VEGETATIVE PERFORMANCE OF MAIZE (Zea Mays L) ON DEGRADED SOIL AS AFFECTED BY COMPOSTED ORGANIC RESIDUES

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ABSTRACT

The evaluation of five different compost types; Poultry manure + Mucuna husk (PmMh), Poultry manure + Leaf litter (PmLl), Poultry manure + Rice straw (PmRs), Poultry manure + Leaf litter + Rice straw (PmLlRs) and Poultry manure + Leaf litter + Mucuna husk (PmLlMh) on the performance of maize under greenhouse conditions was investigated.

Maize variety ACR 9931-DMRSR treated with 1.5, 3.5, 4.5 and 6.0 t ha-1 each of the compost treatments was used in first cropping, while NPK 15-15-15 applied at 300, 400 and 600 kg ha-1 and control (no fertilizer) were also observed in the second cropping. A completely randomized experimental design with 24 treatments in three replications was conducted. Significant differences ($p < 0.05$) were found in plant height and dry matter yield of maize. N, P and K uptake of maize from 1.5 t ha-1 PmLlMh were 20.4, 6.2, 21.9 mg-1 pot respectively and these values were significantly ($p < 0.05$) higher than that of uptake values obtained from NPK treatment. Residual effect of plant height, dry matter yield and nutrient uptake of maize values obtained from 1.5 t/ha PmLlMh was also significantly ($p < 0.05$) higher than that of NPK values. It was concluded that PmLlMh at 1.5 t ha-1 could serve as effective compost for maize production.

Keywords: Compost, Mucuna husk, Rice straw, Leaf litter, Nutrient uptake

INTRODUCTION

The ever-increasing population of many countries of the world has necessitated the development of intensive agricultural technologies to sustain food yield. Soil fertility maintenance is essential in achieving and maintaining high crop yields over a period of time and fertilizer application has usually been the major means of external supplying plant nutrients. (Makinde and Ayoola, 2010). Use of mineral fertilizers has proven to be more convenient than the use of organic fertilizers that have traditionally been used since pre-industrial age; this is to increase production per unit of land in the face of growing shortage of arable land (Hartemink, 2003). The impact of increased use of mineral fertilizers has been high but the resulting soil physical degradation, increased soil acidity level and soil nutrient imbalance have drawn the attention of researchers back to the use of organic materials as suitable soil amendments for increasing crop production (Makinde and Ayoola, 2010). There is a wide range of technological options for improving soil conservation, either by chemical fertilizer, use of organic wastes, green manuring, farmyard manure, agro forestry technologies, alley farming and fallowing (Kang et al., 1991; Sanchez and Hailu, 1996; Nottifige et al., 2005; Ayoola and Makinde, 2008; Adeoye et al., 2008; Olowoake, 2009).

Researches have shown that continuous cropping have resulted into a decline of soil organic carbon, although the rate and magnitude of the decline is climate and soil dependent and can be ameliorated by wise soil management practices (Reeves, 1997). One of the most promising methods to improve soil fertility in intensified cropping systems is composting of organic residue. By composting, the use of chemical fertilizer could be reduced and energy cost for the manufacturing of this fertilizer could be saved (Qayyum, 2001). Composting of poultry manure, leaf litter, rice straw and mucuna husk can as well provide a compostable mixture in different proportions that will reduce dependence on chemical fertilizers, increase the yield of maize, and improve soil fertility as well as eliminating the problems of high rates of organic fertilizer use. The public outcry by farmers over the acute scarcity and high cost of mineral fertilizer provided a strong case for an accelerated support into the research on the effect of composted organic residues on the vegetative performance of maize (Zea mays, L) in degraded soil.

Materials and Methods

This investigation was conducted under greenhouse condition at the International Institute of Tropical Agriculture (IITA), Ibadan Nigeria. Organic materials investigated included straws of Nerica 1 rice variety, Mucuna husks, poultry manure and leave litters of Gliricidia sepium all obtained at IITA. The Leaf litter, Mucuna husk and rice straw were shredded before they were composted by pit method for nine weeks. Combining organic waste materials of low and high carbon nitrogen (C: N) ratios reduces the overall C: N ratio of one product, which increases the rate at which decomposition takes place. Rice straw, mucuna husk and leaf litter are known to have a high C: N ratio while poultry manure has a low C: N ratio. The mixtures were turned every fortnight and watered. The compost materials were allowed to cure for two weeks. The Nutrient analyses of the various composts: poultry manure and rice straw (PmRs), poultry manure and mucuna husk (PmMh), poultry manure and leaf litter (PmLl), poultry manure, leaf litter and rice straw (PmLlRs), poultry manure, leaf litter and mucuna husk (PmLlMh) were carried out in the laboratory using the procedure described by Okalebo et al (1993).

Soil samples from the top 0-20 cm were collected from the experimental site for laboratory analysis. The samples for pot experiment were air dried ground and screened through 2 mm sieve for physical and chemical characterization of the soil. The soil sample was analyzed for soil texture, pH, organic carbon, total N, extractable P and exchangeable levels of Ca, Mg and K. Soil texture was determined by the Bouyoucos hydrometer method (Juo, 1978). Soil pH was measured electrometrically in a 1:2.5 soil-water suspension (McLean, 1982). Organic carbon was determined by rapid dichromate oxidation method. Total nitrogen was determined by the Micro Kjeldahl method (Bremner and Mulvaney, 1982), whereas extractable P was determined by Bray 1 Method (Bray and Kurtz, 1945). Exchangeable levels of Ca, Mg and K were determined by the atomic absorption spectrophotometer following the procedures outlined by Wilde et al (1979).

Experimental Design and Treatments

The first and second experiments were conducted in the greenhouse. They were laid out in a completely randomized design (CRD) with three replications. The compost treatments were thoroughly mixed with 2.5 kg of soil in plastic pots. Maize variety ACR9931-DMRSR (Yellow variety, Downy mildew streak resistance) was planted into the pots at the rate of three seeds / pot and later thinned to two seedling / pot. The treatments used in this experiment are summarised below;

1 Control (No fertilizer)	13 PmRs – 1.5 t/ha
2 NPK 15 –15-15 – 400 kg /ha	14 PmRs – 3.5 t/ha
3 NPK 15 –15-15 -300 kg /ha	15 PmRs – 4.5 t/ha
4 NPK 15 –15-15 - 600 kg /ha	16 PmRs – 6.0 t/ha
5 PmLlRs- 1.5 t/ha	17 PmLl- 1.5 t/ha
6PmLlRs- 3.5 t/ha	18 PmLl- 3.5 t/ha
7 PmLlRs- 4.5 t/ha	19 PmLl- 4.5 t/ha
8 PmLlRs- 6.0 t/ha	20 PmLl- 6.0 t/ha
9 PmMh- 1.5 t/ha	21 PmLlMh- 1.5 t/ha
10 PmMh- 3.5t/ha	22 PmLlMh - 3.5 t/ha
11 PmMh- 4.5 t/ha	23 PmLlMh - 4.5 t/ha
12 PmMh - 6.0 t/ha	24 PmLlMh - 6.0 t/ha

Key: Pm- Poultry manure, Rs - Rice straw, Mh - Mucuna husk, Ll - Leaf litter

In the first experiment, maize plants were grown for six weeks on the soil collected from the field that has been exhaustively cultivated with various crops ranging from cowpea, maize and yam for over eight years at IITA, Ibadan after which they were harvested. Parameters measured included plant height and leaf dry matter yield. At six weeks after planting (6 WAP), maize shoots were harvested from the ground level, oven dried at 70oC to a constant weight; and the weight recorded as dry matter yield.

The second experiment was set up to investigate the residual effects of compost on the dry matter yield of maize. The soil in each of the pots was air dried separately; watered and maize variety ACR9931-DMRSR was re-seeded without application of treatment. Watering and weeding were carried out throughout the experimental period. The experiment was terminated at six weeks after planting (6 WAP). The plant parts were analyzed for their nutrient concentration N, P and K (Okalebo et al., 1993). Data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Duncan's Multiple Range Test (DMRT) at 5 % level of probability (SAS, 1999).

Results and Discussion

The physico-chemical properties of the experimental soil revealed that the soil was moderately acidic and of sandy clay loam texture (Table 3). The total carbon value of 3.0 g kg-1 was less than the critical level of 8.7 g kg-1 for soil in Southwestern Nigeria (Sobulo and Adepetu, 1987). The total N content of 2.66 g kg-1 was above the critical level of 1.5 g kg-1 (Enwenzor et al., 1979), while the available P of 9 mg kg-1 was below the critical level of 10-16mg kg-1 (Adeoye and Agboola, 1985). The K status of the soil which was 0.1 cmol kg-1 was also less than the critical level of 0.2 c mol kg-1 (Adeoye, 1986). Therefore, the soil was generally low in total C, P and K; indicating possible positive response of crops to the applied compost. The results of nutrient analysis of compost show that N content of PmLl and PmLlRs were significantly different from other compost. The P content of compost PmLlMh which was 13.1 g kg-1 was also significantly higher than other compost indicating that this compost contains high P nutrient element. However, K content shows that there were no significant differences ($p<0.05$) between PmMh, PmLlRs, PmRs and PmLl (Table 1). Growth parameters were significantly ($p<0.05$) affected by compost in both cropping cycles (Table 3 and 4). In general, crop performance in the second cropping experiment was better than in the first cropping indicating that the added composted organic fertilizer, which had been applied to the pot before planting, was still available to the plants. In the first cropping and for most parameters, the values obtained for the compost PmLlMh at 1.5 t /ha were significantly higher than what was observed for NPK and control plants. The application of compost PmLlMh at 1.5 t /ha had higher dry matter yield when compared to NPK in the first cropping. This agrees with findings of Kihanda (2003), Oghoghoddo and Ilegar

(1995) and Titiloye (1982) who reported that the quantity of organic residues added to the soil might influence the rate of decomposition which in turn affects the dry matter yield. In the second cropping, the tallest plant were produced by application of 2.5 t /ha PmLlMh compost. These values were 32 % higher than that obtained from the control plants. The dry matter yield values obtained for PmLlMh at 1.5 t /ha were higher than the values obtained for NPK and control plants. Nevertheless, for nutrient uptake, PmLlMh at 1.5 t /ha performed significantly ($p<0.05$) better than NPK and control treatment in both first and second cropping (Table 5 and 6). For the second cropping plants, application of 1.5 t /ha PmLlMh compost gave the highest plant height while the least was recorded in control treatments.

The significant increase in the maize growth and dry matter yield with the addition of compost during both first and second cropping may be due to the supply of essential nutrients especially N, P, K and S by the compost which are important in the determination of yield components (Jones, 1993). Similar observations were also reported by several researchers including Jama et al (2000) and Smaling et al (2002) who reported significant increases in the maize yield with the addition of organic manure.

Conclusion

The study has shown that irrespective of cropping cycle, the use of 1.5 t /ha PmLlMh produced the highest plant height, dry matter yield and nutrient uptake. This was significantly higher than NPK and control treatment. Similar results were observed in the second cropping.

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Table 1: Nutrient analysis of the compost materials

Nutrient	Compost				
	PmMh	PmLlRs	PmRs	PmLl	PmLlMh
pH (H_2O)	5.9b	6.1a	6.3a	5.8b	6.7a
N (g /kg)	8.1b	10.5a	7.0c	10.4a	6.9c
Org. C (g /kg)	75.5b	78.1a	75.6b	74.3b	70.4b
P (g /kg)	4.4c	6.1b	4.8c	5.6b	13.1a
K(g /kg)	6.0a	5.7a	6.0a	5.8a	5.0b
Ca (g /kg)	1.6d	2.8c	2.0c	4.4b	7.8a
Mg (g /kg)	1.5c	2.2b	2.0b	3.1a	2.9a
Zn (mg kg)	11.8c	11.6c	9.9c	13.0b	17.3a
Fe (mg /kg)	65.4a	57.9b	56.5b	44.2c	41.3c
Cu (mg /kg)	25.9b	23.4b	20.0c	28.7a	28.4a
Na (mg /kg)	16.4d	48.5b	49.6b	63.5a	38.2c
C:N ratio	9:1	7:1	11:1	7:1	10:1

Source: Field Survey 2010

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level

Legend:

PmRs = Poultry manure + Rice straw,
PmMh = Poultry manure + Mucuna husk
PmLlMh = Poultry manure + Leaf litter + Mucuna husk
PmLl = Poultry manure + Leaf litter
PmLlRs = Poultry manure + Rice straw + Leaf litter

Table 2: Physico-Chemical Properties of the experimental soil.

Parameters	Soil test value
pH	5.5
Org. C (gkg^{-1})	3.0
Total N (gkg^{-1})	2.66
P Mehlich ($mgkg^{-1}$)	9
Exchangeable bases (c mol kg^{-1})	
K	0.1
Mg	0.2
Ca	0.2
Extractable micronutrients (cmol kg^{-1})	
Fe	87
Zn	69
Textural Class (cmol kg^{-1})	
Sand	892
Silt	74
Clay	34
Textural class	Sandy clay loam

Source: Field Survey 2010

Table 3: Growth parameters of maize as influenced by application of compost during the first cropping in the greenhouse

Treatment	Rate (t /ha)	Plant height (cm) ---------- WAP ----------			Number of Leaves ---------- WAP ----------			Stem girth (cm) ---------- WAP ----------		
		2	4	6	2	4	6	2	4	6
Control	0	17.0bc	24.9b	32.4c	5	6b	10b	1.6b	2.2c	2.3c
PmMh	1.5	19.4ab	25.7ab	34.2bc	5	7ab	11ab	1.8ab	2.4b	2.4c
	3.5	21.2ab	29.7ab	39.0bc	5	7ab	11ab	1.9a	2.5b	2.6b
	4.5	21.3ab	29.1ab	40.8bc	5	7ab	11ab	1.9a	2.5b	2.3c
	6.0	20.9ab	27.2ab	39.5bc	5	8a	11ab	1.8ab	2.5b	2.5b
PmRs	1.5	19.7ab	24.4b	35.8bc	6	8a	11ab	1.7ab	2.0c	2.1c
	3.5	17.9bc	24.3b	34.3bc	6	8a	11ab	1.6b	1.9c	2.0c
	4.5	19.0ab	25.4ab	34.2bc	6	8a	11ab	1.7ab	2.1c	2.1c
	6.0	21.5a	27.8ab	42.0b	5	7ab	11ab	1.8ab	2.4b	2.5b
PmLl	1.5	20.5ab	28.2ab	37.7bc	5	7ab	11ab	1.7ab	2.3b	2.5b
	3.5	21.0ab	28.2ab	39.5bc	5	7ab	11ab	1.8ab	2.2c	2.4c
	4.5	20.2ab	27.2ab	37.2bc	6	8a	13a	1.8ab	2.4b	2.3c
	6.0	20.2ab	26.8ab	37.9bc	5	8a	12ab	1.8ab	2.3b	2.4c
PmLlRs	1.5	19.8ab	29.7ab	40.7b	5	6b	10b	1.8ab	2.4b	2.5b
	3.5	19.6ab	27.8ab	40.0b	5	7ab	11ab	1.8ab	2.4b	2.4c
	4.5	22.6ab	29.7ab	40.3b	5	8a	11ab	1.8a	2.5b	2.6b
	6.0	19.8ab	23.3b	40.7b	5	8a	11ab	1.9a	2.5b	2.5b
PmLlMh	1.5	23.3a	32.7a	48.8a	5	8a	13a	2.0a	2.7a	2.9a
	3.5	22.1ab	29.7ab	38.5b	5	7ab	11ab	1.9ab	2.5b	2.6b
	4.5	21.2ab	30.1ab	40.7b	5	7ab	11ab	1.7ab	2.4b	2.3c
	6.0	19.8ab	26.3ab	41.8b	5	8a	11ab	1.7ab	2.3b	2.4c
NPK	0.3	19.8ab	28.5ab	32.8c	5	7ab	12ab	1.7ab	2.4b	2.4c
	0.4	20.4ab	29.8ab	40.8b	6	8a	13a	2.0a	2.5b	2.7b
	0.6	20.6ab	28.4ab	32.2c	5ns	7a	12ab	1.9a	2.5b	2.7b

Source: Field Survey 2010

Means having the same letter along the c olumns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Legend:

PmMh = Poultry manure + Mucuna husk

PmRs = Poultry manure +Rice straw

PmLl = Poultry manure + Leaf Litter

PmLlRs= Poultry manure + Leaf Litter + Rice straw

PmLlMh = Poultry manure + Leaf Litter + Mucuna husk

Table 4: Growth parameters of maize as influenced by application of compost during the second cropping in the greenhouse

Treatment	Rate (t /ha)	Plant height (cm) ---------- WAP ----------			Number of Leaves ---------- WAP ----------			Stem girth (cm) ---------- WAP ----------		
		2	4	6	2	4	6	2	4	6
Control	0	22.3b	29.0b	30.0c	5.0	8.3c	10.0c	1.7b	2.1b	2.4c
PmMh	1.5	26.3ab	34.5ab	48.2b	6.0	8.7bc	10.7c	1.7b	2.2ab	2.6b
	3.5	29.7a	40.0a	48.3b	6.0	9.0b	11.3a	1.9ab	2.3ab	2.5b
	4.5	27.0ab	38.8a	48.4b	6.0	8.7bc	11.0b	1.9ab	2.2ab	2.4c
	6.0	29.3a	37.3ab	49.3b	6.0	9.0b	12.3b	2.1ab	2.5ab	2.5b
PmRs	1.5	26.7ab	34.7ab	48.3b	6.0	9.0b	11.0bc	1.8ab	2.3ab	2.4c
	3.5	28.3ab	36.3ab	47.7b	6.0	9.0b	12.0b	2.2ab	2.3ab	2.6b
	4.5	27.3ab	36.3ab	53.3a	6.0	9.0b	12.0b	2.0ab	2.3ab	2.5b
	6.0	27.2ab	37.7a	55.0a	6.0	8.7bc	11.7b	2.1ab	2.6ab	2.5b
PmLl	1.5	27.0ab	34.7ab	49.3b	5.7	9.0b	11.0b	1.8ab	2.5ab	2.6b
	3.5	29.3a	36.3ab	55.3a	6.0	9.3b	11.7b	2.2ab	2.3ab	2.6b
	4.5	28.7ab	38.7a	52.5a	5.0	8.7bc	11.3b	2.0ab	2.3ab	2.4c
	6.0	27.7ab	36.7ab	49.2b	6.0	9.0b	11.7b	2.1ab	2.2ab	2.4c
PmLlRs	1.5	28.0ab	38.3a	48.3b	5.0	9.0b	12.3b	1.7ab	2.3ab	2.2c
	3.5	29.0ab	37.3ab	48.7b	5.0	9.0b	12.0b	1.9ab	2.3ab	2.5b
	4.5	26.0ab	37.7a	49.3b	6.0	9.3b	12.3b	1.9ab	2.5ab	2.4c
	6.0	27.0ab	38.3a	47.7b	5.0	8.7bc	12.0b	1.8ab	2.3ab	2.4c
PmLlMh	1.5	29.2a	41.0a	55.7a	6.0	10.3a	13.8a	2.3a	2.7a	2.9a
	3.5	26.3ab	33.3ab	46.7b	6.0	8.7bc	11.3b	1.9ab	2.3ab	2.5b
	4.5	27.7ab	39.0a	48.8b	6.0	9.0b	12.7b	1.9ab	2.3ab	2.3c
	6.0	28.7ab	35.7ab	44.0b	6.0	10.0a	13.0a	1.7b	2.6ab	2.6b
NPK	0.3	27.3ab	38.7a	46.7b	5.0	8.7bc	11.7b	1.9ab	2.3ab	2.6b
	0.4	27.7ab	38.7a	48.3b	6.0	9.0bc	12.0b	1.8ab	2.2ab	2.4c
	0.6	25.7ab	36.0ab	48.3b	6.0ns	8.7bc	11.3b	1.6b	2.3ab	2.5b

Source: Field Survey 2010

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Legend:

PmMh = Poultry manure + Mucuna husk

PmRs = Poultry manure +Rice straw

PmLl = Poultry manure + Leaf Litter

PmLlRs= Poultry manure + Leaf Litter + Rice straw

PmLlMh = Poultry manure + Leaf Litter + Mucuna husk

Table 5: Nutrient uptake by maize as influenced by application of compost during the first cropping in the greenhouse

Treatments	Rate (t /ha)	Dry matter yield (g)	Nutrient Uptake mg pot^{-1} N	P	K
Control	0	2.3c	7.0c	2.0d	10.3c
PmMh	1.5	2.9bc	7.1c	2.8d	14.9bc
	3.5	3.6b	10.6c	3.3c	16.4bc
	4.5	3.2b	8.5c	5.6b	16.8bc
	6.0	3.2b	9.2c	5.6b	17.3b
PmRs	1.5	2.3c	5.2d	3.9c	13.2bc
	3.5	2.1c	4.6d	4.1bc	10.8c
	4.5	2.1c	4.2d	3.6c	11.7c
	6.0	3.4b	11.9bc	5.7b	17.8b
PmLl	1.5	2.8bc	8.6c	2.5d	11.8c
	3.5	3.0b	10.4c	2.9d	13.6bc
	4.5	2.8bc	9.2c	5.5b	15.9bc
	6.0	2.9bc	9.0c	4.8bc	15.1bc
PmLlRs	1.5	3.4b	13.7bc	2.2d	14.9bc
	3.5	2.7bc	8.3c	4.7bc	14.1bc
	4.5	3.1b	12.3bc	4.1bc	12.9bc
	6.0	3.4b	13.4bc	4.1bc	16.1bc
PmLlMh	1.5	4.4a	20.4a	6.2a	21.9a
	3.5	3.1b	12.3bc	4.8bc	17.1b
	4.5	3.0b	12.1bc	2.3d	14.0bc
	6.0	2.6bc	9.6c	2.9d	12.2bc
NPK	0.3	2.6bc	8.5c	2.7d	12.9bc
	0.4	3.4b	13.8bc	4.9bc	18.8b
	0.6	3.5b	15.6b	2.9d	17.2b

Source: Field Survey 2010

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Legend:

PmMh = Poultry manure + Mucuna husk

PmRs = Poultry manure +Rice straw

PmLl = Poultry manure + Leaf Litter

PmLlRs= Poultry manure + Leaf Litter + Rice straw

PmLlMh = Poultry manure + Leaf Litter + Mucuna husk