ASSET Series A (2007) 7 (1): 87-98

ASSET
An
International
Journal

YIELD RESPONSE OF MAIZE TO ANIMAL MANURES AND BULKING AGENTS IN FORTIFIED COMPOSTS

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ABSTRACT

An experiment was carried out to examine the effectiveness of four different composts formulated from poultry (PM) and cowdung (CD) manures as primary constituents and two bulking agents namely sawdust (SD) and sorted refuse (SR) on some yield components of maize for two cropping seasons. All compost mixtures were fortified with rock phosphate and urea. The compost treatments (PM/SD, PM/SR, CD/SD and CD/SR at ratio 3:1) were applied at 2.5 tonnes/ha, replicated three times with NPK (15:15:15) fertilizer applied at 300 kg/ha as reference treatment and a control (no compost, no fertilizer), all arranged in a randomized complete design. The results showed that the composts significantly increased (P<0.05) all the maize yield components measured for the two cropping seasons. The PM/SD and PM/SR produced a higher grain yield of 3326 and 3218 kg/ha, respectively, for the first cropping season and 1603 and 2423 kg/ha, respectively, for the second season compared to the cowdung-based composts, i.e. CD/SD and CD/SR with a range of 3073 and 3044 kg/ha and 1440 and 2051 kg/ha grain yield for the first and second seasons respectively. The sawdust-bulking agent performed better in the first cropping season producing a mean grain yield of 3200 kg/ha compared to sorted refuse with 3131 kg/ha. The study showed that types of bulking agent and animal manure used determined plant refuse to fortified composts.

Keywords: sawdust, sorted refuse, bulking agent, manure, fortified compost, and maize yield.

INTRODUCTION

Agricultural productivity in many African countries must be increased substantially to avert a serious food crisis. Dependence of these African countries on food aid continues to increase (World Bank, 1996) because their agricultural production has not kept pace with population growth. This is most evident in countries where population growth is very high with highly weathered soils having low inherent fertility (Smaling *et al.*, 1997). Many croplands are now continuously cultivated with little nutrient additions (Makken, 1993), resulting in diminishing productivity and declining per capita food production (Woomer and Muchena, 1996; Woomer *et al.*, 1997). A fundamental constraint to crop production in African smallholder agriculture is soil nutrient depletion. Sanchez *et al.* (1997) reported annual losses of 660, 75 and 450 kg/ha of nitrogen (N), phosphorus (P) and potassium (K), respectively, during the past three decades, in about 200 million hectares cultivated in 37 African countries. Apart from nutrient mining from continuous cultivation practices, nutrient depletion also results from erosion, leaching and denitrification. Achieving food security for a rapidly expanding population in the tropics means intensifying food production on existing cropland through enhanced nutrient input and recycling (Juo and Kang, 1989). Nutrient inputs may either be from organic sources i.e. crop residue, green and animal manure or inorganic fertilizers (Juo and Wilding, 1996).

The use of inorganic fertilizer is an important means of supplying the soils with necessary nutrients in crop production (Adeniyi and Ojeniyi, 2003) but its continuous use also have negative effects on the environment (Ojeniyi, 2000; Obi and Ebo, 1995). Nitrate leaching, groundwater pollution, degradation of soil structure, decreased surface water infiltration (Pondel *et al*., 2001) rapid degradation of soil physical, chemical and biological qualities (Ojeniyi and Adejobi, 2000) are sometimes associated with the use of mineral fertilizer. Enhanced soil fertility and improved environmental quality are both important goals of today's agriculture. Therefore there is a global move towards developing an agricultural production system which involves the more efficient utilization of inputs and the reduction of waste products (Ralph, 1996).

Though the nutrient content of organic matter is low and variable, organic manure is very valuable because it improves soil condition generally. The organic matter improves the soil structure, reduces soil erosion, has a regulating effect on soil temperature and helps the soil to store more moisture, thus significantly improving soil fertility. The combination of organic manure/organic matter and mineral fertilizers (Integrated Plant Nutrition System) provides the ideal environmental conditions for the crop, as the organic manure/organic matter improves soil properties and mineral fertilizers supply the plant nutrients needed (FAO/NSPFS, 2002).

Organic manure should, however be well composted and decomposed before application to the soil. Composting provides a management option that allows for the generation of a truly recycled organic product. Compost is an organic matter resource that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. Fortification of composted organic material is the addition of specific minerals from mineral fertilizers to further strengthen the compost. The objectives of this study, therefore, were to (i) carry out composting using two bulking agents and two manure types, (ii) determine the nutrient compositions of different unfortified compost formulations and (iii) to determine the yield response of maize to the different compost formulations after fortification.

MATERIALS AND METHODS

Site description

The composting and field experiments were carried out at the University of Ibadan/Raw Materials Research and Development Council (UI/RMRDC) Organomineral Fertilizer Plant located on a 2-hectare plot on Barth Road, University of Ibadan, Nigeria (7^0 23" N, 3^0 5" E). The average annual and monthly rainfall distribution for twenty seven (27) years (1977-2003) and 2003 respectively are shown in Figures 1 and 2.

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Raw materials and composting process

Poultry manure was collected from a battery cage poultry farm in Ibadan, cowdung was collected from a cattle market in Akinyele Local Government Area in Ibadan. Sawdust was procured from a Sawmill in Ibadan metropolis while refuse were gathered from a refuse dump in Bodija Market and sorted to remove non-biodegradable materials to obtain the sorted refuse. The manures and bulking agents were all mixed in ratio 3:1 as follows (i) Poultry manure and Sawdust (ii) Poultry manure and Sorted refuse (iii) Cowdung and Sawdust (iv) Cowdung and Sorted refuse. The composting of the materials was done in windrows of about 1.2 m height on a concrete floor under a shed. The manures were composted for a period of 12 weeks between February and May 2003. The windrows were watered and turned every 3 days to maintain porosity and optimum process conditions for composting of manure. Samples of the fully composted materials were taken for nutrient analysis using the methods outlined by the Association of Official Analytical Chemists (AOAC, 1990).

Field experiment

The field trial involving maize crop variety AK 9331 DMRSR-Y was conducted on the site described above for two cropping seasons in 2003 from May-July and August-October respectively. The land was manually cleared, packed of debris and tilled. Soil samples were collected from the site before planting at 0-15 cm depths for soil analysis. All the composts were fortified with rock phosphate at 40 kg P/ha and urea at 90 kg N/ha. The treatments were (a) no fertilizer (b) 300 kg/ha NPK 15:15:15 fertilizer (c) Poultry manure/ Sorted Refuse (PM/SR) (d) Poultry Manure/Sawdust (PM/SD) (e) Cowdung/ Sorted Refuse (CD/SR) (f) Cowdung/ Sawdust (CD/SD). The six treatments were replicated three times in a randomized complete block design (RCBD). Each plot size was 3 x 3 m. Three seeds were planted per hole at 0.25 x 0.75 m and thinned to one at two weeks after planting. The fortified composts and NPK fertilizer were applied at two weeks after planting by incorporating them into the soil. Weeding was done one week after application of fertilizer and twice before harvesting. The same procedure was carried out for the second cropping season i.e. August-October 2003 without the application of the fortified composts and the fertilizer to determine the residual effect on the yield and yield components of the plant.

Soil analysis

The soil samples were passed through 2 mm sieve for routine soil analysis. Soil reaction (pH in 1:1 soil/water) was measured using a glass electrode pH meter. Organic matter was determined by Walkley and Black (1934) method, % N was determined using the micro-Kjedahl procedures (Bremmer, 1965; IITA, 1979), available P by Bray and Kurtz (1945) extraction method. Exchangeable cations were extracted using 1 N neutral NH_4OAc solution (Chapman, 1965). Potassium and Na were read using the flame photometer while Ca and Mg were read using atomic absorption spectrophotometer. The particle size distribution for the soil was determined by the hydrometer methods (Bouyoucos, 1962).

Harvesting

At harvest ten plants per plot were randomly selected to determine the following

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yield parameters: grain yield, stover yield, 1000-grain weight and number of kernel per cob for the first cropping season while grain yield and stover yield was determined for the second cropping season. The grain was weighed using a top-loading balance while number of kernel was counted by hand. The data generated were subjected to analysis of variance using the Genstat procedure of analysis.

RESULTS AND DISCUSSION

Surface soil and compost characteristics before planting maize

Table 1 shows the soil physical and chemical characteristics before planting maize. The soil used is an alfisol, slightly acidic and clayey in texture. The soil organic carbon and total N are high while available P is low (Tekalign, 1991). The high organic C and N in the experimental soil might be as a result of the high clay content of the soil; also this explains the low availability of P in the soil (Okalebo *et al*., 1993). Brady and Weil (1996) posited that P availability tends to be lowest in soils with high clay content as encountered in the present study. The laboratory analysis result of the different compost formulations before fortification is presented in Table 2.

The poultry manure and sawdust compost had the highest phosphorus, potassium and magnesium content though the cowdung and sorted refuse compost had the highest nitrogen content of 2.40 %. The higher N content of the cowdung and sorted refuse might be due to the presence of the sorted refuse.

Table 1: Physico-chemical properties of the surface soil at the experimental site before planting maize

Parameter	Property
pH	6.5
Organic C (%)	3.6
Total N (%)	1.5
Available P (mg/kg)	2.67
Exchangeable bases (cmol/kg)	
Ca	0.58
Mg	0.44
K	0.11
Na	0.16
Particle size distribution (%)	
Sand	8.8
Silt	10.0
Clay	81.2

Table 2: Nutrient content of unfortified composts

Nutrient element	PM/ SD	PM/SR	CD/SD	CD/SR
pH	8.43	8.14	8.55	8.63
N (%)	1.97	1.82	1.48	2.40
P (%)	3.14	2.44	0.88	0.65
K (%)	1.46	1.04	1.37	1.02
Ca (%)	3.65	3.24	1.48	1.23
Mg (%)	0.83	0.61	0.42	0.31

The pH of composted materials determines their usefulness as a liming material. All the composts mixtures have pH higher than 7.00 indicating alkalinity, cowdung and sorted refuse compost possess the highest pH of 8.63. Composting increases the pH of manurial materials, which can help make acidic soil a better environment for plant growth (Anonymous, 1992).

Effect of fortified composts on some maize yield component

Table 3 shows the effect of the fortified composts on some maize yield components for the two cropping seasons. For both cropping seasons, the fortified composts produced a higher grain and stover yield compared to the control plots. The PM/SD, among the composts, gave the best result with 3326 kg/ha grain and 6244 kg/ha stover yield for season one; these were significantly different ($P<0.05$) from the control and cowdung composts. The CD/SD and CD/SR, however, gave lower grain and stover yields for the first cropping season compared to the PM/SD and PM/SR. This might be as a result of the poultry manure-fortified composts mineralizing easily and faster than the cowdung fortified-composts on the field, hence releasing their nutrients rapidly in the first cropping season to give a higher yield. This can also be noticed in the NPK reference treatment where the yield is higher than all the compost-treated plots. Mineral fertilizers are readily available to crops because they break down easily (FAO/NSPFS, 2002). The second cropping season, however, showed a different trend in the grain and stover yields produced by the composts. The PM/SR fortified compost produced the highest grain and stover yields of 2423 kg/ha and 3606 kg/ha respectively compared to PM/SD with 1603 kg/ha and 3159 kg/ha respectively. It is possible that the materials in sorted refuse might have affected the rate of mineralization of the compost, which might also be due to blending of the materials in the sorted refuse during composting, thereby reducing the rate of release of the nutrients in the field for plant uptake. This suggests that the sorted refuse composts might have a higher residual effect on the field than the sawdust composts. The NPK gave a lower yield compared to all the composts. This might be as a result of the fertilizer being quickly mineralized and taken up by the plants during the first cropping season while the unused nutrients are probably leached away beyond the plant roots' zone (Adeniyan and Ojeniyi, 2003). Generally, for the first cropping season, the PM/SD composts performed better than all the other composts in all the parameters taken as is observed in the number of kernel/cob and 1000-grain weight measured. Poultry manure had been found to have higher values of available N and P (Schlegel, 1992; Wright et al., 1995) this might explain the better performance of the poultry manure composts.

Table 3: Effect of fortified composts on some maize yield component for two cropping seasons

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)		Number of kernel/cob	1000-grain weight (g)
	1st season	2nd season	1st season	2nd season	1st season	1st season
N.P.K	3464.3	1391	7484	2542	457	396.6
CONTROL	2950.1	724	3137	2015	415	207.2
PM/SD	3326.4	1603	6244	3159	487	307.2
PM/SR	3217.6	2423	5681	3606	458	266.5
CD/SD	3073.1	1440	4274	3003	429	250.7
CD/SR	3044.1	2051	3667	3025	403	224.8
Mean	3165.3	1605	4966.5	3025	444.3	262.3
L.S.D (0.05)	214.2	562.5	510.2	909.2	78.3	23.95
CV (%)	1.6	10.4	5.5	10.2	9.7	4.8

Effect of poultry manure and cowdung on some yield components

Table 4 shows the effect of the primary constituents (poultry manure and cowdung) of the composts formulation on some yield components of maize for the cropping seasons. Poultry manure formulated composts had a significantly higher yield (p<0.05) of 3272.0 kg/ha for grain and 5963 kg/ha for stover yield in the first season. The number of kernel per cob and 1000-grain weight was also higher for poultry manure in the first season. For the second season, PM still produced a higher grain yield than CD but the stover yield for CD was slightly higher at 3423 kg/ha compared to 3359 kg/ha for PM. Poultry manure has been reported to significantly affect growth and yield of various plants either as a straight manure or fortified with

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mineral fertilizer. Shado (1983) reported that various levels of poultry manure produced significant growth on various *Eucalyptus* seedlings at the nursery stage. Fagbenro and Adeola (1981) also used this manure successfully in raising vigorous *Tectona grandis* and *Pinus carribeae* in the nursery. In comparing the effectiveness of different animal manures (poultry manure, goat manure nad dairy cow manure) on some soil chemical properties, yield and root growth of *Amaranthus cruentus*, Maerere *et al.* (2001) showed that poultry manure resulted in significantly higher mineral N and P compared to the other two manures. They attributed their results to the higher level of N in the PM compared to the other manures which might also be the case in this present study, although, sorted refuse-composted cowdung had the highest N (Table 2).

Bomke and Lavkulich (1975) and Schlegel (1992) also reported that poultry manure had the highest effect on soil available levels of N and P compared to other animal manures. In another study by Adeniran and Ojeniyi (2003), unfortified and fortified poultry manure were found to increase residual concentration values of micro- and macro-nutrients tested for on the field for both years of study compared to NPK alone. They also wrote that both unfortified and fortified PM increased significantly the nutrient uptake and yield of maize for the two years. The better performance of poultry manure than cow dung might also be due to its higher mineralization potential enabling it to actively and quickly make its nutrient available for plant uptake and use.

Table 4: Effect of poultry manure and cow dung on some maize yield components for two cropping seasons

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)		Number of kernel/cob	1000-grain weight (g)
	1st season	2nd season	1st season	2nd season	1st season	1st season
N.P.K	3464.3	1407	7484	2542	457	396
CONTROL	2950.1	724	3137	1986	415	207.2
POULTRY MANURE (PM/SD and PM/SR)	3272	1999	5963	3359	472	286.9
COW DUNG (CD/SD and CD/SR)	3058.6	1768	3970	3423	416	237.8
Mean	3179.3	1611	5081	3015	442	275.5
L.S.D (0.05)	43.4	598.4	386.5	683.1	ns	18.95
CV (%)	2.4	15.4	5.8	12.2	10.3	5.3

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Effect of bulking materials on some yield component

Table 5 shows the effect of the bulking agents (sawdust and sorted refuse) in the composts on some of the yield components of maize. The bulking materials had significant effect on grain yield, stover yield and 1000-grain weight of maize in the first season compared to that obtained in the control plot. The sawdust-bulked composts (CD/SD and PM/SD) produced higher yields for all the components measured in the first season over the sorted refuse-bulked composts (CD/SR and PM/SR). The differential effects of the bulking agents in the composts may be explained on the basis of biodegradability in soil (Blanco and Almendros, 1994). Most nutrients, especially N and P, in composts are generally found in both "plant-available" forms (NO_3, NH_4 and P_2O_5) and organic forms (Edward, 1992; Porter, 2004). Much of these nutrients are, however, made "plant-available" as the organic matter decomposes and at longer periods. From the results obtained for the first season, it is possible that the sawdust-bulked composts might have the advantage of being able to degrade faster than the sorted refuse-bulked composts. These results further affirm our earlier hypothesis of the possibility of the sorted refuse consisting of materials that might have affected the rate of mineralization of the composts, thereby, delaying the release of the nutrients in the soil. Wang *et al*. (2004) had criticized the use of wood industry waste in composting as it might introduce N nutrition problems. It is likely that the performance of the sawdust composts may be as a result of it being of uniform material. The fortification and the time allowed for the composting process to take place might also be factors responsible for the performance of the sawdust composts. The sorted refuse-bulked composts, however, performed better than the sawdust-bulked composts in the second season. It is evident that the SR-bulked composts was able to further release its nutrients for plant uptake and that it might have a higher residual effect on the soil over sawdust which might have released most of its nutrients for plant use in first season.

Table 5: Effect of bulking agents on some yield component the two cropping season

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)		Number of kernel/cob	1000-grain weight (g)
	1st season	2nd season	1st season	2nd season	1st season	1st season
N.P.K	3464.3	1407	7484	2542	457	397
CONTROL	2950.1	724	3137	1986	415	207
SAWDUST (CD/SD and PM/SD)	3199.8	1533	5374	3073	455	292
SORTED REFUSE (CD/SR and PM/SR)	3130.9	2234	4789	3708	428	259
Mean	3186.7	1611	5196	3015	439	289
L.S.D (0.05)	43.4	369.2	386.5	514.3	Ns	18.95
CV (%)	2.4	12.8	5.8	10.6	10.3	5.3

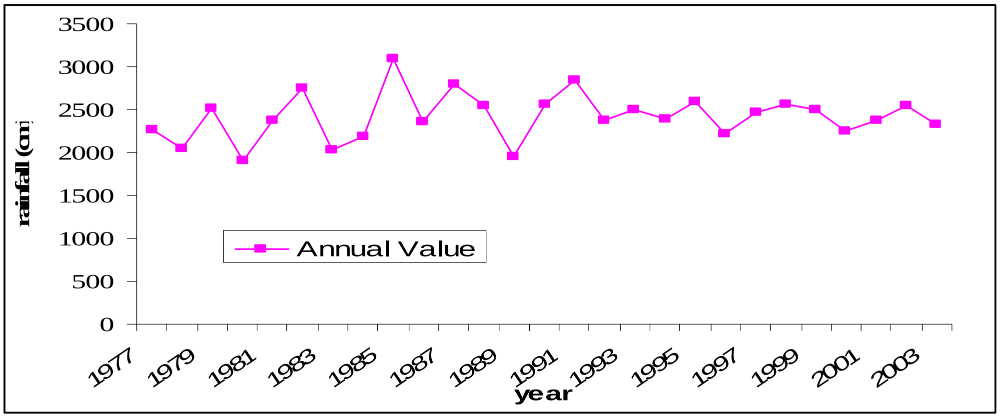

Figure 1: 27-yr average annual rainfall from 1977-2003

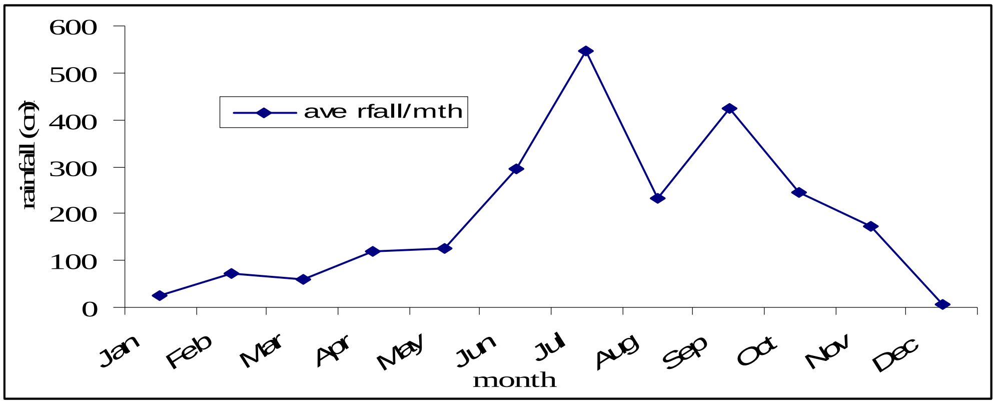

Figure 2: Average monthly rainfall for year 2003

CONCLUSION

Response of some maize yield components to two bulking agents (sawdust and sorted refuse) and animal manures in fortified composts were measured. This study showed that types of bulking agent and animal manure used determined crop response to fortified composts. Maize responded well to the sawdust-composted materials in field during the first cropping season. The sorted refuse composts, however, affected the yield of maize better during the second cropping season than the sawdust compost indicating longer lasting and better residual effects in the soil for plant use. Poultry manure gave the best performance for the two cropping seasons compared to the cow dung as seen in the effect it had on the some of the maize yield components measured.

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