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Comparative Effects of Separate Incorporation of Cowdung and Rice-Husk Materials on Nutrient Status of some Lithosols

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ABSTRACT

In this study, the effects of separate incorporation of cowdung and rice-husk materials were investigated between the rainy months of June and September, 2008. Four incorporation levels 0, 25, 50 and 75 tons ha^{-1} were experimented for each fertilizer material over an incubation period of 4 months. Representative soil samples were collected, prepared and analysed. Data showed that soil physical properties accounted the soil particle size proportions as significantly different ($P<0.05$) between the incorporated fertilizer sources, while the soil densities, porosity and WHC did not. Likewise, about half of the soil chemical properties differed significantly from the untreated control and between the incorporation types. On the average, results suggested a greater effectiveness with increased rates (50 & 75 tons ha^{-1}) of especially rice-husk incorporation. It is recommended that farmers should use higher incorporation of the resourcefully cheap rice-husk materials for adequate soil fertilization and physical conditioning of the highly depleted soils. © 2010 Friends Science Publishers

Key Words: Soil incorporation; Cowdung; Rice-husk; Soil fertility

INTRODUCTION

The principal factor limiting optimum crop yields especially in cereal based farming systems is low fertility amidst land degradation. Over the years, continual cropping beyond soil threshold limits has resulted into high depletion in crop returns due to deplorable state of soil organic matter, which is rarely remedied through supplementation with only mineral fertilizers. In view of this, farmers now prioritize integration of feasible crop management practices, which emerged from farming experiences, observation, experimentations and wise adoption of farming cultures shaped by socio-economic and ecological factors (Hiol *et al*, 1996; Ray, 2006; Reij *et al*., 2006; Tekwa & Belel, 2008). Several indigenous local technologies have recorded huge successes, especially among peasant farmers (Tekwa & Belel, 2008). The positive roles of soil organic matter such as poultry manure, cowdung and rice wastes, includes facilitation of microbial nutrition, soil structural aggregation, infiltration and enhanced mineral nutrient uptake in plants (Brady & Weil, 2002).

Recent studies have evidenced high percentage of plant nutrient stocks in rice-husk, capable of profitable soil improvement (Akanmu & Shridha, 2002). Studies show that organic matter influences the rates of water loss, evapotranspiration, soil temperature, aeration, microbial metabolism and the capacity of shallow soils (Lithosols) to store and provide moisture and nutrients for plant uptake (Agbim, 1985; Mbagwu & Ekwealor, 1990). Similarly, cowdung has a reasonably high content of N, K and fibrous materials that favourably regulates soil moisture, temperature and even prevents multiplication effects of weeds on soil surfaces (Adetunji, 1991; Adeoye *et al.*, 2004). The cheaply available organic matter sources such as the rice wastes in several localities demands appropriate utilization in view of its plant nutrient potentials, with a thorough scientific investigation. This research was aimed at evaluating the potential soil nutrition achievable from incorporation of cowdung and rice-husk materials on the marginally depleted soils.

MATERIALS AND METHODS

Field study: A field experiment was carried out between the rainy months of June and September, 2008 to compare the effects of separate incorporation of cowdung and rice-husk materials on the nutrient status of some Lithosols in Mubi, Nigeria. The experiment was set-out on the Teaching and Research farms of the Department of Agricultural Technology, Federal Polytechnic, Mubi, Northeastern Nigeria, situated between latitudes 9°26' and 10°10'N and longitudes 13°11' and 13°44'E (Nwagboso & Uyanga, 1999).

Rice-husk (waste) material was collected from some rice milling shops and cowdung obtained from cattle pen in the institution. The experiment consisted of two organic fertilizer sources (Cowdung & rice-husk) administered in a randomised complete block design (RCBD), on a land area of 144 m^2. The experimental plan comprised of four (4)

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blocks replicated thrice. The experimental plot sizes (3 m × 3 m) were separately treated with four (4) levels (0, 10, 20 & 30 kg per plot size, equivalent to 0, 25, 50 & 75 tons ha^{-1}, respectively) of each fertilizer source. Individual plot area (4 m^2) was separated between blocks and plots at an alley of 0.5 m width. A total of 48 representative composite samples were collected within soil rooting zone (0-15 cm & 15-30 cm) after a soil incubation period of four months using a bucket soil auger and packed in well labelled polythene bags, then air dried, crushed, sieved through a 2 mm sieve and made ready for prescribed laboratory analysis.

Laboratory study: Basic soil properties such as the particle size distribution were determined using Bouyocous Hydrometer method (Trout *et al.*, 1987). The soil bulk density was determined using Clod method (Klute, 1986). The soil porosity was computed from the soil densities, while the water holding capacity (WHC) was obtained using gravimetric water content of a given quantity of soil fully saturated with water. Soil pH, organic carbon, total N, extractable P, exchangeable bases and exchange acidity were determined using the routine analytical methods by IITA (1979); cation exchange capacity and total exchangeable bases were computed from the soil bases.

Data analysis: Data collected was subjected to analysis of variance (ANOVA) using the general linear model (SAS, 1990). The mean separation was performed using the least significant difference (LSD) at $P<0.05$.

RESULTS AND DISCUSSION

Regarding the soil physical properties, data showed that the rice-husk had no significant effects on both sand and clay contents for all treatments (0, 25, 50 & 75 tons ha^{-1}) (Table I). Silt fractions however, recorded significant effect with higher rates (50 & 75 tons ha^{-1}) of incorporation. Hence, there was a significant difference between the control (0 tons ha^{-1}) and the other treatments on the soil particle density (Pd), bulk density (Bd), porosity (Poros.) and WHC. This implied that rice-husk materials could significantly improve porosity and moisture retention capacity of the soils.

Cowdung, compared with rice-husk, was not only effective on the soil densities (Pd & Bd). This was perhaps caused by the decomposable cowdung particles that probably migrated down the soil profile (Bouwer & Powell, 1995). Both sand and silt content of untreated control were significantly different (P < 0.05) from all the treatment levels. Unlike rice-husk, the cowdung recorded a significant effect on clay proportion, especially at increased levels of incorporation. The influence of cowdung on soil porosity also significantly varied between the treatments and especially from the untreated control. The WHC did not show significant difference between the control and a plot treated with 25 tons per ha, but was significantly influenced at higher levels (50 & 75 tons ha^{-1}) of cowdung incorporation. Powell and Williams (1993) recorded similar significant influence on WHC of some soils treated with higher rates of livestock wastes in Sahelian zone of West Africa.

As for soil chemical properties, even though the result indicated unequal sodium (Na) and pH levels, rice-husk incorporation still had no great influence on all the treatment levels (Table II). Both the electrical conductivity (EC) and total exchangeable acid (TEA) had similar effects exerted by the incorporated rice-husk. In either case, the untreated control did not differ significantly from that of 25 tons ha^{-1} trials. Similar was the case for the 50 and 75 tons per ha rates of rice-husk incorporated. This was probably due to the low acidity index, as adjudged by the near neutral to slightly alkaline soil conditions (Batiano & Mokwunye, 1991).

The organic matter (O.M), N and P contents corresponded well with the treatment levels, which also significantly differed from the untreated control (Table II). The rice-husk fertilizer materials portrayed uniform significant differences at 50 and 75 tons per ha treatment levels. This is usually true with increased organic matter content of tropical soils (Kang & Span, 1986; Brady & Weil, 2002; Akanmu & Shridha, 2002). By implication, still an increased incorporation of rice-husk could be effective on vastly degraded savannah soils of Northern Nigeria. The treatment levels and the control showed significant difference for both K and Ca contents. However, Mg contents were alike with the untreated control at 25 tons per ha and significantly differed at 50 and 75 tons per ha. This behaviour was still noticed with the total exchangeable bases (TEB) and cation exchange capacity (CEC) of the soils under rice-husk incorporation. This common soil property could have been as a function of cumulative effects of the soil bases.

The effects of cowdung fertilizer on the soil chemical properties were largely not significant in terms of EC, O.M, N, P, Mg, Na and TEA contents. Even though, their contents increased with increasing treatment levels. This further suggested that rice-husk was more effective than cowdung in terms of soil nutrition. However, the soil pH and K content, which increased with the treatment levels, also differed significantly from the untreated control. The Ca and Mg contents equally increased with enhanced incorporation levels and were also significantly different from the untreated control. Similar proportionality was observed for TEB and CEC of the soils (Adetunji, 1991; Akanmu & Shridha, 2002; Tekwa & Makama, 2008). This explains the potentials of cowdung in supplying adequate basic cations as nutrient sources in the study area.

The cumulative effects of both rice-husk and cowdung fertilizers on the soil properties is presented in Table III. The result revealed the sum potentials of each nutrient supplied by either of the fertilizer sources. Of all the physical properties of the treated soils, only the soil particles (sand, silt & clay) indicated significant differences between the fertilizer treatments, while the soil densities, porosity and WHC were not significantly influenced at the same incorporation levels. Similarly, the pH, EC, O.M, P, K, Ca, TEA and TEB contents were significantly different (P <

Table I: Mean effects of separate incorporation of rice-husk and cowdung fertilizers on the soil physical properties

Fertilizer source	Rate (tons ha^{-1})	Sand (%)	Silt (%)	Clay (%)	Pd (Mg m^{-3})	Bd (Mg m^{-3})	Pors (%)	WHC (%)
Rice-husk	0	49.43	17.92^{a}	32.65	1.21^{b}	1.60^{ab}	24.29^{a}	15.09^{c}
	25	53.25	14.98^{ab}	31.77	1.31^{a}	1.62^{ab}	18.74^{b}	21.68^{b}
	50	54.10	13.55^{b}	31.63	1.21^{b}	1.58^{b}	23.05^{ab}	26.82^{a}
	75	54.82	13.37^{b}	32.53	1.25^{ab}	1.68^{a}	25.11^{a}	21.09^{b}
	SE$\pm$	2.53	1.73	1.11	0.04	0.04	2.25	1.55
	LSD	NS		NS				
Cowdung	0	47.88^{b}	19.00^{a}	33.12^{a}	1.18	1.65	28.51^{a}	22.85^{b}
	25	51.72^{a}	15.25^{b}	33.03^{a}	1.27	1.61	20.93^{b}	22.88^{b}
	50	54.60^{a}	15.83^{b}	29.57^{b}	1.24	1.62	22.88^{ab}	27.47^{a}
	75	53.60^{a}	14.52^{b}	31.87^{ab}	1.20	1.67	28.15^{b}	20.77^{b}
	SE$\pm$	1.67	0.99	1.52	0.04	0.04	2.85	1.71
	LSD				NS	NS		

Key: 1. Pd=Particle density, Bd=bulk density, Pors=porosity, WHC=water holding capacity
2. Means with the same letter are not significantly different (*P* > 0.05)

Table II: Mean effects of separate incorporation of the rice-husk and cowdung fertilizers on soil chemical properties

Fertilizer source	Rate (tons ha^{-1})	pH	EC (dS m^{-1})	OM (%)	N (%)	P (ppm)	K	Ca	Mg	Na	TEA	TEB	CEC
							←			Cmol (+) kg^{-1}			→
Rice-husk	0	7.36	34.38^{b}	1.31^{c}	0.06^{c}	0.01^{d}	0.33^{c}	1.47^{b}	3.33^{b}	0.09	0.65^{b}	5.31^{b}	7.67^{b}
	25	7.03	56.61^{ab}	1.96^{b}	0.10^{bc}	0.05^{c}	0.82^{b}	2.38^{a}	2.70^{b}	0.26	0.77^{b}	6.16^{b}	8.22^{b}
	50	6.93	127.47^{a}	2.66^{a}	0.16^{a}	0.09^{b}	1.05^{b}	2.47^{a}	4.42^{a}	0.13	0.87^{a}	8.07^{a}	9.08^{ab}
	75	7.44	124.98^{a}	2.16^{b}	0.02^{b}	0.12^{a}	1.42^{a}	2.78^{a}	4.65^{a}	0.14	0.92^{a}	9.11^{a}	10.27^{a}
	SE$\pm$	0.25	34.99	0.19	0.02	0.01	0.17	0.25	0.46	0.11	0.08	0.70	0.71
	LSD	NS											
Cowdung	0	6.82^{b}	79.40	1.65	0.06	0.013	0.17^{c}	1.50^{c}	3.35	0.08	0.68	5.10^{c}	7.64^{b}
	25	6.76^{b}	53.50	1.73	0.07	0.05	0.68^{b}	2.00^{bc}	3.43	0.12	0.75	6.22^{b}	8.55^{ab}
	50	6.89^{b}	86.78	1.78	0.09	0.07	1.20^{a}	2.64^{ab}	2.83	0.41	0.83	6.88^{ab}	8.51^{ab}
	75	7.41^{a}	97.81	2.95	0.23	0.11	1.21^{a}	2.97^{a}	3.35	0.15	0.80	7.66^{a}	9.62^{a}
	SE$\pm$	0.20	26.72	0.35	0.09	0.05	0.51	0.32	0.50	0.22	0.08	0.50	0.83
	LSD		NS	NS	NS	NS			NS	NS	NS		

Key: 1. pH=soil reaction, EC=electrical conductivity, OM=organic matter, N=nitrogen, P=phosphorus, K=potassium, Ca=calcium, Mg=magnesium, Na=sodium, TEB=total exchangeable sodium, TEA=total exchangeable acid, CEC=cation exchange capacity
2. Means with the same letter are not significantly different (*P* > 0.05)

Table III: Cumulative effect of separate incorporation of rice-husk and cowdung on soil chemical properties

Characters	Sand (%)	Silt (%)	Clay (%)	Pd (Mg m^{-3})	Bd (Mg m^{-3})	Pors. (%)	WHC (%)	pH	EC (dS m^{-1})	OM (%)	N (%)	P (ppm)	K	Ca	Mg	Na	TEA	TEB	CEC
													←		Cmol (+) kg^{-1}				→
Rice-husk	50.60^{b}	116.85^{a}	32.81^{a}	1.23^{a}	1.61^{a}	23.29^{a}	23.15^{a}	6.90^{b}	59.83^{b}	1.54^{b}	0.11^{a}	0.04^{b}	0.64^{b}	2.03^{b}	3.49^{a}	8.71^{a}	0.73^{b}	6.33^{a}	8.71^{a}
Cowdung	54.26^{a}	14.26^{b}	31.23^{b}	1.24^{a}	1.65^{a}	24.62^{a}	21.52^{a}	7.23^{a}	105.40^{a}	2.28^{a}	0.11^{a}	0.09^{a}	1.09^{a}	2.53^{a}	3.52^{a}	8.68^{a}	0.83^{a}	7.30^{b}	8.68^{a}
LSD				NS	NS	NS	NS				NS				NS	NS			NS
SE$\pm$	2.14	1.30	1.33	0.04	0.04	2.56	1.63	0.23	31.13	0.28	0.07	0.03	0.16	0.29	0.48	0.77	0.08	0.61	0.77

Key: 1. Pd=Particle density, Bd=bulk density, Pors=porosity, WHC=water holding capacity, pH=soil reaction, EC=electrical conductivity, OM=organic matter, N=nitrogen, P=phosphorus, K=potassium, Ca=calcium, Mg=magnesium, Na=sodium, TEB=total exchangeable sodium, TEA=total exchangeable acid, CEC=cation exchange capacity
2. Means with the same letter are not significantly different (*P* > 0.05)

0.05), compared to most of the soil bases (Ca, Mg & Na) and CEC levels, which did not differ significantly between the fertilizer sources.

CONCLUSION

The incorporation of rice-husk and cowdung fertilizer sources cumulatively influenced the soil properties. The soil aggregate proportions significantly differed between the separate trials, while the soil densities, porosity and WHC did not differ significantly. Also, about half of the chemical properties investigated did not differ significantly between the fertilizer treatments. On the average, rice-husk comparatively had significant nutrient stocks (e.g., O.M, N, P & Mg), giving it an edge over cowdung. Results suggested that rice-husk incorporation at higher rates (50 & 75 tons ha^{-1}) could improve soil aggregate stability and even supplement essential nutrients demanded for profitable crop production.

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