cmol/kg)			
Ca	3.78	4.32	5.33	5.45
Mg	1.97	1.83	6.37	13.35
K	0.09	0.10	8.14	19.62
Na	0.26	0.28	4.67	6.42
Exchangeable Acidity	0.24	0.24	4.00	9.20
ECEC	6.34	6.53	24.51	44.84
Particle Size (g/kg)				
Clay	14.00	18.00		
Silt	52.00	50.00		
Sand	934.00	932.00		
Textural Class	Sandy loam	Sandy Loam		

3.2 CMF --- Compost – Mineral Fertilizer

3.2.1 Effect of Compost-Mineral Fertilizer, NPK 15:15:15 and Urea on The Vegetative Growth of Maize (Weeks After Planting – WAP).

The period of fertilizer application is a very important aspect for consideration before planting and application of fertilizer. Different application time affects the growth, yield and nutrient uptake of maize. Throughout the growth season of maize, the application of fertilizer two after planting significantly ($p \leq 0.05$) increased the height, stem girth and leaf area of maize (Table 2). According to time application significantly affection the utilization of fertilizer by crops such as maize (David et al., 2020). The growth of maize was enhanced with the application of fertilizer at two weeks after planting. The application of fertilizer significantly ($p \leq 0.05$) increased the height of maize compared to the control. At Ujemen experimental site, the tallest maize plant at 4 WAP was obtained from the application of 6 t ha^{-1} compost - mineral fertilizer (119.6cm) while the least was recorded from the control (91.90 cm). At 5 and 6 WAP, tallest maize plant measuring 161.10 cm and 200.70 cm were also recorded from the application of 6 t ha^{-1} compost-mineral fertilizer, but values were not significantly different from other treatments except the control and NPK application (Table 3).

The stem girth of maize was significantly ($p \leq 0.05$) increased with application of fertilizers; however, 6 t ha^{-1} compost-mineral fertilizer had the highest stem girth. Also, the leaf area was significantly ($p \leq 0.05$) increased with application of 6 t ha^{-1} compost-mineral fertilizer compared to other treatments. At Emaudo location, the measurement of maize height obtained from the application of 8t/ha compost-mineral fertilizer was significantly ($p \leq 0.05$) higher compared to other treatments (Table 4). The stem girths of maize were not significantly different among treatments except at 5 WAP when the application of 6 t ha^{-1} compost-mineral fertilizer significantly ($p \leq 0.05$) increased the stem girths. It was also observed that the application of 4, 6 and 8 t ha^{-1} significantly ($p \leq 0.05$) increased the leaf area of maize compared to other treatments. The earlier experiment carried out by confirmed the results obtained from this study (Caulibaly et al., 2019). They reported that the application of compost and NPK significantly ($p \leq 0.05$) improved the growth of maize vegetative growth.

The application of compost mineral fertilizer mostly at the rate of 4, 6 and 8 t ha^{-1} significantly ($p \leq 0.05$) increased the growth of maize compared to the application of NPK, Urea and control. This could be linked to the ability of compost and mineral fertilizer to improve soil fertility, which in turn increased the nutrients availability for plant growth. A group researcher reported a significant increase in the vegetative growth of maize when composted poultry manure was applied (Ali et al., 2003). The growth of maize was significantly ($p \leq 0.05$) increased with the combine application of manure and chemical fertilizer. The efficiency of compost mineral fertilizer could be explained by the combined effect of organic and inorganic fertilizer to improve the organic matter content, soil structure, nutrient retention, aeration, soil moisture holding capacity and water infiltration for plants. Compost, NPK and the mixture of compost and NPK are known for containing plant nutrients that can improve plant growth and yield attributes (Mahmood et al., 2017).

3.2.2 Yield of Maize in Response to Compost Mineral Fertilizer, NPK 15:15:15 and Urea

The application of compost – mineral fertilizer at two weeks after planting positively affects the growth and yield of maize. From the results, application of fertilizer at two weeks after planting had the yield value of 5.65 t ha^{-1} which was significantly ($p \leq 0.05$) higher compared to other periods of applications. According to a study, application of fertilizer at two weeks after planting increased the growth and yield of maize and this confirmed the results obtained from this experiment (Amali and Otsanugu, 2015). Since maize is short period crop and a deep feeder, early application of fertilizer mostly compost – mineral fertilizer is very necessary for effective mineralization and nutrient uptake by maize.

The dry matter yield (DMY) of maize varied significantly with respect to the various treatments. At Ujemen location, the DMY of maize was significantly ($p \leq 0.05$) higher with the application of 6 and 8 t ha $^{-1}$ with values 16.02 and 16.26 t ha^{-1} respectively compared to other treatments (Table 3). It was observed that the application of 6 and 8 t ha^{-1} were also significantly ($p \leq 0.05$) higher in DMY with values 14.92 and 15.11 t ha^{-1} compared to other treatments at Emaudo experimental site (Table 3). The application of NPK in both locations had significant higher DMY compared to Urea, control, 2 and 4 t ha^{-1}. According to the combine application of inorganic and organic fertilizer significantly ($p \leq 0.05$) increased the dry matter yield of maize, which agreed with the results obtained from this experiment (Ronley, 2018). It has also been reported by the combine application of inorganic and organic fertilizer significantly ($p \leq 0.05$) increased the dry matter yield of maize (Adamu et al., 2016).

The highest maize grain yields of 5.78 t ha^{-1} and 5.69 t ha^{-1} were obtained from 8 and 6 t ha^{-1} of compost mineral fertilizer treatments respectively (Ujemen). In Emaudo, 8 and 6 t ha^{-1} had the highest grain yields of 5.49 and 5.56 t ha^{-1} respectively. The yields values obtained from the application of NPK were 4. 67 t ha^{-1} and 4.51 t ha^{-1} at Emaudo and Ujemen location respectively. The yield obtained with the application of 6 and 8 t ha^{-1} of compost- mineral fertilizer were significantly ($p \leq 0.05$) higher compared to other treatments. A group researchers reported significant increase in maize yield from the combine application of mineral fertilizer and organic manure (Makinde et al., 2007). The increase in yield could be due to the synergetic effects of compost and mineral fertilizer. Some researchers also reported significantly ($p \leq 0.05$) increase in sorghum yield when 5 t ha^{-1} of farmyard manure was combined with 20kgN+10kg P/ha (Bayu et al., 2006).

4. CONCLUSION

From the experiment, best time to apply compost- mineral fertilizer to maize was two weeks after planting, for proper release and uptake of mineral nutrients by plants. Maize growth and grain yield were significantly ($p \leq 0.05$) increased with the application of higher rates of compost - mineral fertilizer (6 and 8 t ha^{-1}). These treatments had the highest values over NPK, urea and control. From the experiments, the application of compost – mineral fertilizer had a comparative advantage over the application of mineral and organic manure alone. Farmers in the study area are therefore encouraged to adopt the application of compost-mineral fertilizers in their cropping system. The recommended rate was 6 t ha^{-1} of compost – mineral fertilizer for a highly degraded soil and 4 t ha^{-1} for moderately suitable soils.

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Table 2: Effect of Time of Application of Compost-Mineral Fertilizer at 6 T Ha^{-1} on The Growth and Yield of Maize

Treatment (WAP)	PLANT HEIGHT (cm)			STEM GIRTH (mm)			LEAF AREA (cm²)			DMY (t/ha)	GRAIN WT. (t/ha)
	5	6	7	5	6	7	5	6	7		
1	122.3a	171.0ab	185.0b	28.00a	28.33b	34.00a	530.20b	558.00a	564.90b	5.83b	4.42ab
2	127.3a	198.7a	227.0a	31.33a	34.00a	35.67a	597.40a	642.40a	695.20a	9.00a	5.65a
3	79.0b	125.3c	164.3b	26.33a	27.33b	28.33a	403.00c	419.20b	474.00b	5.75b	4.18b
4	90.7b	143.3bc	165.8b	25.33a	26.67b	27.67a	427.10c	454.30b	502.20b	5.09b	4.44ab
LSD (0.05)	31.04	34.16	24.83	NS	2.69	NS	57.77	95.90	104.90	3.23	1.29

The mean values with the same letter in the vertical column are not significantly ($p \leq 0.05$) different using LSD to separate means.
WAP: Week After Planting.

Table 3: Effects of Compost – Mineral Fertilizer, NPK and Urea on the Growth and Yield of Maize at Ujemen

Treatment (t/ha)	PLANT HEIGHT (cm)			STEM GIRTH (mm)			LEAF AREA (cm²)			DMY (t/ha)	GRAIN YIELD(t/ha)
	4	5	6	4	5	6	4	5	6		
C	91.90c	125.60c	166.20b	21.11b	25.44c	25.63b	430.10c	522.70c	523.20c	5.32c	2.37c
2	103.90b	150.10a	198.00a	24.77a	27.11ab	27.78a	503.20bc	583.40bc	616.50bc	7.37d	4.14ab
4	99.30c	143.90a	200.00a	25.11a	27.22a	28.89a	598.20ab	687.30ab	763.50ab	9.27c	4.52ab
6	119.60a	161.10a	200.70a	26.78a	29.33a	29.22a	711.90a	817.90a	855.00a	16.02a	5.69a
8	105.70b	144.40a	186.30a	27.78a	28.33a	29.45a	650.70ab	739.30ab	764.80ab	16.26a	5. 78a
NPK	100.80b	139.40b	181.50a	26.28a	26.66b	28.23a	597.40ab	650.70ab	764.80ab	14.22b	4.51ab
Urea	110.30a	154.60a	194.40a	26.89a	28.33a	28.22a	616.80ab	706.20ab	770.40ab	8.75c	4.14ab
LSD (0.05)	11.24	19.48	20.62	4.64	2.21	2.03	155.60	157.00	165.30	1.33	1.36

The mean values with the same letter in the vertical column are not significantly ($p \leq 0.05$) different using LSD to separate means.

Table 4: Comparative Effects of Compost –Mineral and Mineral Fertilizer on The Growth and Yield of Maize at Emaudo Site

Treatment (t/ha)	PLANT HEIGHT (cm)			STEM GIRTH (mm)			LEAF AREA (cm²)			DMY t/ha	GRAIN YIELD (t/ha)
	4	5	6	4	5	6	4	5	6		
C	58.78b	87.70b	119.60b	25.00	25.11bc	24.83	356.20	391.50c	523.20c	4.22f	1.54f
2	63.89b	93.40b	140.40ab	25.61	25.67b	26.11	365.50	467.50bc	770.40ab	6.23e	3.03e
4	62.78b	99.20b	137.10ab	24.89	25.78b	25.67	428.60	642.80a	763.50a	8.17c	4.31c
6	62.76b	98.10b	152.30a	26.00	27.11a	25.33	489.10	689.90a	855.00a	14.92a	5.49a
8	84.24a	140.39a	156.49a	24.78	26.67a	26.33	476.60	675.50a	764.80a	15.11a	5.56a
NPK	67.50b	106.70b	149.10ab	26.11	26.00ab	26.33	372.54	465.50bc	693.30ab	13.20b	4.67b
Urea	65.69b	94.30b	132.40ab	25.22	24.68c	24.33	339.00	410.20c	616.50bc	7.65d	4.05d
LSD (0.05)	11.66	24.99	27.10	N.S	1.22	N.S	N.S	195.40	165.30	0.32	0.16

The mean values with the same letter in the vertical column are not significantly ($p< 0.05$) different using LSD to separate means.

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