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Comparative efficacy of NPK fertilizer and composted organic residues on growth, nutrient absorption and dry matter accumulation in maize

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ABSTRACT

Scarcity and exorbitant cost of inorganic fertilizers has prompted the use of compost by farmers in Nigeria. However, response of crops to compost differs based on the components of the compost. This study, therefore, evaluated the comparative efficacy of NPK fertiliser and composted organic residues on growth, nutrient absorption and dry matter accumulation in maize. The potentials of five different composts namely; Poultry manure + Mucuna husk (PmMh), Poultry manure + Leaf litter of *Gliricidia* plant (PmLl), Poultry manure + Rice straw (PmRs), Poultry manure + Leaf litter of *Gliricidia* plant + Rice straw (PmLlRs) and Poultry manure + Leaf litter of *Gliricidia* plant + Mucuna husk (PmLlMh) were studied. The investigation was done in a greenhouse potted experiment using two varieties of maize, TZE COMP4C2 (V_1) and ACR 9931-DMRSR (V_2) as test crop treated with different rates of the compost treatments in a completely randomized design. Significant differences ($P< 0.05$) were observed in the height and dry matter yield of maize. N, P and K uptake of maize V_1 and V_2 were 20.4, 6.2, 21.9 mg^{-1} pot and 14.8, 4.1, 17.7 mg^{-1} pot, respectively with 1.5 t ha^{-1} PmLlMh and these were significantly ($p< 0.05$) higher than that of N,P, and K treatments Thus, from the study PmLlMh at 1.5 t ha^{-1} could be effective compost for maize production.

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

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INTRODUCTION

Over the years, the use of organic materials in farming has been reduced significantly due to inorganic fertilizers being rich and ready source of plant nutrients. Most of the farming communities have been forced to rely on mineral fertilizers, due to increase in population growth, rapid urbanization and mechanization. Excessive use of inorganic fertilizers, however, created concerns due to energy crises, stagnant yield and soil (physical, chemical and biological properties) health (Ahmad, 2006). To reduce high cost of crop production and environmental pollution, integrated approaches which could sustain both agriculture and environment are needed.

Use of organic materials as soil amendment is one of the approaches for sustainable agriculture. Organic materials are available in huge amounts in the form of farm waste, poultry litter and industrial waste. The continuous accumulation of these wastes is becoming a nuisance to the environment, particularly major cities (Olowoake 2009). Most of the organic residues are potential sources of plant macronutrients besides large quantities of micronutrients (Fening *et al*., 2009). These materials could be utilized more effectively and sustainably through recycling rather than being destroyed through burning as commonly practiced by many farming communities, where it causes air pollution. In the past, composted organic materials were applied to the soil as organic fertilizer at several tons per hectare for the improvement of crop productivity (Loecke *et al*., 2004). Also, preparation and constituents of the compost are usually not determined before applications; thus causes unpredictable crop performance. The use of large volumes of compost was cumbersome, labour intensive and expensive. Therefore, there was a need to investigate the possibility of reducing these high rates of application of organic fertilizer to obtain maximum crop yield.

The objective of this study was to investigate the efficacy of NPK fertiliser and composted organic residues on growth, nutrient absorption and dry matter accumulation in maize.

MATERIALS AND METHODS

The investigation was a greenhouse experiment. The top soil used was an Alfisol, characterised by low nutrient status and collected from the field 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

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shredded before they were composted by pit method for 9 weeks. 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 as described by Okalebo *et al*., (1993).
The results are presented in Table 1.
Soil samples used were air-dried and pass through a 2 mm sieve. Soil pH in KCl, organic carbon, total N, exchangeable K, Mg and Ca were determined using procedures outlined by Okalebo *et al*., (1993). Micronutrients were extracted with 0.1 N EDTA and determined using atomic absorption spectrophotometer

Table 1: N, P and K contents in the compost materials

Compost	Nutrients (gkg^{-1})		
	N	P	K
PmMh	8.1b	4.4c	6.0a
PmLIRs	10.5a	6.1b	5.7a
PmRs	7.0c	4.8c	6.0a
PmLI	10.4a	5.6b	5.8a
PmLIMh	6.9c	13.1a	5.0

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

Experimental Design and Treatments

The experiment was greenhouse study 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. Two maize varieties: ACR9931-DMRSR (Yellow variety, Downy mildew streak resistance) and TZE COMP 4C2 (White variety, Downy mildew resistance) were planted into the pots. The treatments used in this experiment are summarised in the table 2.

Table 2: Treatments and their application rates

Treatments	Rate (t/ha)
Control	0.0
NPK 15-15-15	0.3, 0.4, 0.6
PmMh	1.5, 3.5, 4.5, 6.0
PmRs	1.5, 3.5, 4.5, 6.0
PmLl	1.5, 3.5, 4.5, 6.0
PmLlRs	1.5, 3.5, 4.5, 6.0
PmLlMh	1.5, 3.5, 4.5, 6.0

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

Leaf litter:

The plants were grown for six weeks 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 70^{o}C to a constant weight; and the weight recorded as dry matter yield. 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 treatments means were separated by Duncan's Multiple Range Test (DMRT) at 5 % level of probability (SAS, 1999).

RESULTS

The physico-chemical properties of the experimental soil revealed that the soil is moderately acidic and of loamy sand 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 South-western 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*., 16mg kg^{-1} (Adeoye and Agboola, 1985). The K status of the soil which was

Table 3: 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)	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
Mechanical composition (cmol kg$_{-1}$)	
Sand	892
Silt	74

0.1 c mol kg^{-1} was also less than the critical level of 0.2 c mol kg^{-1} (Adeoye, 1986). Therefore, soil is generally low in total C, P and K; this shows that there is going to be a positive response of crops to the applied compost.
The results of nutrient analysis of compost show that the 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 between PmMh, PmLlRs, PmRs and PmLl (Table 1).

The result of growth parameter of maize shows that there was a general increase in the plant height throughout the growing period and there were significant differences ($P < 0.05$) at 6 WAP. PmLlMh 1.5 t / ha gave the highest height values of 48.8 cm and 44.3 cm from the maize varieties and shortest maize plants were observed in soils amended with PmMh 1.5 t / ha (Table 4). The results of dry matter accumulation are shown on Table 5. Maize dry matter yield significantly increased ($p<0.05$) with application of the different soil amendments. There were significant differences among all the treatments in both maize varieties investigated. Dry matter accumulation of PmLlMh 1.5 t / ha application were significantly ($P< 0.05$) more than when conventional NPK fertilizer was used (Table 5). The PmLlMh 1.5 t / ha produced the highest dry matter yield of 4.3 and 4.6 g / pot respectively. This treatment increased dry matter yield by 53 and 50 % respectively over the control. The control plots had the lowest dry matter yields of 2.0 and 2.3g /pot for the two varieties of maize; ACR9931-DMRSR and TZE COMP4C2 respectively (Table 5).

Table 4: Plant height of maize as influenced by application of compost in the greenhouse

Treatment	Rate (t/ha)	ACR9931-DMRSR ....WAP............ Cm			TZE COMP4C2 ....WAP........... Cm		
		2	4	6	2	4	6
Control	0	17.0bc	24.9b	32.4c	14.3d	23.5d	34.2b
PmMh	1.5	19.4ab	25.7ab	34.2bc	17.2bc	24.8d	34.7c
	3.5	21.2ab	39.7ab	39.0bc	17.2bc	24.1d	35.2b
	4.5	21.3ab	29.1ab	40.8bc	19.2b	27.0c	40.8b
	6.0	20.9ab	27.2ab	39.5bc	19.1b	27.3c	37.0bc
PmRs	1.5	19.7ab	24.4b	35.8bc	18.8b	25.8c	37.3bc
	3.5	17.9bc	24.3b	34.3bc	19.2b	26.4c	39.0bc
	4.5	19.0ab	25.4ab	37.2bc	17.3bc	26.0c	36.7bc
	6.0	21.5ab	27.8ab	42.0b	18.0b	30.8b	43.2a
PmLI	1.5	20.5ab	28.2ab	37.7bc	19.5b	31.5b	38.0bc
	3.5	21.0ab	28.2ab	39.5bc	19..1b	30.2b	37.7bc
	4.5	20.2ab	27.2ab	37.3bc	19.1b	29.7b	37.8bc
	6.0	20.2ab	26.8ab	37.9bc	19.5b	28.5c	36.8bc
PmLIRs	1.5	19.8ab	29.7ab	42.7b	18.5b	24.5d	32.3b
	3.5	19.6ab	27.8ab	40.0bc	19.2b	28.2c	35.5bc
	4.5	22.6ab	29.0ab	41.3bc	19.5b	28.3c	34.00b
	6.0	19.8ab	23.3b	39.8bc	17.2bc	26.7c	40.7ab
PmLIMh	1.5	23.3a	32.7a	38.8a	23.9a	35.3a	44.3a
	3.5	22.1ab	29.7ab	38.5bc	19.4b	31.2b	41.7b
	4.5	21.2ab	30.1ab	40.7bc	18.8b	30.5b	40.0b
	6.0	19.8ab	26.3ab	41.8b	17.4bc	30.7b	41.2b
Npk	0.3	19.8ab	28.5ab	42.3b	19.3b	31.0b	39.0bc
	0.4	20.4ab	29.8ab	43.7b	17.1bc	28.5c	41.5b
	0.6	20.6ab	28.4ab	42.2b	18.6b	27.2c	41.8b

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level. *PmMh = Poultry manure + Mucuna husk, PmRs = Poultry manure + Rice straw, PmLI = Poultry manre + Leaf litter, PmLIRs Poultry manure + Leaf litter + Rice straw, PmLIMh = Poultry manure + Leaf litter + Mucuna husk*

Table 5.Dry matter yield of maize as influenced by application of compost.

Treatment	Rate (t / ha)	Dry matter yield ------------ (g / pot)--------------- ACR9931-DMRSR	TZE COMP4C2
Control	0	2.0c	2.3c
PmMh	1.5	2.9bc	2.5bc
	3.5	3.6bc	2.5bc
	4.5	3.2bc	2.9bc
	6.0	3.2bc	2.9bc
PmRs	1.5	2.3c	2.5bc
	3.5	2.1c	2.7bc
	4.5	2.1c	2.8bc
	6.0	3.4bc	3.3b
PmLI	1.5	2.8bc	3.4b
	3.5	3.0bc	3.3b
	4.5	2.8bc	2.8bc
	6.0	2.9bc	2.9bc
PmLIRs	1.5	3.4bc	2.4bc
	3.5	2.7bc	2.9bc
	4.5	2.4bc	2.9bc
	6.0	3.4bc	3.1b
PmLIMh	1.5	4.3a	4.6a
	3.5	3.1bc	3.1b
	4.5	3.0bc	2.9bc
	6.0	2.6bc	3.2b
NPK	0.3	2.6bc	2.9bc
	0.4	3.4bc	3.2b
	0.6	3.9b	3.2b

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.
PmMh = Poultry manure + Mucuna husk, PmRs = Poultry manure + Rice straw, PmLI = Poultry manure + Leaf litter, PmLIRs = Poultry manure + Leaf litter + Rice straw,
PmLIMh = Poultry manure + leaf litter + Mucuna husk

Treatmet	Rate (t / ha)	Nutrient Uptake ....Mg / pot.............................. ACR9931-DMRSR N	P	K	TZE COMP4C2 N	P	K
Control	0	4.6d	2.0d	10.3c	4.3d	0.9e	10.2c
PmMh	1.5	5.2d	2.8d	14.9bc	4.9d	2.5c	12.3bc
	3.5	10.6	3.3c	16.4bc	4.8d	1.7d	11.6bc
	4.5	8.5c	5.6b	16.8bc	6.7c	1.4d	12.1bc
	6.0	9.2c	5.6b	17.3b	7.2c	2.2c	15.9b
PmRs	1.5	7.0c	3.9c	13.2bc	6.1c	2.2c	10.6c
	3.5	7.1c	4.1bc	10.8c	7.3c	2.9c	14.2bc
	4.5	4.2d	3.6c	11.7c	9.9c	1.9d	12.5bc
	6.0	11.9bc	5.7b	17.8b	11.1b	1.6d	16.2b
PmL	11.5	8.6c	2.5d	11.8c	12.8b	3.7b	16.3b
	3.5	10.4bc	2.9d	13.6bc	12.4b	3.0b	16.7b
	4.5	9.2c	5.5b	15.9bc	11.5b	3.7b	15.8b
	6.0	9.0c	4.8bc	15.1bc	9.4bc	2.4c	16.0b
PmLIRs	1.5	13.7bc	2.2d	14.9bc	6.3c	2.3c	12.5bc
	3.5	8.3c	4.7bc	14.1bc	9.6bc	1.6d	14.0bc
	4.5	12.3bc	4.1bc	12.9bc	9.6bc	2.7c	12.3bc
	6.0	13.4bc	4.1bc	16.1bc	10.8c	2.3c	14.6bc
PmLIMh	1.5	20.4a	6.2a	21.9a	14.8a	4.1a	17.7a
	3.5	12.3bc	4.8bc	17.1b	12.3b	1.9d	13.2bc
	4.5	12.1bc	2.3d	14.0bc	11.5b	3.7b	15.8b
	6.0	9.6c	2.9d	12.2bc	12.9b	0.8	12.2bc
NPK	0.3	8.5c	2.7d	12.9bc	9.1bc	2.6c	16.6b
	0.4	13.8bc	4.9bc	18.8b	11.3b	1.9	14.3bc
	0.6	15.6b	2.9d	17.2b	11.5b	1.8	14.8bc

Means having the same letter along th4e columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability Level.

PmMh = Poultry manure + Mucuna husk, PmRs = Poultry Manure + Rice Straw, PmLI + Poultry manure + Leaf litter, PmLIs = Poultry manure + Leaf litter + Rice Straw, PmLIMh = Poultry manure + Leaf litter + Mucuna husk

DISCUSSION

The focus of soil fertility research in recent years has been shifted towards the use of organic fertilizer to reverse the negative effect of inorganic fertilizer (Olowoake, 2009). Organic materials differ considerably in their ability to supply nutrients to the soil and crop. The resource quality analysis of compost materials used in this study indicates that they contain appreciable quantities of nutrients which suggest their suitability for soil fertility management. Application of PmLlMh 1.5 t / ha produced the highest dry matter of 4.3 and 3.6 g / pot of the two maize varieties evaluated. This can be attributed to the fact that there was an increased supply and availability of plant nutrients derived from the compost (Amoding *et al.,* 2005). The effects of compost rates on maize varieties N, P and K uptake are presented in Table 6. Application of compost rates had significant effects on N, P and K uptake ($p < 0.05$). Soil treated with PmLlMh 1.5 t / ha produced the highest N, P and K uptake. The uptake values obtained from compost PmLlMh at 1.5 t / ha was significantly ($P< 0.05$) higher from what was recorded for NPK at 0.3, 0.4 and 0.6 kg / ha (Table 6). Higher plant height produced by compost PmLlMh at 1.5 t / ha may be linked to its N content. This is in line with report from (Adeoye *et al*, 2008, Togun *et al,* 2004., Wolkowski, 2003) that better plant vegetative development occurs, most especially when soil is amended with compost made from materials of low C: N ratio.

Application of compost PmLlMh at 1.5 t /ha had significantly ($P <0.05$) higher maize dry matter yield of varieties ACR9931-DMRSR and TZE COMP4C2 when compared to NPK fertilizers. This is in agreement with findings of Oghoghodo and Ilegar (1995) and Kihanda, (2003) that the quantity of organic residues added to the soil might influence the rate of decomposition, which in turn affect the dry matter yield. Also, 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. The uptake of N, P and K by the maize reveals in which PmLlMh at 1.5 t / ha performed better could be as a result of nutrient release pattern on the treatment during the planting. In addition, works carried out by Stoffella and Graetz, (1996), shows that compost proved more satisfactory in providing plant nutrients than the mineral fertilizers and this was attributed to the increased supply and availability of plant nutrients derived from the compost.

CONCLUSION

From this study Poultry manure + Leaf litter + Mucuna husk (PmLlMh) at 1.5 t/ha could be used effectively in increasing soil fertility for maize production.

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