Utilization of Different Crop Residues as Organic Fertilizer

[1]Olowoake, A. A.and [2]G. O. Adeoye
[1]Department of Crop Production and Forest Resource Management Kwara State University P.M.B. 1530, Ilorin, Kwara State Nigeria.[2] Department of Agronomy, University of Ibadan, Ibadan, Nigeria.
Corresponding author: e-mail:aolowoake@yahoo.com

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Abstract
Various organic residues are abundant in the most communities and farms in Nigeria. The management of such organic residues poses a serious problem to community hygiene. Surplus farm waste can be recycled into useful product for meeting the nutrient requirement of crops. Poultry manure, Mucuna husk, Gliricidia leaves and Rice straw were collected and composted to produce organic fertilizer.

The estimation of time of maturity 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) was investigated as well as the effects of the compost on yield of maize in the field. The experimental design was randomized complete block design with three replications.

Composting of organic residues of high and low carbon–nitrogen ratios together reduce the composting cycle to 49 days. Significant differences ($P < 0.05$) were found in plant height, stem girth, leaves area, stover dry weight and grain yield with 1.5 t ha^{-1} PmLlMh.

Grain yield value of maize 3.4 t /ha with PmLlMh at 1.5 t/ha were significantly ($p < 0.05$) higher than that of NPK treatment (3.0 t/ha) after the cropping.

Thus, from this study it can be deduced that PmLlMh at 1.5 t ha^{-1} can serve as an alternative to mineral fertilizer.

Keywords: *Compost, Mucuna husk, Rice straw, Leaf litter*

Introduction

Organic wastes are considered as a rich source of macro and micronutrients (Shah and Anwar, 2003). In an extensive survey of organic manurial materials available for use locally by Sridhar, (1989) as reported by Omueti *et al*.(2000) reveal that stalks of various crops (corn, guinea corn, sorghum) rice husks, wheat straws, vegetable peelings, banana leaves, excreta from poultry, cows piggery sheep and goats, wastes from breweries and other crop residues which possess organically rich materials were being used in various parts of the country, but the potential of these organic manures in Nigeria are not explored to the fullest extent.

With the advent of chemical fertilizers, the use of organic wastes as plant nutrient source was restricted. It is continuous stress on national economy, as rich pool of nutrients contained by organic wastes is being lost and at the same time potential threat for sustainability of environment (Ahmad, *et al*., 2006). Many strategies are being adopted to dispose off organic wastes but none of them is safer for environment and sustainable for nutrient conservation. Direct application of organic waste as such intothefieldhasmanydrawbacks as un-composted organic materials have wider C: N ratio than composted organic material, this causes immobilization of applied N and hence N becomes un-available to plant. Finished compost is generally more superior to uncomposted materials having more concentrated of nutrients, narrower in C: N ratio and also being effectively free from pathogens, weed seeds and other potential contaminants that cause pollution (Zia *et al.*, 2003). Composting is one of the best solutions to reduce the huge piles of organic wastes and convert it in 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 (Ahmad *et al.*, 2006). Compost improve soil texture, reduce erosion, disease and weed germination by enhancing the nutrient and water retention capacity, improve tilth and over all productivity of the soil. 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 (Olowoake, 2009). All these constraints coupled with 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 grain yield of maize (*Zea mays* L) as influenced by composted organic residues. The objectives of this study were; (i) estimation of time of maturity of different compost and (ii) to determine the effect of different rates of composted crop residues on growthand yield of maize as an alternative to mineral fertilizer.

Materials and Methods

Preparation of compost

The following organic materials, Nerica1 variety rice straw was obtained from WARDA farm plot IITA, Ibadan, Mucuna husk and Poultry manure were supplied by IITA research farm office. Leaf litter was obtained by gathering leaf falls from *Gliricidia sepium* tree at IITA Yam barn. The leaf litter, mucuna husk and rice straw were shredded before they were composted. Pit composting method was used to compost the organic residues. The pit size measuring 1m x 1m x 1 m was used for the composting. Leaf litter, (Ll) Rice Straw (Rs) Mucuna husks (Mh) and Poultry manure (Pm) were co-composted in different pits. 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. Rice straw, mucuna husk and Gliricidia leaf litter was measured by volume on dry matter basis with PmRs, PmMh and PmLl in a ratio of 1:3 while PmLlRs, and PmLlMh, in a ratio of 1:1.5:1.5. A $1m^3$ box was constructed to measure the volume of organic waste materials before composting. The organic waste mixtures were composted in a pit for 9 weeks. The mixtures were turned every fortnight and watered. Temperature readings were taken every day with thermometer on each pit of the organic materials. The daily temperature was compared with the ambient temperature. The compost materials were allowed to cure for two weeks.

When the compost temperature declined from its peak to near ambient temperature and remained constant for a week the compost cycle had been completed as shown in Fig.1. The decline in the compost temperature to a constant level is an indication of a completed cycle (Papadimintriou and Balis, 1996). The nutrients such as N, P and K concentration in various residues used for composting were carried out in the laboratory as described by Okalebo *et al*., (1993). The results are presented in Table 1.

Field Experiment

The study was carried out at the main station of the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria. ($3^{\circ}54'$E longitude, $7^{\circ}30'$N latitude, 213 m altitude). The area has a bimodal rainfall pattern with an annual mean of 1278 mm and a mean annual temperature ranges between 22°C and 38°C. The soil for the experiment were Alfisol, locally classified under Egbeda soil series; it had not been fertilized and exhaustively cultivated with various crops ranging from cowpea, maize and yam for over eight years. The land was later abandoned by the Research Farm Unit (RFU) since it was no more fertile. The field was cleared, and ploughed. The size of each sub plot was 3.0 X 3.0 (9 m^2), with an inter-plot space of 0.5 m. The compost was applied to the maize ACR9931-DMRSR (Yellow, Downy Mildew Streak Resistance). The experimental design was laid out in a randomized complete block design (RCBD) with three replications. The planting distance was 75 cm x 25 cm at two plants/ stand. However, maize plant was later thinned to one after seedling emergence. The compost was applied 2 weeks after planting in a ring, 5 cm radius and about 2 cm deep around maize.

The treatments used in this experiment were result from the screening carried out in the greenhouse based on their performance on growth parameters and nutrient uptake. The treatments are as follows: (1) Control-No fertilizer (2) NPK - 0.4 t/ha (3) PmLl (Poultry manure and Leaf litter) - 4.5 t/ha (4) PmLlRs (Poultry manure, Leaf litter and Rice straw) - 4.5t/ha (5) PmLlMh (Poultry manure, Leaf litter and Mucuna husk) - 1.5 t/ha.

The maize growth and yield parameters collected include plant height, leaf area, number of leaves per plant, stem girth at 4 weeks interval, Stover dry matter, cob dry matter per plant and grain yield. Data collected were subjected to Statistical Analysis System (SAS) for Analysis of variance (ANOVA) and the treatments were compared at 5 % level of significance using the Duncan's Multiple Range Test (DMRT).

Laboratory Analysis

The soil sample was analyzed for soil texture, pH, organic carbon, total N, extractable P, exchangeable levels of Ca, Mg, K and cation exchange capacity. 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 Malvaney, 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). The results of these were summarized in Table 3.

Results

Temperature change during composting

Figure 1 shows the average temperature regime in the various composts during composting process. Generally there were sharp rise in temperatures in all the compost pits between 1 to 2 weeks of composting. At the 7th weeks of composting the temperature dropped to between 34 to 38 ^{0}C in PmRs, PmRsLl, PmLl and PmMh, PmMhLl respectively. Beyond this period, the temperature of the pits tends towards being constant with the ambient temperature.

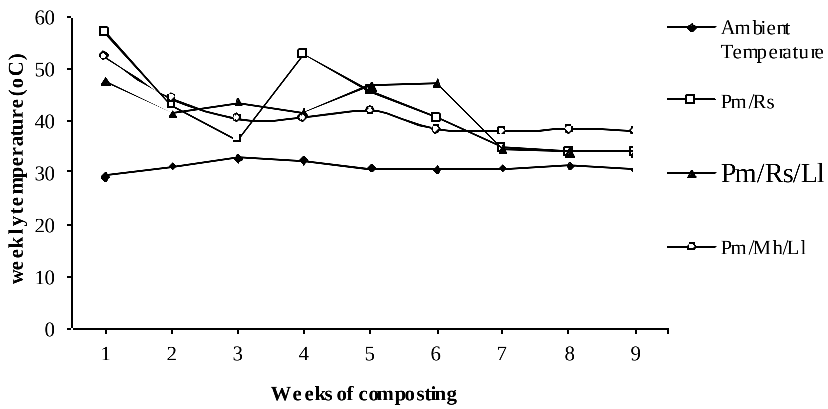

Figure 1. Weekly temperature (oC) of composting materials during composting process

Nutrient content of composts

Table 1 shows the results of nutrient analysis of compost. 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).

Table 1. Nutrient content of composts

Compost	Nutrient g kg^{-1}		
	N	P	K
PmMh	8.1b	4.4c	6.0a
PmLlRs	10.5a	6.1b	5.7a
PmRs	7.0c	4.8c	6.0a
PmLl	10.4a	5.6b	5.8a
PmLlMh	6.9c	13.1a	5.0b

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

Pre-cropping soil properties

Table 2 shows some of the physico-chemical properties of the soil used for the experiment. The soil is moderately acidic and of sandy clay loam texture. 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 0.26 g kg^{-1} was below 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 c mol 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,N, P and K; this shows that there is going to be a positive response of crops to the applied compost.

Parameters	Soil test value
pH	5.5
Org. C (gkg^{-1})	3.0
Total N (gkg^{-1})	0.26
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
Mechanical composition (cmol kg^{-1})	
Sand	892
Silt	74
Clay	34
Textural class	sandy clay loam

Table 2: Soil Physico-Chemical Properties

Effects of compost on growth parameters and yield components of maize

Compost application generally enhanced height, stem girth, leaf area, 100 seeds weight cobs dry matter per plant and Stover dry matter of maize (Table 3 and 4). Maize plant height at 12 weeks after planting (WAP) was significantly (P= 0.05) increased with application of compost PmMhLl 1.5 t /ha by 13% and 54 % over NPK and control respectively (Table 3). There was a significant difference in the leaf area of maize plants nourished with different compost. Similarly, application of PmMhLl 1.5 t /ha produced significantly larger leaf area than compost PmLl, PmLlRs and NPK respectively. Compost PmMhLl 1.5 t /ha gave the widest leaves of 574.2 cm^2 when NPK fertilizer application had leaves 424.1 cm^2wide (Table 3). Stem girth of maize plants was at highest with application of 1.5 t ha compost while the least was obtained with control. All compost treatments gave significantly higher grain yield ranging between 2.2 to 3.4 t /ha than the control plots with maize grain yield of 1.6 t /ha. Grain yield from PmMhLl 1.5 t /ha were significantly different from application of NPK which gave a maize grain yield of 3.0 t /ha (Figure 2). The stover dry matter, cob dry matter and weight of 100 seeds followed the same pattern. The observed values were similar with the plants fertilized with compost PmMhLl 1.5 t /ha and were both significantly higher than what was observed from the control, unfertilized plants. The Stover dry matter, cob dry matter per plant and 100 seeds weight were 60%, 37% and 44% with PmMhLl at 1.5 t/ha than control.

Table 3 :Maize growth parameters as influenced by application of compost

Treatment	Rate (t /ha)	Plant Height (cm)	Stem Girth (cm)	Leaf area (cm^2)
Control	0	88.0c	3.8c	247.6c
NPK	0. 4	166.9b	6.6ab	424.1b
PmLl	4.5	165.4b	6.1b	445.8b
PmLlRs	4.5	161.7b	5.7b	462.2b
PmLlMh	1.5	191.1a	7.3a	574.2a

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

Legend
NPK = NPK 15:15:15; PmLlMh = Poultry manure + Leaf litter + Mucuna husk
PmLlRs = Poultry manure + Leaf litter + Rice straw; PmLl = Poultry manure + Leaf litter

Table 4. Effects of compost and NPK on yield components of maize

Treatment	Rate (t / ha)	Stover dry matter (g)	Cobs dry matter (g)	100 Seeds weight (g)
Control	0	16.4c	193.0d	36.8c
NPK	0.04	30.4b	280.7b	56.4b
PmLl	4.5	22.6b	255.3c	49.4b
PmLlRs	4.5	24.6b	226.7c	49.4b
PmLlMh	1.5	40.5a	306.7a	65.9a

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

Legend
NPK = NPK 15:15:15; PmLlMh = Poultry manure + Leaf litter + Mucuna husk
PmLlRs = Poultry manure + Leaf litter + Rice straw; PmLl = Poultry manure + Leaf litter

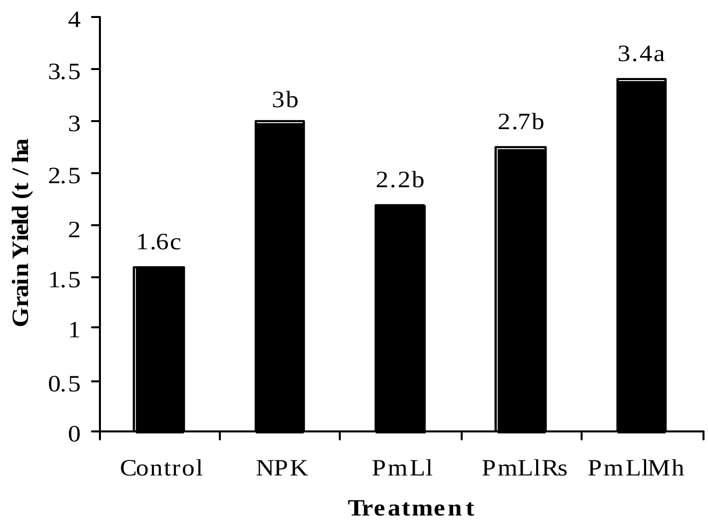

Figure 2. Effects of compost and NPK on grain yield of maize

Legend
NPK = NPK 15:15:15; PmLlMh = Poultry manure + Leaf litter + Mucuna husk
PmLlRs = Poultry manure + Leaf litter + Rice straw; PmLl = Poultry manure + Leaf litter

Discussion
The type of organic material is one of the important factors that can lead to successful composting. The organic materials used in this experiment varied with nutrient composition and after composting gave different concentrations of plant nutrients. The temperature regime in the various composts indicated that the organic materials passed through similar degradation process independent of the type of material used for composting. Monitoring of the composting cycle using daily temperature for each composting cycle gave the 7^{th} weeks as the week the temperature remained constant, this signifies a complete compost cycle. This agrees with the results obtained in many other composting systems between 42-60 days (Adediran *et al*, 2003, Ogazi and Omueti 2000, John, *et al*, 1995). The general rise in temperature of the compost in the early stage of composting was caused by rapid mineralization of organic carbon and nitrogen in the presence of adequate aeration and moisture as required by microbes responsible for the breakdown of organic compounds. This was also supported by work of Adediran, *et al* (2003) that increase in temperature in the system could be as a result of generated reactions whereby CO_2 and heat were released into the compost system.

Maize plant height, stem girth, leaves area and yield parameters of maize were positively influenced by addition of composted organic residues. This could be due to the presence of more nutrients supplied from the compost which were effective enough than those supplied with inorganic fertilizer.

This agreed with the work of Ouedraogo, *et al* (2001) who, although working on Sorghum discovered that the grain yields were higher in composts plots. Composts generally improve drainage and waterretention of amended soils and release essential nutrients during the growing season at rates required for crop up take if appropriate amended rates are utilized (Olowoake, 2009). Furthermore, increased in growth of maize might have contributed from application of composted crop residues which improve the water-holding capacity of soil and allowing faster plant establishment. This agrees with the published accounts on such effects of compost incorporated into soils (Maynard, 1994). The significant increase in the stover dry matter, cob dry matter and 100 seeds weight with the application of PmLlMh at 1.5 t /ha in the experiment may be due to the supply of essential nutrients especially N, P, K and S by the composts which are important in the determination of yield components (Jones, 1993). Similar observations were also reported by Udom and Bello (2009) who reported significant increases in the maize yield components with the addition of organic manure. The increase in grain yield may be due to the supply of nutrients especially N by the compost which is known to be the most spectacular in plant growth and development. Similar observations were reported by several researchers including Silva *et al*., (2003) and Zublena *et al*.,(1993). Thus in this study, compost PmLlMh at 1.5 t / ha did better than the plot fertilized with NPK mineral fertilizer due to availability of nutrient present in the compost than other treatments.

Conclusion

The nutrient concentrations of the organic residues used for composting varied with type of material. Therefore, the tropical Africa farmer using similar crop residues materials in this study can estimate the duration of a complete compost cycle as from 7 weeks after that the compost is ready to be applied. In summary, from this study it can be deduced that composted organic residue used for the compost can serve as an alternative to mineral fertilizer. Furthermore, application of compost PmLlMh at the rate of 1.5 t/ha led to higher maize yield than using NPK 15- 15-15.

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