EFFECT OF COMPOST, COMPOST TEA, AND INORGANIC FERTILIZER ON NUTRIENT UPTAKE, PHOTOSYNTHETIC PIGMENT, GROWTH, AND YIELD OF MAIZE (*Zea mays* L.)

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ABSTRACT

Despite the wide promotion given to organic agriculture over the conventional method of farming due to numerous advantages, adoption of the practice on a commercial scale is still very low due to bulkiness and slow release of mineral nutrients. Field experiments were carried out to compare the effect of matured compost, compost tea, and inorganic fertilizer (NPK 15:15:15) on yield, growth, and photosynthetic pigment of maize. The compost used was poultry manure and Tithonia diversifolia in the ratio of 3:1 by weight. Compost tea was obtained by water extraction from dried compost and was applied at two rates: Dry compost (10 and 15 t ha^{-1}), compost tea (40 and 60 m^3 ha^{-1}), and N.P.K (100 and 150 kg N ha^{-1}), and no fertilizer application served as control. The plots were laid out in a randomized complete block design (RCBD) with four replicates. Data were collected on growth and yield attributes of maize, nutrient uptake by plant tissues, and pre- and post-planting soil nutrient contents. Mineral fertilizer performed better in all the growth parameters measured, though not significantly different ($P \leq 0.05$) from dry compost treatment at 15t ha^{-1}. Compared to NPK and control, compost and compost tea increased maize dry matter accumulation and concentrations of Ca, Zn, Na, and Fe (effect on Fe was not significant) both in the soil and in maize plants, with higher concentration being superior to lower concentration. The application of compost to soil at 15t ha^{-1} increased the dry matter accumulation in maize by 147% compared to the control. Similarly, plants grown on soil amended with compost at 15t ha^{-1} did not differ significantly from N.P.K at 15kgN ha^{-1} in chlorophyll content but had significantly the highest carotenoid contents compared to other treatments. Compost fertilizer at 15 t ha^{-1} proved effective on yield performance and competed favourably with N.P.K. mineral fertilizer. Therefore, organic farming may be one of the solutions to food insecurity.

Keywords: ***Compost tea, Compost, Tithonia, growth, yield, fertilizer, nutrient, chlorophyll***

INTRODUCTION

The world population (7.5 billion) is growing fast, and to feed this ever-growing population, agricultural productivity must be increased. This has become a great challenge for agriculturists and policy-makers. FAO (2009) projected an increase in the world's population to reach 9.1 billion by 2050. Food production, as estimated by FAO, especially cereals, must be increased by 70% in order to meet this emerging challenge of boosting agricultural productivity

Maize (*Zea mays* L.) is a vital cereal crop that serves as a staple food for a significant portion of the global population (Murdia *et al.,* 2016). It ranks as the third most cultivated cereal crop worldwide, following wheat and rice (USDA, 2022), and holds particular importance as a primary grain food in developing countries. Beyond its role as a food source, maize serves as a critical industrial raw material in the production of corn starch, corn oil, dextrose, and corn flakes. Despite its significance, maize production faces numerous challenges, including pests and diseases (CIMMYT, 2011), access to high-yielding varieties (Li *et al.*, 2020), and most especially the issue of declining soil fertility (Lal, 2020). Considering the importance of maize crop especially in the developing countries, it is important that strategies be developed to remove constraints and increase production. The soil fertility must be improved and sustained to enhance maize yield by the application of different sources of fertilizer. The application of inorganic fertilizers is now being advised against, as it poses significant risks to both human well-being and environmental sustainability. (Adeoluwa and Adeogun, 2010). Recently, an awareness of the problem of "hidden hunger," also known as micronutrient deficiency associated with the use of mineral fertilizers on crops and humans, is being raised in sub-Saharan Africa (von Grebmer, 2014; Joy *et al.*, 201). This problem of micronutrient deficiency in crop production has been blamed on the incessant application of synthetic fertilizers, which are known only to supply the constituted elements (Kihara, 2020). With this problem and its implication for sustainable crop production and food security, attention is now shifting towards the use of organic fertilizers for soil fertility improvement and sustainable crop production. This shift in paradigm involves the optimum and sustainable utilization of natural resources for increasing agricultural productivity, which in turn improves food security (Mohamed *et al.*, 2007). The use of organic fertilizers improves the environmental and human health associated with conventional farming systems (IPCC, 2022). It involves the use of organic manure such as compost, green and animal manure as a means of improving soil fertility. Organic fertilizer is also important because it enhances the soil quality, conserves natural resources, is more effective, is economical and above all, it is able to supply all the necessary micro and macro- nutrients in available forms and sufficient amount (El-Shaieny *et al.*, 2022) thereby improving the physical and biological properties of the soil (Abou-El-Hassan and El-Batran, 2020).

Despite the benefits of organic fertilizer, it is still faced with low patronage due to bulkiness, lack of transportation, labour-intensive operations, unavailability of already prepared compost unlike mineral fertilizer, and slow rate of mineralization that makes it last longer in the soil compared to inorganic fertilizer. Although nutrients in manure are slowly released for plant uptake, this ensures a longer residual effect and higher crop yield (Ramamurthy and Shivashankar, 1996). To remove some of these constraints, the use of liquid fertilizer like compost tea is a better approach (Litterick *et al.*, 2004; Abbasi *et al.*, 2002). Numerous studies have demonstrated that the application of compost tea significantly enhances growth, yield, and quality across various crops. For instance, research by Awoyode and Adejumo (2017) revealed the residual benefits of compost tea on maize yield. Similarly, Giménez *et al*. (2020) observed improved outcomes in baby leaf lettuce, while Khoerunnisa *et al.* (2022) reported enhanced results in Black Rice (Oryza sativa L. indica). These findings underscore the potential of compost tea to promote sustainable and productive agricultural practices. Hence, the objective of this study was to compare the effectiveness of compost, compost tea, and inorganic fertilizer (NPK) on the growth, yield, nutrient uptake, chlorophyll, and carotenoid contents of maize under field conditions.

MATERIALS AND METHODS

Description of Experimental Site and Pre-Cropping Soil Analysis

The study was conducted between June and September 2019 at the Teaching and

Research Farm, University of Ibadan, Ibadan, Nigeria. It lies on longitude 7°24'N and latitude 3°54'E with an altitude of 122 m above sea level and an annual precipitation of 1,000 – 2,000mm. Temperature ranged from 21°C to 28°C. The experimental site was first cleared, and representative soil samples were taken from 15 points at 0-15cm soil depth for pre-cropping soil analysis prior to setting up the experiment. Samples were then pooled together, air dried, ground, and sieved using a 2mm mesh sieve. The total nitrogen of the soil was determined by the macro Kjedahl techniques using selenium tablets and boric acid as an indicator, while phosphorus was determined by the colorimetric method. Potassium and sodium were determined by flame photometry, while calcium, zinc, iron, and magnesium concentrations were determined using the Atomic Absorption Spectrophotometric method as described by IITA (1987) after digestion with 0.1 normal HCl. The soil pH in a soil water mixture of ratio 1:1 was determined using a pH meter-Electrometric Method, while organic carbon and organic matter were determined by the Walkley-Black method.

Compost and Compost Tea Preparation

Compost was prepared from *Tithonia diversifolia (*Mexican sunflower*)* and poultry manure in the ratio of 3:1 by weight. *Tithonia* was chopped, weighed, and mixed with poultry manure using the Partially Aerated Composting Technique (PACT-2) (Adediran *et al.*, 2006) and left to decompose for a period of three months. Continuous turning and watering were done fortnightly to quicken the decomposition rate. Compost tea was obtained by water extraction from dried compost. The extract was obtained by mixing compost and tap water in the ratio of 1:4 W (g) / V (L). The dried compost (500g) was soaked in 2 litres of water inside a perforated bucket for two weeks (Deschêne, 2007). The mixture was then passed through a 0.1mm sieve. The chemical characteristics of compost and compost tea were then determined following standard procedure.

Determination of Chlorophyll and Carotenoid Contents

Chlorophyll and carotenoid contents were determined four weeks after planting. This was carried out by incubating 1.0 g of fresh maize leaves in 15 mL of 96 % (v/v) ethanol in a water bath for 3 h at a temperature of 79.8 °C until complete discolouration of samples. The absorbance of chlorophylls a and b was measured at 665 and 649nm, respectively.

Total chlorophyll was determined according to Wintermans and Mots (1965) following the equations:

$$Chloropyll(a+b) = (6.10 \times A665 \times 20.04 \times A649) \times \frac{15/1000}{\mathrm{FW}}$$

Carotenoid analysis was determined from the equation below:

$$(4.69 \times A44 - 1.96 \times A665 - 4.7 \times A649) \times vol\ of\ supernatant(15ml) \times \frac{dillution\ factor}{\mathrm{FW}}$$

Experimental Procedure and Data Collection

The experimental site was marked out into different plots, and the size of each plot was 5 m x 4 m (20 m^2). Each plot was separated by an alley of 1 m. Treatments used included: control (without compost or inorganic fertilizer), compost 10 t ha^{-1}= 20 kg/20 m^2 (Mexican sunflower with poultry manure at 10 t ha^{-1}), compost 15 t ha^{-1}=30 kg/20 m^2 (Mexican sunflower with poultry manure at 15 t ha^{-1}), compost tea (40 m^3ha^{-1}= 80 litres/20m^2 and 600 m^3ha^{-1}=120litres/20m^2) and inorganic fertilizer (100 kgN ha^{-1}= 200 g/20m^2 and 150 kgN ha^1=300 g/20 m^2; these rates were applied because the soil test showed very low nitrogen levels of 0.11%)

using randomized complete block design (RCBD) replicated four times. Dried compost was applied on the plot receiving compost two weeks before planting while inorganic fertilizer and compost tea were applied two weeks after planting. The maize plots were sown with about 3-4 maize seeds per hole at a spacing of 0.75 cm × 0.25 cm and later thinned down to 2 seedlings/hole. The missing hills were replanted to meet the target plant population per unit area. There were 105 hills of maize per plot of 5 m x 4 m.

Data on growth parameters (plant height, leaf area, stem girth, leaf number) were collected fortnightly on the five maize stands that were tagged per plot during the vegetative growth stage. At maturity/harvesting, data were also collected on husk weight, 100 grain weight, cob weight, seed weight, and dry matter accumulation. The plant nutrient analysis was carried out following the dry ashing procedure. Soil samples from each treatment were also taken after harvesting and analysed for organic matter content, Mg, Ca, P, N, K, Fe, Zn, and Cu using the same procedure as described for pre-cropping soil physico-chemical analysis.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA), and means were separated using Duncan's multiple range tests (DMRT) at $P<0.05$ confidence level (Duncan, 1995).

RESULTS

Pre-Cropping Soil Analysis

Results of analyses of chemical and physical properties of the soil used for the experiment showed a soil pH of 7.02, which is neutral to slightly alkaline. The soil was low in essential nutrients like Nitrogen (N), Phosphorus (P), Potassium (K), and Magnesium (Mg) with 0.11 %, 5.95 mg/kg, 0.31 cmol/kg, and 0.46 cmol/kg, respectively. The soil was also low in organic Carbon (Table 1). The N, P, K., Calcium (Ca) and Sodium (Na) of the *Tithonia diversifolia* dry compost were 1.92%, 7.84%, 6.80cmol/kg, 0.43%, 14.80cmol/kg, respectively while the N, P, K, Ca and Na of compost tea were 1.89%, 3.51%, 4.27cmol/kg, 1.50%, and 10.17cmol/kg, respectively. This result revealed that dried compost is richer in macronutrients than compost tea, except for calcium. It was observed that dry compost contains high amounts of primary nutrients, which is an indication that it was well-cured. These analytical results revealed the suitability of Mexican sunflower as an excellent organic fertilizer (Table 1).

Table 1: Physicochemical properties of soil and chemical composition of compost

Parameters	Soil	Dried compost	compost tea
pH(H_2O)	6.37		-
Organic carbon (%)	1.33	16.70	-
Total Nitrogen (%)	0.18	1.92	1.89
Exchangeable base (cmol/kg)			
Potassium	0.27	6.80	4.27
Calcium	0.50	0.43	1.50
Magnesium	0.68	11.87	10.60
Sodium	0.17	14.3	10.17
Phoshorus	0.18	7.48	3.51

Parameters	Soil	Dried compost	compost tea
Extractable micronutrient (mg/kg)			
Iron	2.30	9.73	6.77
Zinc	88.00	2.05	0.75
Copper	44.50	75.00	79.50
Manganese	88.50	16.00	12.75
Particle Size Distribution			
Sand	84.50	-	-
Silt	7.40	-	-
Clay	8.00	-	-

Effect of Compost, NPK Fertilizer, and Compost Tea on Chlorophyll and Carotenoid Contents

Soil amendment with both dry compost and compost tea favoured chlorophyll formation in the maize plant more than NPK fertilizer application (Fig 1). Photosynthetic pigment increased in all the maize plants treated with dry compost and compost tea compared to the application of inorganic fertilizer and the control, although the difference was significant only for dry compost applied at 15t ha^{-1} (Fig 1). Dry compost performed better than compost tea, with a statistically higher value of chlorophyll content. The chlorophyll content of maize plants treated with compost at 15t ha^{-1} (2.40 µg/gfw) was more than other treatments (Fig 1). This was followed by a lower rate of compost. The chlorophyll content of maize plants treated with compost tea was also superior to those of NPK fertilizer at both rates, although not significantly so. The lowest value was recorded in the control plants. A similar trend observed with the chlorophyll content was also recorded for carotenoid. Carotenoid content was significantly more in all maize plants treated with dry compost compared to compost tea, inorganic fertilizer and control. The carotenoid content in maize plants treated with compost at 15t $ha-^{1}$ (2453.20 µg/gfw) was more than those of the other fertilizer treatments (Figure 2).

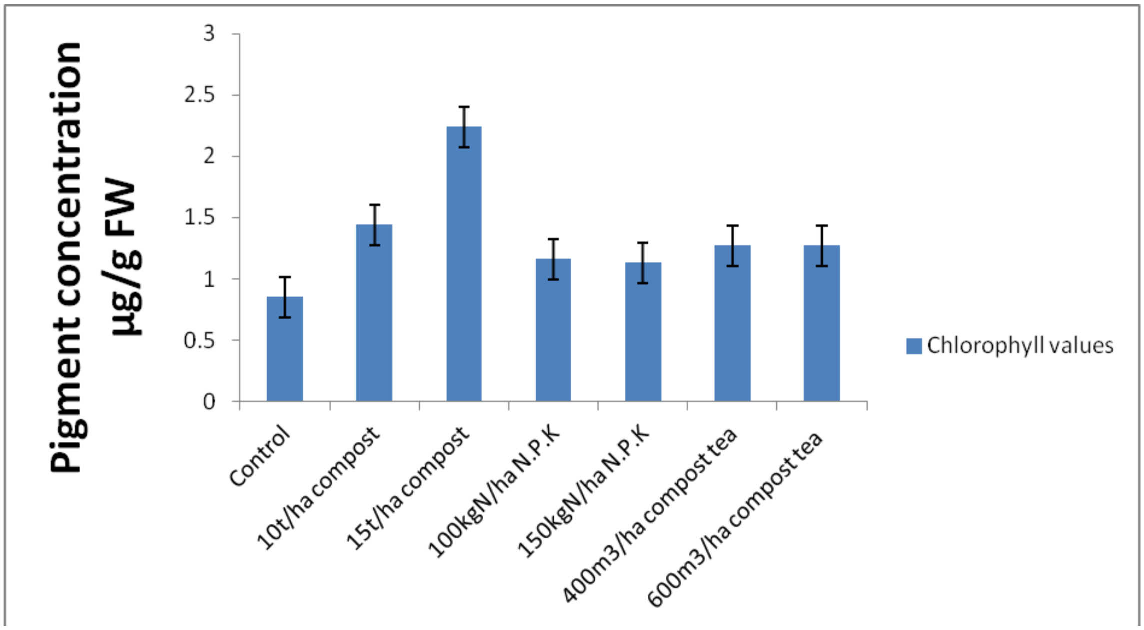

Figure 1: Effects of compost, compost tea and N.P.K fertilizer treatments on pigment concentration (Chlorophyll). Bars of chart represent standard error.

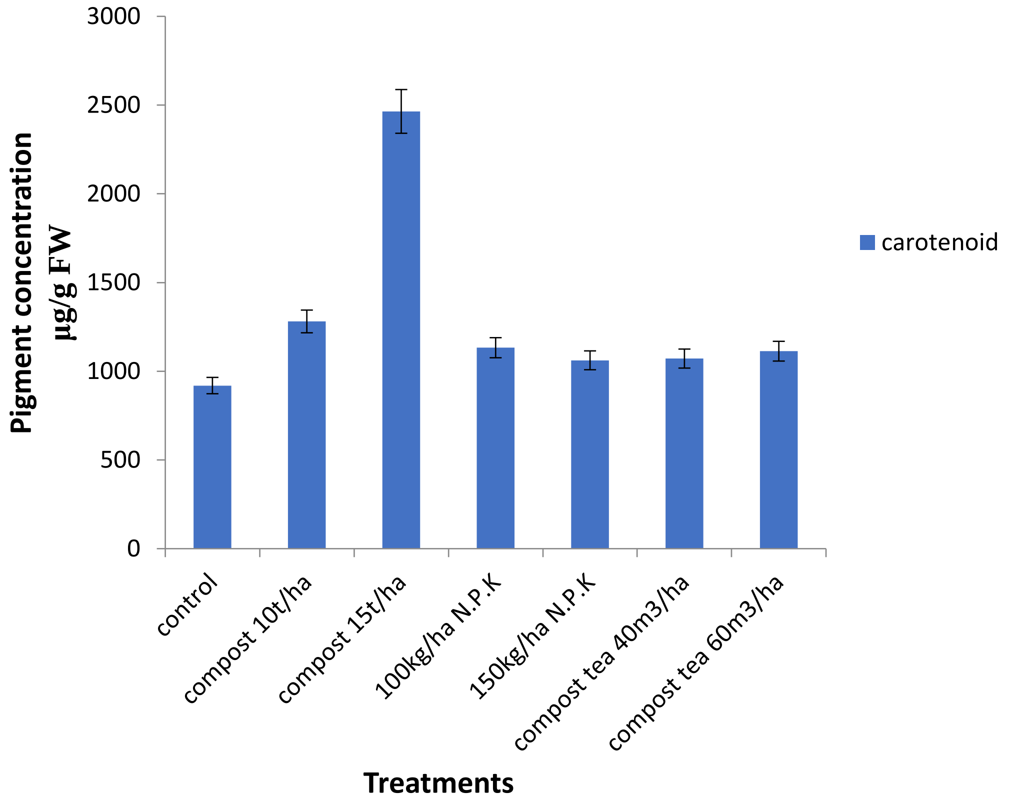

Figure 2: Effects of compost, compost tea, and NPK fertilizer treatments on pigment concentration (Carotenoids). Bars on the chart represent standard error.

Growth Response of Maize to Dry Compost, Compost Tea, and Inorganic Fertilizers Applied at Different Rates

Generally, the application of NPK fertilizer and dry compost performed better than compost tea on all the growth parameters. The effect of dry compost was more pronounced at 6, 8, and 10 weeks after sowing (WAS). The higher rate of compost tea had superior results to the lower rate. The availability of nutrients from compost, compost tea, and NPK fertilizer had a significant effect ($p<0.05$) on maize plant height across the sampling periods compared to the control. The application of N.P.K fertilizer at 150 kg N ha^{-1} and dry compost amendment at 15 t ha^{-1} gave the highest plant height of 143.03 and 141.13 cm, respectively (Table 2). They both performed better than other treatments, and they increased plant height by 83.53% and 81.09%, respectively, when compared to the control treatment. Also, at the same sampling period, compost amendment at 10tha^{-1} increased the plant height by 56.51% compared to the control treatment. A higher rate of all fertilizer applied produced taller plants compared to the lower rate. At 10 WAS, it was observed that soil amendment with compost at 15t ha^{-1} had the same height with that of NPK fertilizer at 150 kg N ha^{-1} with the mean values of 254.83cm and 254.30 cm, respectively.

The application of compost and NPK fertilizer increased the plant height by 43.56% and 43.26 %, respectively. Control plants produced shorter plants compared to all fertilized maize plants (Table 2). Control plants produced shorter plants compared to all fertilized maize plants (Table 2).

There was an increase in leaf area production with the addition of fertilizers across the sampling periods. A significant increase in the leaf area was recorded in plants treated with compost at 15 t ha^{-1} and in plants treated with 150 kg N ha$^{-1,}$ and they differed significantly from other treatments. Leaf area production increased progressively from 2 WAS to 10 WAS with the application of compost at 15 t ha^{-1} and by NPK fertilizer at 150 kg N ha^{-1}, which were not significantly ($p\leq0.05$) different from each other, and they both increased leaf area formation by 35.04% and 34.18 %, respectively. The application of compost tea also increased leaf area production compared to the control treatment, and the difference was significant at the higher rate (Table 3).

The number of leaves produced by maize in response to treatments showed that the application of compost at 15 t ha^{-1} competes favourably with NPK fertilizer as it enhanced higher leaf formation. Maize plants grown on soil amended with compost at 15 t ha^{-1} and NPK fertilizer at 150 kg N ha^{-1} produced the same number of leaves during the growing periods of 8 and 10 WAS and performed better than compost tea. The higher rate of compost tea performed better than the lower rate as observed in all growth parameters (Table 4). The application of fertilizer at 150 kgN ha^{-1} produced maize plants with the highest stem girth, although the difference was not significant to compost at 15 t ha^{-1}. Stem girth was significantly lower in control plants across the growth periods (Table 5).

Effect of Compost, Compost Tea, and Inorganic Fertilizer on Maize Yield Parameters

All the yield parameters showed that compost amendment was not significantly different from inorganic fertilizer, with the sole exception being yield per ha^{-1}. The lowest yield was obtained in the control treatment. There was no significant difference in the 100 seed weight of maize plants treated with 10t ha^{-1} dry compost and 150 kgN ha^{-1}. The trend was the same for total seed weight with compost at 15 t ha^{-1} being not significantly different from NPK treatment at 150 kgN ha^{-}

1 and all the fertilizer treatments were significantly higher than the control. The application of compost at 15 t ha^{-1} did not have a significant difference in cob weight by N.P.K fertilizer at 150 kg N $ha^{-1,}$ and these had higher output than 100 kg N ha^{-1}, dry compost at 10 t ha^{-1} compost, and compost tea at 60 m^3 ha^{-1} and 40 m^3/ha. The control plant had the least cob weight, although compost tea at 40 m^3 ha^{-1} was not significantly different from the control. Compost amendment at 15 t ha^{-1} also produced the highest seed/cob (468.55 g), which was not significantly different from NPK fertilizer and compost tea. It increased the number of seeds/cob by 67.8% when compared to the control (unfertilized plant), which had the smallest number of seeds/cob. Contrary to what was observed for cob weight, total seed weight, seeds/cob, and 100 seed weight, it was observed that NPK at 150 kg N ha^{-1} and compost at 15 t ha^{-1} were not significantly different from each other. Less yield in t/ha was observed in the control plot where there was no augmentation of fertilizer (1.00 t ha^{-1}). Meanwhile, the application of compost at 15 t ha^{-1} produced the highest grain yield of maize (3.10 t ha^{-1}), and it was significantly different from all other sources of fertilizers applied. Higher rates of all the fertilizers applied performed better than the lower rates (Table 6).

Table 2: Effect of Compost, Compost tea, and N.P.K fertilizer on maize plant height at 2, 6 4, 8 and 10 weeks after sowing (WAS)

	PLANT HEIGHT (cm)				
Treatments	**2 WAS**	**4 WAS**	**6 WAS**	**8 WAS**	**10 WAS**
Control	20.72^{e}	63.93^{e}	90.21^{d}	124.10^{d}	177.50^{c}
10t ha^{-1} compost	60.11^{b}	121.96^{b}	147.39^{b}	184.99^{b}	214.83^{b}
15t ha^{-1} compost	70.31^{a}	141.13^{a}	164.55^{a}	207.33^{a}	254.83^{a}
100kgN ha^{-1} N.P.K	56.28^{b}	110.33^{c}	145.64^{b}	180.70^{b}	215.23^{b}
150kg N ha^{-1} N.P.K	74.70^{a}	143.03^{a}	170.10^{a}	211.03^{a}	254.30^{a}
40 m^3 ha^{-1} compost tea	40.75^{c}	70.15^{d}	100.00c	120.03^{d}	182.00^{c}
60 m^3 ha^{-1} compost tea	43.33^{c}	102.83^{c}	111.11^{c}	144.40^{c}	209.00^{b}

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by DMRT

Table 3: Effects of Compost, Compost tea, and N.P.K. Fertilizer Treatments on the leaf Area (cm) at 2, 4, 6, 8, and 10 weeks after sowing (WAS)

	LEAF AREA (cm^2)				
Treatments	**2 WAS**	**4 WAS**	**6 WAS**	**8 WAS**	**10 WAS**
Control	78.74^{d}	251.53^{d}	293.48^{d}	317.40^{c}	403.66^{c}
10t ha^{-1} compost	113.90^{b}	312.43^{ab}	350.33^{ab}	382.73^{b}	477.53^{b}
15t ha^{-1} compost	150.88^{a}	331.83^{a}	393.40^{a}	430.63^{a}	548.36^{a}
100kgN ha^{-1} N.P. K	120.23^{b}	319.73^{ab}	354.00^{ab}	394.83^{b}	487.16^{b}
150kg N ha^{-1} N.P. K	155.20^{a}	333.73^{a}	383.99^{a}	425.90^{a}	542.76^{a}
40m^3 ha^{-1} compost tea	83.21^{d}	279.67^{c}	308.55^{c}	327.87^{c}	408.86^{c}
60m^3 ha^{-1} compost tea	98.30^{c}	303.90^{bc}	324.54^{bc}	376.93^{b}	470.33^{b}

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by DMRT

Table 4: Effects of Compost, Compost tea, and N.P.K. Fertilizer Treatments on the Number of leaves at 4, 8, and 12 weeks after sowing (WAS)

	MEAN NUMBER OF LEAVES				
Treatments	**2WAS**	**4WAS**	**6WAS**	**8WAS**	**10WAS**
Control	4.00^{d}	8.00^{d}	8.00^{d}	9.33^{d}	12.66^{bc}
10t ha-1 compost	5.54^{b}	10.33^{ab}	10.57^{b}	11.00^{b}	13.66^{b}
15t ha^{-1} compost	6.70^{a}	11.33a	11.49^{a}	13.00^{a}	15.66^{a}
100 kgN ha^{-1} N.P. K	5.52^{b}	10.33^{ab}	10.52^{b}	11.00^{b}	15.00^{a}
150 kg N ha^{-1} N.P. K	6.69^{a}	11.00^{ab}	9.66^{d}	13.00^{a}	15.66^{a}
40 m^{3} ha^{-1} compost tea	4.00^{d}	8.66^{cd}	8.88^{d}	9.66^{d}	12.00^{c}
60 m^{3} ha^{-1} compost tea	4.98^{c}	9.66^{bc}	9.38^{c}	10.33^{c}	13.33^{b}

Means followed by the same letter in a column are not significantly different from each other at $P \leq 0.05$ by DMRT

Table 5: Effect of Compost, Compost tea, and N.P.K fertilizer on Stem Girth at 2, 4, 6, 8, and 10 weeks after sowing (WAS)

	MEAN STEM GIRTH (cm)/plant				
Treatments	**2WAS**	**4WAS**	**6WAS**	**8WAS**	**10WAS**
Control	1.00^{e}	3.36^{d}	3.50^{d}	4.00^{d}	5.000^{e}
10t ha-1 compost	1.53^{b}	3.83^{b}	4.20^{b}	4.53^{c}	5.80^{c}
15t ha^{-1} compost	2.00^{a}	4.06^{a}	4.80^{a}	5.11^{a}	6.06^{a}
100kgN ha^{-1} N.P. K	1.58^{b}	3.86^{b}	4.33^{b}	4.60^{b}	5.90^{b}
150kg N ha^{-1} N.P. K	2.11a	4.13^{a}	4.84^{a}	5.06^{a}	6.02^{a}
40m^{3} ha^{-1} compost tea	1.29^{d}	3.49^{d}	3.80^{d}	4.17^{d}	5.20^{d}
60m^{3} ha^{-1} compost tea	1.43^{c}	3.63^{c}	3.99^{c}	4.33^{c}	5.36^{d}

Means followed by the same letter in a column are not significantly different from each other at $P \leq 0.05$ by DMRT

Effect of Compost, Compost Tea, and Inorganic Fertilizer on Dry Matter Accumulation

1. **Root Dry Weights**

The fresh dry of roots of maize plants treated with compost at 15 t ha^{-1} was significantly higher than that of plants treated with NPK fertilizer at 150 kgN ha^{-1}, whereas the opposite was true at the lower application rate. Maize plants treated with compost at 15 t ha^{-1} increased the root dry by 138 %, followed by NPK fertilizer at 150 kg N ha^{-1}, which increased dry weight by 128 % when compared with the control treatment (Figure 3).

2. **Shoot Dry Weights**

Similar to the root dry weight, there was no significant difference in the shoot dry weight of the maize plants treated with compost at 15t ha^{-1} and NPK fertilizer applied at 150 kgN ha^{-1}. Additionally, there was no significant difference in the shoot dry weight of maize treated with compost at 10 t ha^{-1} and NPK fertilizer at 100 kg N ha^{-1} (Figure 4).

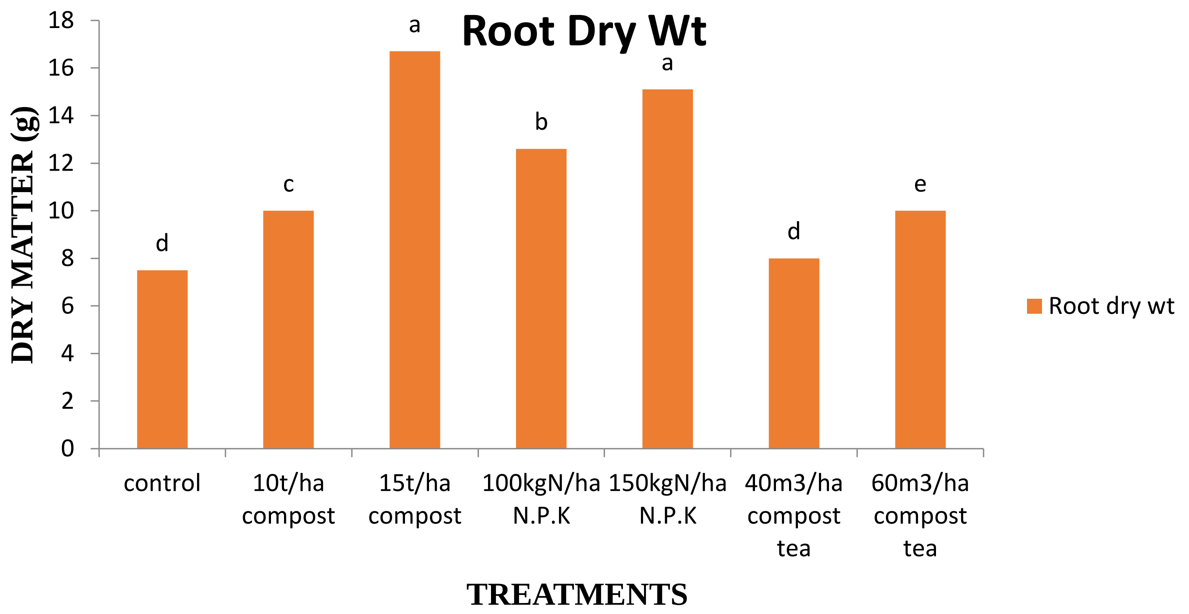

Figure 3: Effect of compost, Compost tea, and N.P.K fertilizer on Root dry matter yield of maize

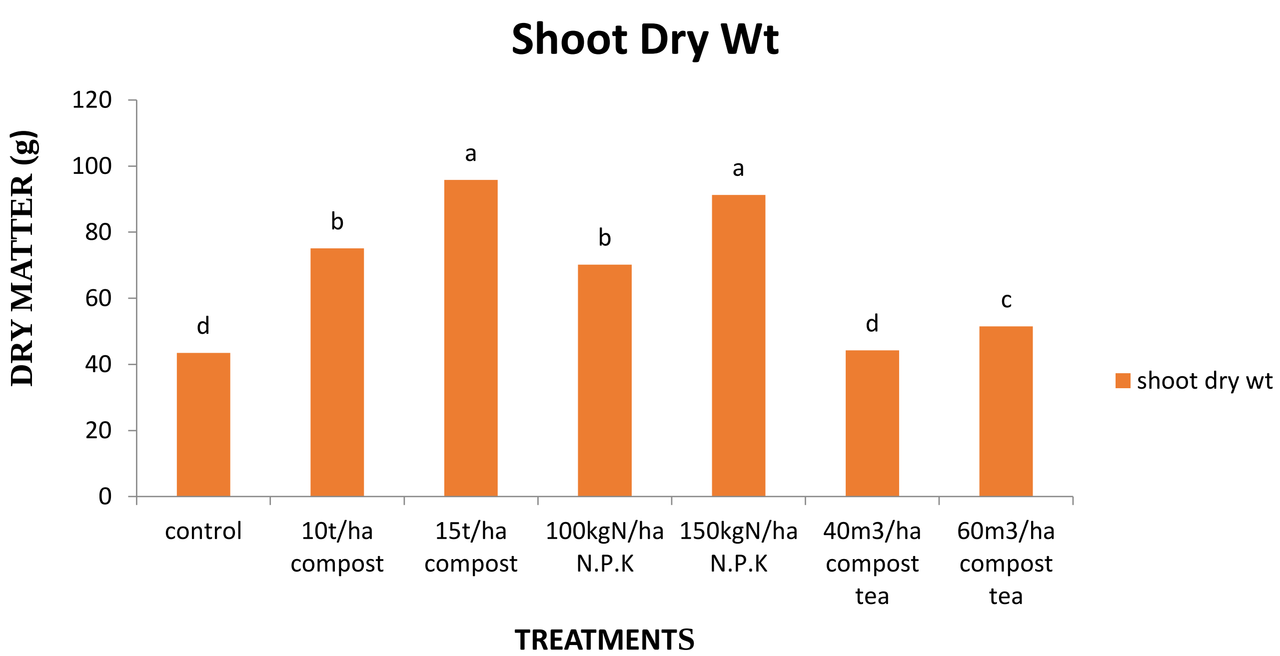

Figure 4: Effect of Compost, Compost tea, and N.P.K fertilizer on Shoot dry matter yield of Maize

Effect of Compost, Compost Tea, and N.P.K Fertilizer on Post-Cropping Soil Nutrient Compositions

Soil analysis after harvesting showed a significant increase ($p<0.05$) in the nutrient content of the soil treated with soil amendments (Table 7). The application of N.P.K fertilizer at 150 kg N ha^{-1} significantly increased the soil Nitrogen, Phosphorus and Potassium concentrations to 0.34 %, 28.30 mg/kg and 0.50 Cmol/kg, respectively as against the baseline soil (pre-cropping) nutrient values of 0.11 %, 5.95 mg/kg and 0.31 Cmol/kg, for soil N, P, and K, respectively. The application of compost at 10 and 15 t ha^{-1} significantly ($p< 0.05$) increased the post-harvest soil calcium, magnesium, zinc, and iron concentrations more than the NPK fertilizer and compost tea. Soil organic matter and organic carbon were much higher in soil treated with compost and compost tea when compared to NPK fertilizer and the control (Table 7).

Effect of Compost, Compost Tea, and NPK Fertilizer on Plant Nutrient Uptake

The result of plant tissue nutrient analysis showed that the addition of either organic or inorganic fertilizers to the soil generally increased nutrient uptake by maize plants compared to the control (Table 8). Inorganic fertilizer at both rates (150 kg N ha^{-1} and 100 kg N ha^{-1}) increased Nitrogen, Phosphorus and Potassium contents of maize plants significantly more than dry compost and compost tea ($p<0.05$), while compost increased the concentration of Ca and Mg as well as Fe and Zn more than NPK fertilizer. Both rates of the N.P.K fertilizer (150 kg N ha^{-1} and 100 kg N ha^{-1}) enhanced the uptake of Nitrogen, Phosphorus, and Potassium by the maize plants more than other treatments, including the control. This was followed by maize plants grown on plots treated with dry compost. However, maize plants treated with a higher rate of compost (15 t ha^{-1}) had higher Nitrogen, Phosphorus, Calcium, Magnesium, and Potassium contents than those treated with the lower rate (10t ha^{-1}). The same observation was made with the application of compost tea applied at the highest rate (600 m^3 ha^{-1}), which showed the highest Nitrogen, Phosphorus and Potassium contents. The effect of treatments on essential micronutrient contents of the maize plant showed that maize plants treated with a higher rate of compost 15 t ha^{-1} had the highest concentrations of micronutrients such as Zinc and Iron, followed by a lower rate of compost at 10 t ha^{-1}.

Table 6: Effect of Compost, Compost Tea, and N.P.K Fertilizer on Maize Yield and Yield Components

Treatments	100 Seed weight (g)	Cob weight (g)	Total seed weight (g)	No of seed/cob (g)	Husk weight (g)	Grain yield t/ha^{-1}
Control	89.73^{c}	260.33^{c}	220.33^{c}	284.90^{e}	104.76^{e}	1.00^{c}
10t ha^{-1} compost	185.55^{ab}	320.57^{bc}	300.83^{b}	320.33^{b}	168.70^{c}	2.29^{b}
15t ha^{-1} compost	200.57^{a}	460.93^{a}	468.55^{a}	355.50^{a}	200.80^{a}	3.10^{a}
100kgN ha^{-1} N.P. K	160.43^{bc}	340.97^{b}	319.33^{b}	322.83^{b}	179.83^{b}	2.00^{b}
150kg N ha^{-1} N.P. K	180.74^{ab}	441.33a	455.94^{a}	353.83^{a}	210.53^{a}	2.86^{b}
40m^3 ha^{-1} compost tea	99.99^{c}	274.19^{c}	269.73^{b}	291.06^{c}	112.08^{e}	1.87^{bc}
60m^3 ha^{-1} compost tea	111.23^{c}	300.42^{bc}	286.33^{b}	299.90^{c}	125.7^{d}	1.90^{bc}

Means followed by the same letter in a column are not significantly different from each other at P≤0.05 by DMRT

Table 7: Effect of Compost, Compost Tea, and Inorganic Fertilizer On Post-cropping Soil Nutrient Concentrations

Treatments	N%	Org C %	Org M %	Av P (mg/kg)	Zn(mg/kg)	Fe (mg/kg)	K (Cmol/kg)	Ca (Cmol/kg)
Control	0.10c	1.10b	1.05b	6.17c	1.07b	0.89b	0.21c	4.25b
10 t ha^{-1} compost	0.16b	1.68a	2.89a	20.90ab	2.92a	1.53a	0.68a	13.00a
15 t ha^{-1} compost	0.20b	1.70a	2.92a	23.10ab	2.98a	1.59a	0.71a	15.00a
100 kgN ha^{-1} N.P. K	0.30a	1.19b	2.05ab	24.15ab	2.16a	1.27a	0.81a	9.20ab
150 kgN ha^{-1} N.P. K	0.34a	1.22b	2.13ab	28.30a	2.28a	1.30a	0.90a	10.11ab
40 m^3 ha^{-1}compost tea	0.12b	1.35b	2.11ab	18.20abc	2.50a	1.46a	0.42b	11.80ab
60 m^3 ha^{-1}compost tea	0.16b	1.41b	2.43a	19.20abc	2.54a	1.47a	0.42b	12.70ab

Means followed by the same letter in a column are not significantly different from each other at P<0.05 by DMRT

Table 8: Effect of Compost, Compost Tea, and NPK Fertilizer on Plant Nutrient Uptake of Maize

Treatments	N%	P%	K%	Ca%	Mg%	Zn%	Fe%	Na%
Control	0.38d	0.11b	0.31c	0.18c	0.20c	0.09c	1.19a	0.80b
10t ha^{-1} compost	2.55b	1.45a	3.05ab	2.19a	1.53ab	1.89ab	1.81a	1.79ab
15t ha^{-1} compost	2.61b	1.50a	4.43ab	2.72a	2.00a	2.15a	1.98a	2.27a
100kg N ha^{-1} NPK	3.21a	1.87a	5.06a	1.40b	0.85bc	0.19b	1.50a	0.81b
150kg N ha^{-1} NPK	3.57a	1.99a	5.73a	1.72b	0.87bc	0.26b	1.68a	0.87b
40m^3 ha^{-1} compost tea	1.98c	0.88ab	2.32b	1.89b	0.95abc	0.30b	1.77a	0.91b
60m^3 ha^{-1} compost tea	2.00c	0.93ab	2.96b	1.98b	1.05ab	1.58ab	1.79a	1.53ab

Means followed by the same letter in a column are not significantly different from each other at P<0.05 by DMRT

DISCUSSION

The result of this study confirmed the previous findings on the potential of compost on soil fertility improvement for crop production. The compost effect was significant on all the growth and yield parameters of maize. An increase in plant growth confirms that the application of compost competes significantly with NPK fertilizer and control (Nikejah *et al.,* 2014). The observed increase in the growth parameters of maize during the sampling periods with respect to organic and inorganic fertilizer over that of control is attributed to the availability of soil nutrients in the compost and inorganic fertilizer. The N.P.K mineral fertilizer gave the highest plant height with a mean value of 2, 4, 6 cm at 8 WAS, while dry compost gave the highest plant height at 10 WAS. This may be due to a slow rate of mineralization or release of nutrients commonly attributed to dry compost, especially regarding nitrogen and phosphorus availability for plant growth. The competitive effect of compost with mineral fertilizer on maize performance may be due to the ability of compost to supply many of the essential nutrients needed by the plant in sufficient amounts and available forms (Abou El-Magd *et al.,* 2006; Arifah, 2021). For instance, nitrogen and phosphorus availability for plant growth was enhanced probably with the help of soil microbes present in compost (Rengel and Damons 2008). These nutrients are then converted from unavailable forms to available forms for plant growth and development. Compost also made available sufficient nutrients required for plant growth (Gallardo-Larva and Nogales, 1987; Ojo *et al.,* 2018). This might be the reason for the higher number of leaves and leaf area/plant produced by compost over that of mineral fertilizer, although the difference was not statistically significant. It has also been asserted that nutrient availability in sufficient amounts improves plant leaf area development (Olabode *et al.*, 2007).

Furthermore, fertilization in the form of compost enhanced dry matter accumulation compared to the control treatment. The higher yield observed from the 15 t ha^{-1} of compost treatment can be attributed to the higher nitrogen content and availability from the *Tithonia* compost (Malama, 2001 and Olabode *et al.*, 2007). Due to the high level of nutrients in the Mexican sunflower plant, many research scientists are encouraging the use of this plant as a good source of plant nutrients (Achieng *et al.*, 2011 and SCARED Africa, 2007). The high yield obtained from the use of Mexican sunflower in this study confirms the finding of some researchers who reported the effectiveness of Mexican sunflower compost in soil fertility improvement (Jama *et al.*, 2000, Adediran *et. al.*, 2003 and Shokalu *et. al.*, 2010).

The ultimate goal of all physiological processes occurring during plant growth and development is to increase grain yield. The application of *Tithonia diversifolia* compost due to adequate nutrient supplied brings about more seed weight and better grain development which resulted to increase in yield (Quilty, 2011). A higher rate of compost (15t ha^{-1}) caused an increase in plant height, dry matter yield, leaf area, and grain yield per hectare. Higher rates of compost application appeared to have produced better yield in maize production, probably due to an increase in the photosynthetic capability of the treated plants as a result of an increase in the number of leaves and leaf area (Aguyoh *et al.*, 2010). This suggested that when there is an optimal nutrient supply to a plant, assimilate production by that plant is enhanced (Meena *et al.*, 2021) Since leaf is the main organ for photosynthesis, a high number of leaves recorded with application of compost could have led to increase in light interception, thereby enhancing photosynthetic rate which later resulted in high dry matter accumulation. Compost has also been reported to contain growth-promoting hormones (Dobbss, 2010). The response of maize on compost-treated plots could, therefore, be attributed to growth-promoting substances present in *Tithonia* compost. Researchers have also reported an increase in the fresh weight of maize with the addition of compost (Raddy, 2016). The increase observed in root and shoot weight with the application of compost at 15 t ha^{-1} might be due to the fact that maize roots respond positively to essential macro and micro-nutrient availability, thereby resulting in an increase in dry matter accumulation (Fashina *et al.*, 2002). Poor rooting system has been reported to lead to reduction in shoot growth, partitioning of assimilate, yield, water and nutrient use efficiency (Zhang, 1995**)**. It is, therefore, important that soil supply adequate nutrients in available forms for root uptake (Sarwar *et al.*, 2005). The dry weight of the root and shoot of maize increased significantly with the use of compost compared to the control due to efficient use and continued supply of all available nutrients as well as more water absorption (Michael *et al.*, 2010).

The application of organic fertilizers (in the form of compost and compost tea) increased the photosynthetic pigments of maize compared to the control treatment and NPK fertilizer. The plants grown on soil amended with compost at 15 t ha^{-1} had high chlorophyll content compared to the control and other treatments. This study indicated that maize plants responded better with respect to chlorophyll content with the application of compost at 15 t ha^{-1}. The observation was in agreement with the findings of an experiment conducted on the determination of the effect of organic fertilizer on chlorophyll formation and photosynthetic rate (Shudong *et al.*, 2024). The increase in the photosynthetic pigment of maize with the application of compost might also be attributed to the high nutrient content of the compost, especially Mg and Fe (Marschner, 2005). Magnesium is the main nutrient required for chlorophyll synthesis, while Iron is necessary for the maintenance and synthesis of chlorophyll and RNA metabolism in the chloroplasts (Nelson and Cox Lehninger, 2004; Levy and Taylor, 2003).

Furthermore, application of inorganic fertilizer at 100 kg N ha^{-1} and 150 kg N ha^{-1} increased the concentrations of Nitrogen, Phosphorus and Potassium, while compost and compost tea fertilizer increased the concentrations of other macronutrients and micronutrient such as Calcium, Iron, Magnesium and Zinc in both post-cropping soil and maize plant tissue (effect of Fe was not significant). Organic carbon and organic matter concentration in compost also contributed to the organic matter content of the soil. All these could have contributed to an increase in grain yield per ha (Cheema *et al.,* 2010). The fact that higher fertilizer treatments gave the highest growth and yield parameter is an indication that abundant nutrient supply is directly correlated to plant growth. Compost tea had little influence on both the growth parameters and dry matter accumulation compared to all other treatments, and this may be attributed to its liquid nature. Compost tea, however, performed better on the maize than the control.

CONCLUSION

This study concludes that inorganic fertilizer increased the vegetative growth of maize, but Mexican sunflower compost at 15 t ha^{-1} increased nutrient uptake (for nutrients other than N, P and K) and chlorophyll content of maize plant better than synthetic fertilizer and compost tea. The effect on the yield of Mexican sunflower compost at 15 t ha^{-1} was not significantly different from that of synthetic fertilizer at 150kg ha^{-1}. The use of organic fertilizer for improving soil fertility has the potential to sustain high crop production. This study showed that compost made with *Tithonia diversifolia* is an excellent source of plant nutrients. It is, therefore, recommended that the use of compost for maize production should be encouraged because of its nutrient composition of all the requirements of macro and micronutrients of the maize plant compared to mineral fertilizers and its environmental friendliness compared to the inorganic fertilizers and their health hazards. The comparative increase in the yield of maize grown on plots amended with 15 t ha^{-1} and synthetic fertilizer implies that compost can serve as an alternative to mineral fertilizer.

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