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Composted municipal solid waste and NPK fertilizer effect on yield, yield components and proximate composition of maize

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Two year experiment was conducted in the Teaching and Research Farm of Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka to: compare the effect of combined municipal solid waste (MSW) and NPK fertilizer application on yield components, yield and proximate composition of maize. A 4 × 4 factorial experiment in Randomized Complete Block Design (RCBD) with three replications was used for the study. The two factors: MSW (0, 1000, 1500 and 2000 kg/ha) and NPK (20:10:10) (0, 100, 200 and 300 kg/ha) were combined to get 16 treatment combinations. Sole application of 2000 kg/ha of MSW and 300 kg/ha of NPK rates were observed to achieve the highest yield of maize in 2011 and 2012 seasons respectively among their treatment rates. Complementary application of MSW with NPK was significantly higher than either sole application with respect to plant attributes measured. Combination of 2000 kg/ha of MSW with 300 kg/ha of NPK had significantly higher effect than other interactions in both years and was found satisfactory to achieve the best yield performance and proximate composition of maize in the study.

Key words: Municipal solid waste, NPK, maize yield, yield components, proximate composition.

INTRODUCTION

municipalities are facing a growing problem of how to safely dispose off their solid waste. Bryan and Morton (2007) define municipal solid waste (MSW) as waste from multifamily, commercial, and institutional e.g. schools, government offices. This definition excludes many materials that are frequently disposed with MSW in landfills including combustion ash; water waste treatment residuals, construction and demolition waste, and non hazardous industrial process waste (U.S EPA, 2007).

In most developing countries like Nigeria, MSW are used as landfills or dumped in sites where people no longer use. In some sites where MSW are dumped, they are being burnt after heap of it is large and overflows the site at which it is dumped. Many strategies are being adopted to dispose wastes but most of them are neither safe to the environment nor sustainable for nutrient

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conservation (Rizwan et al., 2006). Municipal solid wastes compose of prutesible (biodegradable) and non prutesible (non-biodegradable) constituent. Prutesible fraction includes waste from kitchen, paper industries, wood scraps and others. Non prutesible includes waste from rubber, automobile and polythene industries and others.

Oyinlola (2001) reported that the organic components account for about 76% of total MSW in Nigeria. Anton et al. (2005) stressed that in order to minimize environmental impacts and the loss of organic resources, there should be measures taken to increase and improve sorting at origin, recuperation and recycling, including compositing of organic and green MSW. Organic MSW is described as household waste and other waste which because of its nature of composition, is similar to household waste, capable of undergoing anaerobic or aerobic decomposition, excluding green MSW from gardens and parks, which includes tree cuttings, branches, grass and wood (European Commission, 2001). Composting has been one of the best solutions to reduce the huge pile of organic waste and its conversion to a value added product. It is one of the major recycling processes by which nutrients present in organic materials are returned back to the soil in plant available form (Inckel et al., 1996). The application of organic manure to soil provides benefits including improving the fertility, structure, water holding capacity of soil, organic matter in the soil and reducing the amount of synthetic fertilizer needed for crop production (Phan et al., 2002; Blay et al., 2002).

The low fertility status of most tropical soils hinders crop production as most crops have a strong exhausting effect on the soil. It is generally observed that crops fail to produce reasonably in plots without adequate nutrients. Inorganic fertilizer such as NPK exerts strong influence on plant growth, development and yield (Stefano et al., 2004). The availability of sufficient growth nutrients from inorganic fertilizer lead to improved cell activities, enhanced cell multiplication and enlargement and luxuriant growth (Fashina et al., 2002). However excessive or continual use of NPK will lead to loss of soil fertility due to improper use of it which has adverse impact on agricultural productivity, caused soil degradation and even contaminate underground water resources.

Integrated use of organic nutrient sources with inorganic fertilizer was shown to increase the potential of organic fertilizer (Heluf, 2002) and improve the efficiency of inorganic fertilizer. Incorporation of chemical fertilizers in composted materials improves its efficiency and reduces losses (Gua and Geta, 1993). Rizwan et al. (2006) reported that, the integrated use of organic and inorganic plant nutrient sources not only reduces organic waste causing environmental pollution but also conserves rich pool of nutrients resources, which can reduce the sole dependence on chemical fertilizer. High and sustained crop yield can be obtained with judicious balance of NPK fertilization combined with organic matter amendment.

Maize has immense potential in the tropics and yields up to 7.5 t/ha of grain if the crop is properly managed (Kolawole and Joyce, 2009). Unfortunately, yields are still generally below 5 t/ha in Nigeria (FAO, 2007), and this has caused inadequacy of maize for its numerous usages. Yield differences within temperate areas have been attributed to low nutrient status of its soils especially nitrogen, phosphorus and potassium resulting from the practice of slash and burn farming system associated with bush fallow and excessive leaching of the soil nutrients. This system (slash and burn) is presently unsustainable due to high population pressure and other human activities which have resulted in reduced fallow period (Steiner, 1991). This study was conducted to achieve the following objectives: to compare the response of maize to combined MSW compost and NPK fertilizer application on yield, yield components and to determine the effect of MSW compost and NPK fertilizer on the nutrient composition of maize.

MATERIALS AND METHODS

Two year field experiment was carried out at the Department of Crop Science Teaching and Research Farm, University of Nigeria, Nsukka which is located at latitude 06° 521 N and longitude 07° 241 E with a 447 m altitude above sea level. It is within the lowland humid tropical agro ecology of Nigeria. The municipal solid waste used for the study was generated from waste bins found within University of Nigeria, Nsukka campus. The biodegradable materials were properly sorted before the materials were composted aerobically. The composted material included: food waste, paper, vegetable scrap, plant leaves, banana, cassava and pawpaw peelings and plant cuttings. The composted product used in the study was free of odour and dark in colour, but with small amount of foreign materials as defined by CCME (2000). The chemical fertilizer used was NPK (20:10:10) which was sourced from ENADEP depot in Nsukka. Figures 1, 2, 3 and 4 show stages of compost maturity during composting.

The experimental design was a 4 × 4 factorial in randomized complete block design (RCBD). The two factors: MSW compost (0, 1000, 1500 and 2000 kg/ha) and NPK 20:10:10 (0, 100, 200 and 300 kg/ha) were combined to produce 16 treatment combinations (Table 1) which was replicated three times. Two weeks after planting (WAP), the treatments were applied to the plots accordingly. The treatments were applied in a ring form (10 to 15 cm from the plant) and properly mixed with the soil at the base of the plant. The following parameters were measured: fresh weight, dry weight, ear length, ear weight, ear circumference, cob weight, 100 grain weight, shelling percentage, harvest index and grain yield. The harvested grains from the plots were analyzed in the laboratory to obtain their proximate composition.

Harvest index: This was obtained by calculating from the formula:

$$\frac{\text{Seed weight } (g/\text{plant})}{\text{Total dry matter of plant material} (g/\text{plant})}$$

Data was subjected to analysis of variance (ANOVA); means were separated using Fisher's least significant difference (F- LSD) procedure as described by Obi (2002). Test of significance was at 5% probability level.

Figure 1. Raw material used for the compost.

Figure 2. First stage of maturity.

Figure 3. Another stage of maturity.

RESULTS AND DISCUSSION

Table 2 shows the soil physicochemical properties. The soil is sandy loam in texture and moderately acidic. It is low in organic matter content, total nitrogen and exchangeable bases but had relatively moderate cation exchange capacity (CEC) and available phosphorous

Figure 4. Final stage (Matured compost) ready for use.

values. The low fertility status of the soil is common to most tropical soils due to their advance stage of weathering and high leaching tendency (Ibedu et al., 1988).

The chemical analysis of the municipal solid waste (MSW) showed that the MSW had organic matter (18.3%), total nitrogen (1.4%), potassium (0.28%) and available phosphorous (0.05%) but had a high pH value (8.3) which is capable of ameliorating the acidic content of the soil (Table 3). The MSW pH used for the study was high in water when compared the pH values of the experimental site. This suggests that application of the compost could have buffered the soil which helped the soil to provide the needed nutrient required by the plant after the compost was applied (Onwudiwe et al., 2013). Application of MSW could have also improved the soil structure, porosity, aeration, drainage and moisture holding capacity according to Bresson et al. (2001).

Application of 300 kg/ha NPK had the highest fresh weight of plant among NPK rates. Also, 2000 kg/ha MSW produced the highest fresh weight of plant among MSW rates. It was observed that combination of 2000 kg/ha of MSW with 300 kg/ha of NPK produced the highest fresh weight of plant in both years. The result also showed that application of 2000 kg/ha of MSW with 300 kg/ha of NPK gave the highest dry weight of plant among the treatment interactions.

Ear length was observed to perform highest with the application of 2000 kg/ha of MSW while 300 kg/ha of NPK also acted same among treatment rates in both years. Combined rates of 2000 kg/ha of MSW with 300 kg/ha of NPK produced the highest on ear length in both years. Application of 2000 kg/ha MSW with 300 kg/ha NPK in year 2012 produced the highest cob weight and 100 grain weight among the MSW x NPK treatment combination. Harvest index was observed to follow the same trend with cob weight and 100 grain weight (Table 4). Application of 2000 kg/ha with 300 kg/ha of NPK was observed to perform significantly higher ($P < 0.05$) than other combinations on shelling percentage in 2011 while 2000 kg/ha of MSW with 200 kg/ha of NPK produced the

Table 1. Treatment combinations used for the study.

NPK fertilizer (kg/ha)	MSW kg/ha			
	0	**1000**	**1500**	**2000**
0	0/0	1000/0	1500/0	2000/0
100	0/100	1000/100	1500/100	2000/100
200	0/200	1000/200	1500/200	2000/200
300	0/300	1000/300	1500/300	2000/300

Table 2. Physical and chemical properties of the experimental site prior to planting.

Physical properties	Particle size
Coarse sand (%)	40
Fine sand (%)	31
Clay (%)	24
Silt (%)	24
Class	Sandy clay loam
Chemical properties	Value
P^H in water	4.7
P^H in KCl	3.8
Organic carbon (%)	0.92
Organic matter	1.58
Total N (%)	0.028
P (ppm)	22.38
K (me/100 g)	0.25
Mg (me/100 g)	1.20
Ca (me/100 g)	1.40
Na (me/100 g)	0.23
CEC (me/100 g)	6.00
Exchange acidity	
Al (me/100 g)	2.00
H (me/100 g)	0.8

Table 3. Chemical characteristics of composted MSW used for the study.

Chemical properties	Value
pH in water	8.3
pH in KCl	7.8
Organic carbon (%)	10.64
Organic matter (%)	18.34
Total N (%)	1.401
P (%)	0.048
K (%)	0.279
Mg (%)	2.10
Ca (%)	4.00
Na (%)	0.558

highest shelling percentage in 2012 season. There were significant ($P < 0.05$) differences among the interaction effects in these yield components (Table 4). On grain yield per hectare, combined rate of 2000 kg/ha of MSW

Table 4. Effect MSW x NPK fertilizer rates on yield components and yield traits of maize in two years.

Year	MSW rate (kg/ha)	NPK rate (kg/ha)	FW (g)	DW (g)	EH	EW (g)	EC (cm)	COBW (g)	100GW (g)	SY/ha (kg)	H.I	SH%
2011	0	0	673.5	238.2	24.66	200.00	16.77	121.34	15.05	3477	0.27	54.02
		100	701.3	246.5	25.63	216.67	17.02	127.31	15.37	3764	0.28	55.77
		200	728.4	249.9	25.90	225.00	17.21	129.55	15.69	4111	0.30	59.86
		300	756.7	257.0	26.20	237.33	17.33	132.93	15.95	4299	0.31	61.04
	1000	0	763.5	254.8	25.83	238.33	17.25	129.88	15.85	4213	0.30	61.24
		100	803.3	265.3	26.64	242.00	17.51	138.07	16.26	4652	0.32	64.05
		200	823.7	268.6	26.90	246.67	17.76	140.56	16.36	5029	0.34	67.74
		300	857.7	275.9	27.18	250.67	17.87	142.39	16.58	5354	0.35	71.31
	1500	0	839.0	271.9	26.95	246.67	17.75	139.86	16.37	5041	0.34	68.33
		100	883.2	282.8	27.60	257.33	18.44	147.08	16.81	5352	0.35	69.14
		200	911.9	288.4	27.63	262.50	18.65	150.59	17.10	5818	0.38	73.34
		300	942.3	294.1	28.46	266.67	18.80	154.44	17.48	5978	0.38	73.56
	2000	0	954.3	293.4	28.16	259.33	18.94	153.37	16.92	5865	0.37	72.76
		100	984.1	300.0	28.66	271.67	19.26	157.26	18.97	6364	0.39	76.74
		200	1011.7	310.0	28.97	277.00	19.45	162.99	19.54	6455	0.38	75.29
		300	1037.8	315.3	29.25	286.00	20.30	165.84	19.76	6822	0.40	78.09
2012	0	0	667.5	272.0	25.37	189.20	16.18	159.60	36.00	2978	0.18	35.88
		100	817.5	556.7	26.37	229.00	14.52	185.30	22.00	3228	0.18	33.89
		200	891.6	654.0	27.21	229.90	17.36	193.90	24.00	3605	0.18	36.70
		300	846.7	700.0	27.40	234.70	17.88	194.60	27.00	3681	0.19	34.40
	1000	0	920.5	641.7	26.96	240.80	17.63	215.00	25.00	3818	0.18	37.25
		100	979.5	687.0	27.75	248.80	16.48	216.90	27.00	3994	0.20	35.19
		200	1020.0	708.7	29.09	264.80	16.97	223.90	25.00	4127	0.21	35.09
		300	1058.7	715.3	30.01	274.20	18.45	228.90	28.00	4358	0.23	36.20
	1500	0	1018.2	692.7	28.00	256.60	17.63	206.30	26.00	3066	0.22	40.59
		100	1093.7	730.0	27.88	264.10	16.88	231.70	28.00	4584	0.30	37.59
		200	1118.0	737.3	28.54	281.00	17.23	255.00	29.00	4766	0.25	38.67
		300	1140.0	752.0	29.10	283.20	17.82	237.40	30.00	4996	0.26	40.45
	2000	0	1068.3	725.0	28.63	271.10	17.41	228.94	27.00	5153	0.26	41.56
		100	1135.0	765.2	27.60	286.40	17.09	238.37	30.00	5258	0.27	41.92
		200	1152.3	784.0	28.95	299.20	17.41	238.00	30.00	5603	0.28	44.70
		300	1186.0	805.7	29.90	283.70	18.16	258.00	31.67	5828	0.29	43.06
		$F\text{-}LSD_{0.05}$	64.44	59.65	1.40	10.70	1.17	6.22	9.20	526.5	0.05	9.37

Where FW= Fresh weight, DW= dry weight, EL= ear weight, EC=ear circumference, CobW= cob weight, 100GW= 100 grain weight, SY/ha= seed yield per hectare, H.I= harvest index, SH%= shelling percentage.

with 300 kg/ha of NPK resulted to the highest yield among the treatment combinations.

Irrespective of weather condition of the planting seasons, the increase in MSW resulted to increase in yield components and yield. Municipal solid waste rate of 2000 kg/ha achieved the best yield traits among MSW rates in both planting seasons. This suggested that the increase in rate of MSW resulted to the increase in grain

Table 5. Effect of year on yield components and yield traits of maize plant in 2011 and 2012 planting seasons.

Year	Traits									
	FW 9g)	**DW (g)**	**EL (cm)**	**EW (g)**	**EC (cm)**	**COBW (g)**	**100GW (g)**	**SY/ha (kg)**	**H.I**	**SH%**
2011	854.5	275.8	27.16	248.96	18.14	143.35	16.86	5162	0.34	67.64
2012	1007.1	683.0	28.05	258.11	17.19	218.24	28.04	4315	0.23	38.32
F-$LSD_{0.05}$	16.11	14.91	0.35	2.67	0.29	1.55	2.30	131.6	0.01	2.24

Where FW= Fresh weight, DW= Dry weight, EL= Ear length, EW= Ear weight EG=Ear circumference, COBW= Cob weight, 100GW= 100 Grain weight, SY/ha= Grain yield per hectare, H.I= Harvest index, SH%= Shelling percentage.

Table 6. Meteorological data of the experimental site in 2011 and 2012.

Month	2011						2012					
	Rainfall (mm)		Temperature (°C)		Relative humidity (%)		Rainfall (mm)		Temperature (°C)		Relative humidity (%)	
	Total (mm)	Days	Max	Min	10AM	4PM	Total (mm)	Days	Max	Min	10AM	4PM
Jan.	0.0	0	32.1	18.4	57.1	44.7	0.0	0	31.7	19.8	58.2	48.7
Feb.	54.9	3	32.3	22.1	73.8	60.5	23.1	3	31.8	21.7	73.6	61.3
Mar.	14.5	2	33.5	23.0	72.2	57.7	0.0	0	33.4	23.0	71.3	53.4
Apr.	87.1	8	30.8	22.0	74.3	65.1	103.9	4	31.4	22.4	73.8	62.8
May	140.5	12	31.0	21.9	74.5	70.1	282.1	13	30.2	21.0	74.1	67.8
June	127.3	12	29.9	21.5	75.7	71.3	193.6	13	28.4	20.3	75.8	71.5
July	192.3	13	28.0	21.0	75.7	72.5	276.1	20	27.8	20.3	75.4	72.3
August	149.1	14	27.0	20.7	76.5	74.0	0.0	0	26.6	20.1	74.6	71.5
Sept.	254.0	15	28.0	20.7	76.8	74.0	307.5	16	27.7	20.4	75.8	75.3
Oct.	184.0	12	28.3	20.9	75.6	72.1	291.6	18	28.3	20.1	73.2	73.0
Nov.	28.0	2	30.3	20.8	69.3	59.5	61.0	4	30.1	21.6	73.8	73.8
Dec.	0.00	0	31.6	16.7	56.5	47.4	0.0	0	30.9	18.7	75.0	75.0
Total	**1231.7**	**93**	**362.8**	**228.9**	**818.2**	**768.9**	**1538.9**	**91**	**358.3**	**227**	**950.4**	**806**

filling and dry matter content of plant which resulted to appreciable grain yield. Application of NPK rate of 300 kg/ha followed same trend as MSW. Obidiebube et al. (2012) observed same when NPK at different levels was applied on maize. Combination of 300 kg/ha of NPK and 2000 kg/ha of MSW performed better than other treatment combinations with respect to plant parameters studied in the two planting seasons. Combined application of organic and inorganic fertilizers has been reported to increase plant growth and yield (Mahmoud, 2009; Patil, 2010; Nyangani, 2010; Milosevic and Milosevic, 2009). It was also reported that incorporation of chemical fertilizers in composted materials improves its efficiency and reduces losses (Gua and Geta, 1993).

The yield components and yield were also significantly affected by year of planting. The 2012 planting season performed significantly ($P<0.05$) higher than 2011 planting season in all yield traits except in ear circumference, grain yield per hectare and harvest index that were higher in 2011 (Table 5). This could be attributed to the distribution of rainfall in the two years (Table 6). The month of august marked the silking stage of the plant, when comparing the month of august in both years it was found that there was total drought in year 2012 which explains the better yield had in 2011 (Table 6). Drought stress generally lowers yield potential either by restricting growth during the vegetative period of development and hence the subsequent capacity for photosynthesis during grain filling or by damaging the embryo ears so that the sink for photosynthesis product is reduced (Aderi, 1993). In turn, rainfall plays a major role on nutrient solubility and absorption by plant and on the translocation of photosynthates from the source to the sink (Aderi, 1993). Generally, amount of rainfall that is well distributed is needed for high maize yield.

Table 7 showed that application of NPK, MSW and their interaction had significant ($P < 0.05$) effect on moisture content of grain. The highest moisture content was obtained when 300 kg/ha rate of NPK was applied and significantly ($P < 0.05$) differed from other rates of NPK. Application of 2000 kg/ha MSW also gave the highest moisture content and differed significantly ($P < 0.05$) from other MSW rates. The combination of 2000 kg/ha of MSW with 300 kg/ha of NPK had the highest moisture content among other combinations. Increase in concentration of treatment resulted to increase in the

Table 7. Effect of composted municipal solid waste (MSW) and NPK fertilizer on proximate composition of maize.

NPK Fertilizer (kg/ha)	MSW (kg/ha)				Mean
	0	1000	1500	2000	
Moisture content %					
0	5.590	6.027	6.363	6.540	6.130
100	5.727	6.143	6.373	6.737	6.245
200	5.883	6.210	6.527	6.913	6.383
300	6.033	6.313	6.607	7.060	6.503
Mean	5.808	6.173	6.467	6.812	6.315
Ash content %					
0	1.480	2.093	2.320	2.443	2.084
100	1.700	2.127	2.377	2.447	2.163
200	1.933	2.130	2.380	2.510	2.238
300	1.933	2.313	2.393	2.527	2.292
Mean	1.762	2.166	2.368	2.482	2.194
Crude fibre %					
0	2.007	2.337	2.517	2.720	2.395
100	2.110	2.427	2.587	2.803	2.482
200	2.240	2.480	2.630	2.903	2.563
300	2.350	2.508	2.703	2.977	2.634
Mean	2.177	2.438	2.609	2.851	2.519
Crude protein %					
0	7.520	7.833	8.260	8.397	8.003
100	7.563	8.123	8.383	8.047	8.029
200	7.733	8.203	8.453	9.083	8.368
300	7.937	8.270	8.570	9.220	8.499
Mean	7.688	8.108	8.417	8.687	8.225
Crude fat %					
0	2.467	2.753	3.363	4.210	3.198
100	2.520	3.117	3.940	4.400	3.494
200	2.580	3.273	3.920	4.490	3.566
300	2.867	3.353	4.203	4.593	3.754
Mean	2.608	3.124	3.857	4.423	3.503
Carbohydrate %					
0	82.417	81.050	79.563	78.127	80.289
100	82.247	80.187	78.517	77.347	79.574
200	81.583	79.833	78.580	76.877	79.218
300	80.813	79.557	77.917	76.383	78.667
Mean	81.765	80.157	78.644	77.183	79.437

	MC	Ash C	C. fib	C.P	C.F	Cab
F-$LSD_{0.05}$ for comparing 2 NPK rates:	0.079	0.086	0.070	0.3751	0.1759	0.3414
F-$LSD_{0.05}$ for comparing 2 MSW rates:	0.079	0.086	0.070	0.3751	0.1759	0.3414
F-$LSD_{0.05}$ for comparing 2 NPK x MSW rates:	0.159	0.173	0.140	0.7502	0.1759	0.6828

Where: MC= moisture content, Ash C= ash content, C.fib= crude fibre, C.P= crude protein, C.F= crude fibre, Cab= carbohydrate.

moisture content of grains.

Application of NPK, MSW and their interaction significantly ($P < 0.05$) influenced ash content of grain (Table 7). Application of NPK at 200 and 300 kg/ha gave statistically ($P < 0.05$) similar effect but significantly ($P < 0.05$) higher than 0 kg/ha rate of NPK. Application of 300 kg/ha NPK had significantly (P < 0.05) higher ash content than 0 kg/ha of NPK. The 2000 kg/ha of MSW gave the highest ash content and differed significantly (P < 0.05) from other MSW treatments. Combination of 2000 kg/ha MSW with 300 kg/ha NPK had significantly (P < 0.05) higher ash content over 0 kg/ha of NPK with 0 kg/ha of MSW. Ash content of grain increased with increase in treatment rates.

Crude fibre was significantly (P < 0.05) influenced by the application of NPK, MSW and their interaction (Table 7). The 300 kg/ha rate of NPK gave the highest crude fibre content among NPK rates while 2000 kg/ha of MSW had the highest crude fibre among the MSW rates. Interaction of 2000 kg/ha of MSW with 300 kg/ha of NPK gave significantly (P < 0.05) higher crude fibre content than combination of 0 kg/ha of NPK with 0 kg/ha of MSW.

The application of NPK, MSW with their interaction showed significant (P < 0.05) effect on crude protein content (Table 7). The effect of 200 and 300 kg/ha rates of NPK were statistically (P < 0.05) similar but significantly (P < 0.05) higher than 0 kg/ha of NPK. The 300 kg/ha of NPK produced significantly (P < 0.05) higher crude protein than 0 kg/ha of NPK. Application 1500 and 2000 kg/ha of MSW produced statistically (P < 0.05) the same effect but significantly (P < 0.05) higher than 0 kg/ha of MSW. Interaction of 2000 kg/ha MSW with NPK 300 kg/ha obtained significantly (P < 0.05) higher crude protein than interaction of 0 kg/ha of NPK with 0 kg/ha of MSW. Increase in treatment concentration resulted to increase in grain crude protein. The finding suggests that N assimilation increased with increase in treatment application rate especially as it determined the crude protein content of the grain. Also, Table 7 showed that NPK, MSW and their interaction had significant (P < 0.05) effect on crude fat content. The application of 100 and 200 kg/ha rates of NPK were statistically (P < 0.05) the same but significantly (P < 0.05) higher than 0 kg/ha of NPK with respect to crude fat. The 300 kg/ha rate of NPK produced the highest crude fat among NPK treatments while 2000 kg/ha of MSW gave the highest crude fat among MSW rates. Combination of 2000 kg/ha of MSW with 100 kg/ha of NPK gave significantly (P < 0.05) higher crude fat over 0 kg/ha of NPK with 0 kg/ha of MSW.

The application of NPK, MSW and their interaction produced significant (P < 0.05) effect on carbohydrate content (Table 7). Zero kg/ha rate of NPK had the highest carbohydrate among other NPK rates while 0 kg/ha rate of MSW obtained the highest carbohydrate among MSW treatments. Combination of 0 kg/ha of NPK with 0 kg/ha of MSW had the highest carbohydrate content among the treatment combinations. Carbohydrate decreased with increase in concentration of treatment rates. Municipal solid waste increased proximate composition of maize grain as the application rate increased except for carbohydrate that decreased with increase in application rate. Application of NPK followed same trend with MSW. The relationship between N fertilizer and consumption of soluble carbohydrates in plants may be due to metabolism nitrogen fixation. Since some of the intermediate metabolic in TCA cycle is used for amino-acid and protein synthesis, so the amount of carbohydrate is reduced especially in crops like maize (Almodares et al., 2009). This was also observed by Savotskii and Salmanov (1972) and Ghaly (1976) that increasing N fertilizer rate of corn plant decreased the total soluble sugar % and carbohydrate % in grains of corn. Complementary application performed better than sole application. This result is in agreement with those of Akintoye and Olaniyan (2004) when they observed that fertilizer application significantly increased the values of proximate composition of maize grain. Increase in yield attributes and nutritional value of crops arising from the use of combination of organic and chemical fertilizers has also been reported (Bagheri et al., 2011). Ogbonna et al. (2012) also reported that improved nutritional value of maize grain resulting from the application of the formulations may be attributed to the increased soil fertility.

Conclusion

The experiment result showed that combined application of MSW with NPK performed better than sole application of MSW or NPK fertilizer. Municipal solid waste rate of 2000 kg/ha performed better than other lower rate while 300 kg/ha of NPK performed better than other lower rates. Combination of 2000 kg/ha of MSW and 300 kg/ha performed better than other treatment combinations and was found satisfactory to improve yields and proximate composition of maize in the study. It is recommended that further research should be carried out to determine the optimum rate required for maize production since performance increased with increase in rate of application.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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