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Effect of Municipal Solid Wastes On Grain Yield of Three Maize Cultivars

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ABSTRACT: *The growth and yield of three maize cultivars were examined in relation to the impact of Municipal Solid Wastes (MSW) enriched soil. According to the results, plants grown on soil treated with MSW and inorganic fertilizer (NPK) produced significantly (P≤0.05) taller plants, larger leaves and higher number of leaves than plants grown on the control soil. On the other hand, plants grown on soils fertilized with MSW 1 showed significantly (P≤0.05) greater values of these indicators. The study also demonstrated that maize cultivar TZE yellow, EVDT 99 and Comp-1-synthetic showed no significant variation at the later growth stage but TZE yellow significantly (P≤0.05) had taller plants, larger leaves, and higher number of leaves at the early stage of crop growth. Comp-1-synthetic produced more grain and more grains per cob which was statistically at par with TZE yellow but differ significantly (P≤0.05) from EVDT 99. Crops grown on MSW and NPK treated soils had significantly (P≤0.05) higher grain yields and more grains per cob than those grown on the control soil. However, compared to NPK treated soils, MSW treated soils significantly (P≤0.05) produced better grain yield and number of grains per cob. The maize cultivars' differences in crude protein content were significant at P≤0.05. The crude protein content of TZE yellow was significantly (P≤0.05) higher than that of EVDT 99 and Comp-1-synthetic. Additionally, plants cultivated on MSW 1 treated soil had considerably higher crude protein content than plants grown on other soil types. Therefore, if municipal solid wastes are sorted and handled, MSW enriched soils could be employed to boost maize production.*

KEYWORDS: municipal solid waste (MSW), maize, cultivars, grain yield

INTRODUCTION

In Africa and the developing world in general, maize (*Zea mays* L.) is one of the most significant cereal crops (FAOSTAT, 2014, Onumah et al., 2021). It is the primary cereal grain grown in Nigeria and crucial to the nation's food output. Nigeria's annual production of maize was estimated at 20 million metric tons as of 2021 (FAOSTAT, 2022). In 2017, maize yields in Africa averaged less than 2 tons per hectare, which is significantly lower than the global average of roughly 10 tons per hectare. Smallholder rural poor farmers who cannot afford to pay the high cost of fertilizer cultivate the majority of the maize produced and consumed in Africa (Ammani *et al*., 2010). As a result, its cultivation occurs in environments with low soil fertility and limited availability to resources that would increase its productivity, such as inorganic fertilizers.

In recent years, maize production and consumption have greatly expanded as a result of the crop's importance as a staple, cash crop, and industrial crop (FARA, 2009). Demand for the crop by industries is rising, especially in the food, beverage, and livestock feed sectors. Available abandoned urban lands like Municipal Solid Waste (MSW) dump sites have been turned into agricultural fields for its cultivation in an effort to enhance yield and, consequently, its production in order to close the gap between supply and demand. Despite the fact that this approach appears to boost maize output, it has grave implications for human health (Omoloye, 2009). Additionally, low income farmers who are unable to buy chemical fertilizers turn to MSW as an organic manure to replenish such soils with the nutrients needed for plant growth (Abdallah *et al*., 2012).

In Africa, most available lands are indiscriminately used as dumping grounds for solid wastes. Some farmers collect the decomposed portions of these wastes and apply to their farmlands as manure so as to improve soil fertility and increase crop yields without proper knowledge on the chemical composition and the risks associated with such practices. Several literatures have reported that MSW from urban areas are applied as manure on agricultural lands to enrich nutrient depleted soils that have been under cultivation for many years and are deficient in essential nutrients needed for crop growth, thus becoming a cheaper alternative source of nutrients for the farmers (Ogunyemi *et al*., 2003; Amusan *et al*., 2005; Okoronkwo *et al*., 2005; Adajia *et al*., 2008; Ebong *et al*., 2007; Ibrahim and Salem, 2017). The MSW improve both soil physicochemical properties and nutrient status for better crop production. Such soils have increased total porosity; reduced bulk density; and high organic matter, which enrich the soil nitrogen content; cation exchange capacity (CEC) and improve pH (Azeez *et al*., 2011; Amos-tautua *et al*., 2014). However, adding these solid wastes to agricultural soil as organic manure could raise the levels of heavy metals and, as a result, reduce crop yield. Similar responses were observed in crops cultivated on MSW amended soils, ranging from nutrient deficit to poor crop production due to nitrogen immobilization (Erickson *et al*. 1999). As a result, research is required to determine how MSW fertilized soils in Bauchi state affect maize growth and output.

MATERIAL AND METHODS

As depicted in Figure 1, two seasons field experiments were carried out during the cropping seasons of 2013 and 2014 on portions of three farmlands that were previously fertilized with MSW, one farmland that had been fertilized with inorganic fertilizer along the Bauchi-Ningi Road, and an uncultivated land (with neither MSW nor inorganic fertilizer) at the ATBU permanent site in Gubi serving as a control. A Split-Plot Design was used to organize the experiment. The farmland soils (MSW1, MSW2, MSW3, inorganic fertilized and control (uncultivated land)) were the main plots while the maize cultivars {COMP-1- Synthetic (striga resistant), EVDT 99 (early maturing, striga and drought resistant) and TZE yellow (early maturing)} were the sub-plots. Each main plot was divided into 12 sub-plots and the maize cultivars were assigned to the sub-plots at random. Each maize cultivar was replicated four times within the main plot. Inorganic fertilizer (NPK 20:10:10) was applied at the rate of 120kg/ha to the plants cultivated on the NPK fertilized farm. The fertilizer was divided into two splits and applied 5cm away from the plants at two and six weeks after sowing (WAS) using band method (side placement) along the row.

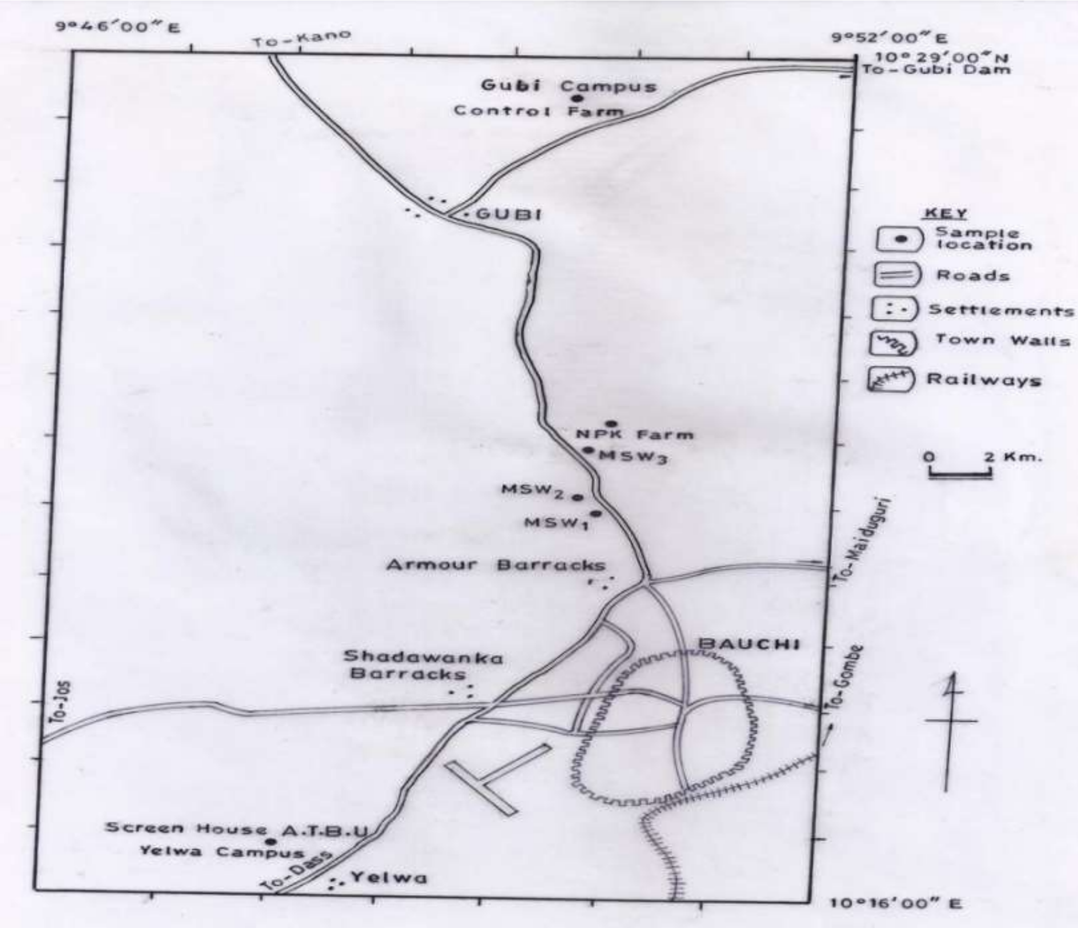

Figure 1: Map of part of Bauchi North - East showing the study areas

Data collection

For a period of 12 weeks, data on plant height, number of leaves, and leaf area of the plants were collected every two weeks. A carpenter's tape was used to measure each plant's height from the base to the apex. Leaf length was calculated by measuring the length of the largest fully expanded leaf using a carpenter's tape and the width of the largest leaf was measured by taking its broadest breath as a reading. In accordance with the methodology outlined by Onasanya *et al*., 2009 and Mokhtarpour *et al*., 2010, the leaf area was estimated by multiplying leaf length by leaf width x a constant (0.75) Number of leaves per plant was counted visually. The maize cobs were manually shelled, and the number of grains per cob, weight of 100 grains per cob, weight of 100 grains per plant, grain yield per plot, and the yield per hectare (kg/ha) were all recorded. The protein content of the maize grains was also determined using the method of Official Analytical Chemists (AOAC, 1990) technique.

Laboratory Analyses

The soils' physicochemical characteristics (nitrogen, phosphorus, potassium, pH, organic matter, and soil texture) were assessed using standard methods. The crude protein content of the maize grains was ascertained using the Association of Official Analytical Chemists (AOAC, 1990) technique. The total nitrogen content was calculated using the micro-Kjeldahl technique. The crude protein value was then calculated by multiplying the nitrogen percentage by a conversion ratio of 6.25.

Statistical Analyses

The Analysis of Variance (ANOVA) approach was used to statistically analyse the data collected on the maize crop's growth and yield parameters. Least Significant Differences (LSD) was performed to determine whether there were any significant differences between the means of the parameters studied from various farmlands and maize cultivars.

RESULTS

Physicochemical Properties of the Experimental Soils

Before planting the maize on the experimental soils, the findings of the physicochemical parameters of the soils are shown in Table 1. In terms of texture, soils fertilized with MSW 1 and 2 were categorized as loamy sand, but soils fertilized with MSW 3, inorganic fertilizer and the control were categorized as sandy loam. Soils treated with NPK and the control had pH values of 6.09 and 6.54, respectively, and were classified as slightly acidic, soils fertilized with MSW 2 and MSW 3 had pH values of 8.13 and 7.52, respectively, and were graded neutral. Only MSW 1 treated soils with a pH of 5.86 were categorized as moderately acidic. Organic carbon content of the MSW soils rated high, while soils fertilized with inorganic fertilizer (NPK) and the control were rated low. Soils treated with MSW 1 showed higher N content and was rated high, soils of MSW 2 and MSW 3 were rated medium while soils treated with NPK and the control were placed in the low category. Available Phosphorus content of the soils were in the following order MSW 1> MSW 2> MSW 3> soil treated with NPK> control soil and was categorized in the medium phosphorus fertility.

Table 1: Physicochemical Properties of the Experimental Soils before the Planting of Maize

	Soil Type				
Parameter	**MSW 1**	**MSW 2**	**MSW 3**	**NPK Farm**	**Control Farm**
pH in H_20(1:1)	5.86	8.13	7.52	6.09	6.54
Org. Carbon (%)	2.63	1.29	1.16	0.43	0.95
Total Nitrogen (%)	0.42	0.16	0.11	0.05	0.09
AVP ((mg/kg))	19.63	15.26	14.11	13.84	10.54
K+ (Cmol/kg)	0.37	0.31	0.34	0.23	0.30
Texture	Loamy Sand	Loamy Sand	Sandy Loam	Sandy Loam	Sandy Loam

Key: LS – Loamy Sand, SL - Sandy Loam, MSW 1, MSW 2and MSW 3 - farmland soils fertilized with Municipal Solid Waste, NPK Farm – farmland soil fertilized with inorganic fertilizer (NPK), Control Farm-Farmland soil without fertilizer (uncultivated land) AVP – Available Phosphorus, K+ - Potassium,

Plant height

Plant height at 2, 4, and 6 WAS were significantly ($P \leq 0.05$) affected by the different soil types (Table 2). At 2 WAS, soil treated with MSW 1, 2 and 3 produced taller plants while soil treated with inorganic fertilizer (NPK) significantly produced ($P \leq 0.05$) shorter plants. At 4WAS, soil treated with MSW 1 produced taller plants which was statistically different from all other soil treatments while the NPK treated soils produced shorter plants. Results of 6 and 8 WAS showed that plants cultivated on soils treated with MSW 1 and MSW 2 were statistically the same and performed significantly better than other soil treatments. Soils treated with NPK and the control produced shorter plants.

The effect of variety showed significant ($P \leq 0.05$) difference in plant height at 2 and 4 WAS. At 2 and 4 WAS, EVDT 99 and TZE yellow significantly ($P \leq 0.05$) produced taller plants while Comp 1- synthetic produced shorter plants. Similarly, plant height of the cultivars significantly ($P \leq 0.05$) varied with cropping seasons at 4, 6 and 8 WAS. Cropping season of 2014 produced taller plant than 2013 cropping season.

Table 2: Effects of year, soil type and variety on percentage germination at 1 WAS not in text and plant height (cm) at 2, 4, 6 and 8WAS

	Plant height (cm) at various weeks after sowing			
Treatment	2	4	6	8
Year				
2013	25.25	65.44b	94.94b	114.57b
2014	24.03	71.44a	108.36a	125.15a
LSD	Ns	2.28	5.28	5.05
Soil Type				
MSW 1	29.24a	92.05a	133.55a	158.86a
MSW 2	27.80a	84.98b	129.79a	149.36a
MSW 3	27.64a	64.43c	88.53b	106.22b
NPK Soil	18.08c	47.20d	79.51bc	92.79c
Control Soil	20.43b	53.55c	76.87c	92.07c
LSD	2.08	7.14	9.25	11.29
Variety				
Comp-1-synthetic	22.75b	64.41b	101.63	124.99
EVDT 99	25.13a	69.39a	101.87	117.45
TZE yellow	26.04a	71.53a	101.45	117.13
LSD	1.2	4.61	ns	ns
Interaction				
Soil x Year	***	*	***	***
Variety x Year	***	*	ns	ns
Variety x Soil	***	ns	ns	ns
Variety x Soil x Year	Ns	ns	ns	ns

Means with the same letters are not significantly different at P≤0.05 using Least Significant Difference (LSD).
Key: Ns-Not significant, MSW 1, MSW 2 and MSW 3 - farmland soils fertilized with Municipal Solid Waste, NPK Farm – farmland soil fertilized with inorganic fertilizer (NPK), Control Farm-Farmland soil without fertilizer (uncultivated land)

Number of leaves

Across the sampling dates, number of leaves were significantly (P≤0.05) higher in 2013 than 2014 planting season. Number of leaves also varied significantly (P≤0.05) with soil treatments at 2, 4, 6, and 8WAS (Table 3). Municipal Solid Waste 1 treated soils significantly (P≤0.05) produced higher number of leaves at 2 and 4WAS compared to other soil treatments while the NPK treated soil and the control produced the least at 2 and 4WAS, respectively. Similarly, at 6 and 8WAS, MSW 2 treated soil significantly (P≤0.05) produced higher number of leaves followed by MSW 1, which was statistically at par with MSW 3. The control and the NPK treated soil at 6 and 8 WAS had the least number of leaves. Significant varietal differences on the number of leaves were observed only at 2WAS (Table 3). TZE yellow significantly (P≤0.05) produced higher number of leaves than Comp 1- synthetic and EVDT 99. The least number of leaves was produced by EVDT 99 which was not significantly (P≤0.05) different from Comp- 1- synthetic.

Table 3: Effects of year, soil type and variety on number of leaves at 2, 4, 6 and 8 WAS

Treatment	2WAS	4WAS	6WAS	8WAS
Year				
2013	4.12a	7.02a	8.80a	12.56a
2014	3.31b	5.71b	6.65b	9.52b
LSD	0.1930	0.6033	0.599	0.3511
Soil Type				
MSW 1	4.30a	7.73a	8.37b	11.54b
MSW 2	4.05b	6.99b	9.30a	12.64a
MSW 3	3.64c	6.01c	7.86b	10.99b
NPK Farm	3.06d	6.03c	6.87c	9.76c
Control Farm	3.53c	5.05d	6.21c	10.27c
LSD	0.2368	0.4701	0.857	0.5726
Variety				
Comp-1-synthetic	3.63b	6.29	7.67	10.94
EVDT 99	3.61b	6.35	7.76	11.16
TZE yellow	3.91a	6.46	7.73	11.03
LSD	0.1554	ns	ns	ns
Interaction				
Soil x Year	***	ns	***	***
Variety x Year	**	ns	ns	**
Variety x Soil	ns	ns	ns	ns
Variety x Soil x Year	ns	ns	ns	ns

Means with the same letters are not significantly different at P≤0.05 using Least Significant Difference (LSD).

Key: Ns-Not significant, MSW 1, MSW 2 and MSW 3 - farmland soils fertilized with Municipal Solid Waste, NPK Farm – farmland soil fertilized with inorganic fertilizer (NPK), Control Farm-Farmland soil without fertilizer (uncultivated land)

Leaf area

Cropping season of 2013 significantly produced plants with larger leaves than 2014 season at 2, 4, and 8 WAS while non-significant (P≤0.05) variation was observed at 6 WAS. Leaf area increased numerically with growth stages of the crops. The effect of soil type on leave area differed significantly (P≤0.05) at all the sampling dates (Table 4). Municipal Solid Waste 1 significantly (P≤0.05) produced plants with larger leaf area at 2, 4, 6 and 8 WAS and did not differ significantly with the leaf area of plants cultivated on MSW 2 at 4 WAS. Statistically, the NPK and the control soil produced smaller leaf area at 2 and 8 WAS while at 6 WAS, MSW 3, NPK treated soils and the control significantly (P≤0.05) produced smaller leaves. However, these values differed significantly (P≤0.05) from all other soil treatments. Furthermore, the NPK and the control soil statistically produced plants with smaller leaves. Varietal differences in leaf area was only significant at 2 WAS. EVDT 99 and TZE yellow produced plants with larger leaves while Comp 1- synthetic recorded plants with smaller leaves.

Table 4: Effects of year, soil type and variety on leaf area (cm2) at 2, 4, 6 and 8 WAS

	Leaf area (cm^2) at various Weeks after sowing			
Treatment	**2WAS**	**4WAS**	**6WAS**	**8WAS**
Year				
2013	36.63a	212.10a	337.92	419.85a
2014	29.02b	169.78b	317.45	390.08b
LSD	4.80	38.71	ns	23.24
Soil Type				
MSW 1	48.39a	321.46a	510.31a	575.56a
MSW 2	40.68b	293.50a	426.22b	505.07b
MSW 3	36.41c	160.24b	266.59c	350.37c
NPK Farm	18.05d	78.53c	215.30c	316.28cd
Control Farm	20.61d	100.98c	220.01c	277.56d
LSD	4.834	43.63	53.89	50.18
Variety				
Comp-1-synthetic	30.07b	184.45	331.23	407.19
EVDT 99	34.77a	192.35	333.79	411.59
TZE yellow	33.63a	196.02	318.03	396.12
LSD	3.126	ns	ns	ns
Interaction				
Soil x Year	***	ns	***	***
Variety x Year	**	ns	ns	**
Variety x Soil	**	ns	ns	ns
Variety x Soil x Year	ns	ns	ns	ns

Means with the same letters are not significantly different at P≤0.05 using Least Significant Difference (LSD).

Key: Ns-Not significant, MSW 1, MSW 2 and MSW 3 - farmland soils fertilized with Municipal Solid Waste, NPK Farm – farmland soil fertilized with inorganic fertilizer (NPK), Control Farm-Farmland soil without fertilizer (uncultivated land)

100 grain weight per plant

The effect of growing seasons on one hundred grain weight was not significant (Table 5). Hundred grain weight was however significantly (P≤0.05) affected by soil treatments. Soil treated with MSW 1 produced plants with higher 100-grain weight and was statistically similar to plants cultivated on soils treated with MSW 2 but differed significantly (P≤0.05) from plants grown on all other soil treatments. The differences observed between soils treated with MSW 2 and MSW 3 was not significant. Also, plants from MSW 3 treated soils were found to be at par with plants from NPK treated soils while those from the control soil which gave the least one hundred grain weight was also found to be at par with plants grown on soils treated with NPK. The effect of variety was not significant on 100 grain weight.

Number of grains per plant

Higher number of grains per plant was significantly obtained from plants cultivated during 2014 growing season than that of 2013. Soils treated with MSW 2 which is at par with MSW 1 significantly (P≤0.05) produced plants with higher number of grains per plant followed by MSW 3 which is also at par with the NPK treated soils. In contrast, the least number of grains was recorded in plants from the control soil. Higher number of grains was recorded from Comp-

1- synthetic. The differences observed between Comp -1- synthetic and TZE yellow was not significant but differed significantly (P≤0.05) from EVDT 99 (Table 5).

Grain yield (Kg/ha)
Plants cultivated in 2014 cropping season performed significantly (P≤0.05) better than those of 2013. Maize crops cultivated on MSW 2 and MSW 1 treated soils significantly (P≤0.05) had higher grain yield. Differences in grain yield in plants from MSW 3 soil and the control were observed to be significant while non-significant difference was observed between plants from the NPK treated soils and the control. Significant varietal difference was observed on the grain yield (Table 5). Comp- 1- synthetic and TZE yellow performed significantly (P≤0.05) better than EVDT 99.

Crude protein content (%)
Crude protein content (CPC) of all the three maize cultivars were significantly (P≤0.05) higher in 2013 cropping season. Grains of plants cultivated on MSW 1 treated soil significantly had higher crude protein content compared to plants from other soil type. Plants cultivated on MSW 2 treated soils and the control produced grains with lower crude protein content. Significant varietal differences were also observed in crude protein content (Table 5). TZE yellow significantly had higher crude protein content while EVDT 99 had the lowest.

Table 5: Effects of year, soil type and variety on 100 grain weight, number of grains per plant and grain yield/ha

Treatment	100 grain weight (g)	Number of Grains per plant	Grain yield (kg/ha)	Crude protein content (%)
Year				
2013	21.46	238.97b	5200.37b	9.67a
2014	21.36	290.28a	6265.81a	8.01b
LSD	ns	23.85	284.3	1.52
Soil Type				
MSW 1	24.77a	338.84a	7994.44a	9.71a
MSW 2	22.99ab	353.26a	8007.60a	8.65c
MSW 3	20.94bc	239.76b	5166.45b	7.68d
NPK Farm	19.85cd	226.64b	4197.65bc	9.40b
Control Farm	18.49d	164.63c	3299.33c	8.75c
LSD	2.34	49.00	1328.8	0.11
Variety				
Comp-1-synthetic	21.39	292.27a	6332.64a	8.651b
EVDT 99	22.10	226.63b	5033.65b	8.540c
TZE yellow	20.73	274.98a	5832.99ab	9.322a
LSD	ns	33.35	1012.1	0.08
Interaction				
Soil x Year	ns	*	*	ns
Variety x Year	ns	ns	ns	ns
Variety x Soil	ns	ns	ns	**
Variety x Soil x Year	ns	ns	ns	ns

Means with the same letters are not significantly different at P≤0.05 using Least Significant Difference (LSD).

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DISCUSSION

Effect of Soil Type on the Growth Parameters of the Maize Cultivars

Plant height, number of leaves and leaf area were found to be significantly influenced by soil types across the sampling periods. Optimal levels of these parameters were generally recorded in plants grown on MSW 1 treated soils. The results further revealed that the growth parameters were significantly higher in plants grown on soils treated with MSW and NPK compared to the control soil. This might be attributed to the nutrient status of the soils (especially N) due to the presence of organic waste (which serve as nutrient reserve) in MSW treated soil and the effect of inorganic minerals in the NPK treated soil. This is in consonant with earlier works carried out by Carmine et al. (2004); Onasanya *et al*. (2009); Vaca *et al*. (2011); Agber and Ali (2012) and Simeon and Ambah (2013) who observed that nutrient availability for plants is strongly influenced by organic and inorganic amendments that usually increase the amount of carbon and other nutrients especially N.

The higher growth parameters of the maize plants cultivated on MSW treated soils compared to the NPK treated soil may not be unconnected with the fact that MSW soils are rich in a wide range of plant nutrients namely N, P, K, Zn, Cu, Fe, etc (Farrell and Jones, 2009). Lakhdar *et al*. (2011) observed that application of MSW at 40t/ha in growing *Mesembryanthemum edule* enhanced nutrients (N, P and K) uptake which led to increase of plant biomass as compared to NPK amended soil and the control. These findings were supported by Papafilippaki *et al*. (2015) who also concluded that MSW compost increased bioavailability of trace elements and stimulate the growth of Cichorium spinosum (Spiny chicory). Some previous studies (Gracia Gil *et al*., 2004; Fuentes et al 2010; Sabir and Zia-Ur-Rehman 2015; Blanchet et al 2016; Meena *et al*., 2016 and Nest *et al*., 2016) have also reported that MSW influenced soil quality thus, improved agricultural productivity.

The variation within MSW treated soil in the growth parameters may not be limited to the age and decomposition of the waste, nutrient content, type of waste containing materials deposited at each dumpsite. The growth parameters of the maize plant were generally higher in MSW 1 treated soil followed by MSW 2 and then MSW 3. The reason for the result could be due to the nutrient content of the soils especially N. The soil analysis revealed that the order of N and other nutrients was in the order of MSW 1>MSW 2>MSW 3. This agrees with the work of Onwudiwe *et al*. (2013) who concluded that the higher the concentration of nutrients in a treatment, the better the performance. Obidebube *et al*. (2012) obtained similar result and reported that maize cultivated on high nutrient soil performed better than those cultivated on low nutrient soil. Similarly, Agber and Ali (2012) reported significant increase in plant height, leaf area and stem diameter with increasing nutrient levels. Studies have shown that higher N level as observed in MSW 1 treated soil compared to MSW 2 and MSW 3 can drastically accelerate leaf elongation, plant height, number of leaves and higher dry matter accumulation (Ingested and Lund 1979).

Effect of Soil Types on Yield and Grain Crude Protein Content of the Maize Cultivars

Yield and yield components of the maize cultivars were generally influenced by the different soil types. Higher yield and yield components were obtained in plants grown on MSW and NPK treated soils compared to the control which agrees with the findings of Warman and Rodd (1998); Carbonell *et al*., (2011) and Gwenzi *et al*., (2016) who reported that MSW and NPK fertilizer substantially improved the yield and yield components of plants compared to those grown on control plot. The field experiment showed that MSW treated soil significantly increased yield and yield components compared to the NPK treated soils. It is known that MSW treated soils are rich in a wide range of plant nutrients which can significantly enhance crop yield. (Farrell and Jones 2009). This result conforms to those obtained by Mazen (1995); Carbonell *et al*., (2011) and Gwenzi *et al*. (2016) who reported higher yield and yield components in plants cultivated on MSW amended soils. The finding is further supported by Papafilippaki *et al*. (2015) who concluded that MSW stimulated the yield of Cichorium spinosum (Spiny chicory) and increase bioavailability of trace elements. Also, higher yield has been reported in Ryegrass and Red clover with addition of MSW (Zheljazkov *et al*., 2006 and Hargreaves *et al*., 2008).

The observation of the lowest and highest yield and yield components in 2013 and 2014 respectively could be attributed to the distribution of rainfall in the two years. Rainfall plays a major role on nutrient solubility and adsorption by plants and on the translocation of photosynthates from the source to the sink (Sangakkara et al. 2000). Generally, the amount of rainfall that is well distributed is needed for high maize yield.

The crude protein content of the maize grains was significantly higher in plants grown on MSW 1 treated soil compared to plants grown on other soil types and this may be adduced to the increased soil fertility. This result is in agreement with Akintoye and Olaniyan (2012) who observed that increase in soil fertility increased the values of proximate composition of maize grains. Similar findings were also reported by previous authors (Rutunga *et al*., 1998; Sevaram *et al*., 1998 and Ma *et al*., 1999). The values of the protein content where lower than the values observed by Malomo et al., (2012; 2013) and comparable to the values documented by Watson (1962).

Effect of Variety on Growth and Yield Parameters of the Maize Cultivars

Varietal variations had a substantial impact on how well the maize crop performed. The study showed that TZE yellow plants grew taller, had more leaves, and produced larger leaves at the early stages of their development but did not exhibit any significant variation at the later stages. These genotypic variations in portioning and redistribution of synthesis products, decreased N, and other N assimilatory pathways could be responsible for the varietal differences.

The trials' findings also showed that Comp-1-synthetic and TZE Yellow had much higher plant yield and yield components. According to Ma *et al*. (1999), Younas et al. (2002), and Nasim et al. (2012), who noted that genetic potentials had a major impact on yield and yield components of maize, the varietal differences in yield have a similar approach. Similar to this, other studies have documented differences in growth and yield among various maize varieties and genotypes (Hamidu, 1999; Bello, 2001; Ogunbode *et al*., 2001; Mani, 2004; Abdulai *et al*., 2007; Abdelmula and Sabie, 2007; Sharifi and Taghizadeh, 2009; Badu-Apraku and Fontem-Lum, 2010 and Sani *et al*., 2013). The variance in yield seen between the various maize cultivars may be due to environmental conditions. The amount of protein in a crop's grains or other edible components determines how well it grows. The amount of grain protein varied significantly between the maize varieties. The highest grain protein concentration was found in TZE Yellow.

CONCLUSION

Comparing TZE yellow to EVDT 99 and Comp-1-synthetic, TZE yellow performed better in terms of growth, yield, and crude protein content. Consequently, TZE yellow is advised for farmers in the agro-ecological zone. Further analysis of the results showed that crops grown on MSW fertilized soils significantly outperformed those grown on inorganically fertilized soils and the control. Hence, it is recommended to utilize Municipal Solid Waste (MSW) as an alternative and cost-effective organic source for enhancing soil fertility and subsequently boosting crop yield, given that these materials have undergone sorting, recycling, and treatment to eliminate detrimental elements.

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