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Effects of Rice-Bran Compost on Growth and Yield of Soybean (*Glycine max*) on an Alfisol in Ibadan, Nigeria.

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ABSTRACT

Farmers in the tropical environment face the acute problem of using mineral fertilizers due to their unsustainable attributes ranging from scarcity and high cost of the material to the adverse effects on tropical soil which resulted to soil acidity and pollution of underground water. This study evaluated the effects of rice-bran compost on the growth and yield of improved variety of soybean on an Alfisol, in Ibadan, Nigeria. The investigation involved a screen house experiment conducted at the Department of Agronomy, University of Ibadan. The experiment comprised five rates of compost (0, 2.5, 5.0, 7.5 and 10 t/ha) replicated four times with two pots per replicate in a Completely Randomized Design (CRD) using soybean (TGX 1740-1F) variety with a total of 40 pots in all. The data collected were subjected to analysis of variance ANOVA and Duncan multiple range test was used to separate the means. The experimental results showed significant differences ($p<0.05$) among the levels of compost on soybean; however, 10 t/ha gave highest value on the number of leaves while 7.5 t/ha performed better in respect of plant height compared with the other treatments. Also, rice bran compost at 10 t/ha produced statistically highest root and grain yields followed closely by 7.5 t/ha. However, 10 t/ha of rice bran compost promoted shoot performance. Soybean yield increased with higher rates of rice-bran compost. Soybean growth and yield are improved with a compost of rice-bran and cattle dung up to 7.5 t/ha to supply 95 kg N, 169 kg P and 12 kg K.

1. Introduction

The capacity of tropical soils to grow food and fiber has progressively decreased each year. This is largely due to the decline in soil fertility due to inherent fragile characteristic of the tropical soils (Adeoye *et al.,* 2005). Soil degradation leading to nutrient depletion has been considered a serious threat to agricultural productivity and a major cause of falling crop yields and per capita food production in sub-Saharan Africa (Henao and Baanante, 2006). The traditional method of bush fallow and shifting cultivation are no longer sustainable due to population pressure and industrialization (FFD, 2012), hence the campaign for soil amendment inputs as alternatives to improve soil nutrient status, for better crop yield in the sub-Saharan Africa.

The use of inorganic (mineral) fertilizers as soil amendment for supplying plant nutrients has been the conventional practice for a long time. However, the intensive use of these mineral fertilizers has been associated with declined soil organic matter content, increase in soil acidity, nutrient imbalance and degradation of soil physical properties leading to soil erosion, with resultant reduction in crop yield over time (Asawalam, 2009; Banful, 2009; Hepperly *et al.,* 2009; Awanlemhen and Ojeniyi, 2012). The long- term use of mineral fertilizers, especially the nitrogenous ones at high rates, could be harmful to soil microorganisms (Barabasz *et al.,* 2002; Mandic *et al.,* 2011) and consequently reduce normal development of crops.

Soybean *(Glycine max* (L) Merrill) is one of the world's most valued oil seed crop and most important grain legume in Nigeria. It is a legume of very high nutritional values that has a tremendous potential for alleviating protein-based malnutrition in Nigeria. The demand for soybean protein is relatively high because of the high cost of other sources of protein such as meat, egg etc (Addo and Oguntona, 1993). Soybean was first introduced into Nigeria in 1908 (Fennel, 1966) while attempt to grow it at Moor Plantation, Ibadan at that time failed. Although, the crop was successfully introduced to Samaru in 1928 where it spread into other parts of Northern Nigeria. Soybean is among the major industrial and food crops grown in virtually every continent. The crop can be successfully grown in many states in Nigeria using low agricultural inputs. Soybean cultivation in Nigeria has expanded as result of its nutritive and economic importance and diverse domestic usage. It is also a prime source of vegetable oil in the international market (IITA, 2009).

Despite the great potential of cultivating soybean, Sanchez and Logan (1992), reported that due to the problem of soil fertility in high rainfall, low-attitude regions of the tropics due to the rapid organic matter mineralization, production can be low. Van Wanbeke (1992), observed that the presence of highly weathered secondary minerals in the soil can result to poor growth and low yield in soybean production. However, fertility can be improved using organic and inorganic fertilizers. The major drawback of inorganic fertilizer are their low accessibility to resource-poor farmers (Garrity, 2004), their low efficiency in highly weathered soils (Baligar and Bennett, 1986) and problem of soil degradation (Khaim *et al.,* 2003) as a result of continuous use of high level of inorganic fertilizers which is detrimental to crop production. Organic fertilizers are able to improve nutrient use efficiency under tropical conditions. If agriculture is to be sustainable, emphasis has to be placed on the use of organic fertilizer to ensure that agriculture remains a viable part of a healthy ecosystem.

Although the performance of soybean with common conventional chemical fertilizers has been reported, the likely benefits of agricultural resources in such system need to be studied. Animal droppings are readily available and can be acquired with minimum cost from livestock farms which are abundant in the region. Rice bran are also better fertilizer materials because of their high organic matter content that can be used to sustain the fragile organic layer of the soil. Effect of climate change which presently encourages leaching and erosion of mineral nutrients from mineral fertilizers applied to the soil into rivers, streams and water ways thereby polluting them can be mitigated with the use of plant biomass.

Since mineral fertilizer is scarce, unaffordable to farmers because of high cost and its inability to sustain tropical soil because of its detrimental effects, rice-bran compost is an alternative because of its availability and affordability. This study was conducted to determine the rate of rice-bran compost that support optimum growth and yield performance of soybean *(Glycine max)* on an Alfisol

2. Materials and Methods

The study experiment was carried out between January and May 2017 in the screen house of the Department of Agronomy, Faculty of Agriculture and Forestry, University of Ibadan (latitude $7^0 20^1$N and $3^0 5^1$E). It was to investigate the response of soybean to organic fertilizer. The experimental soil was an Alfisol collected from Parry road, University of Ibadan. A sample of the soil was taken to the laboratory for the determination of pre-cropping physicochemical properties.

Rice bran compost (RBC) was prepared using windrow aeration composting method based on the standardized procedure adopted for use at the organomineral fertilizer plant at Barth road, the University of Ibadan with roof protection from rain and sun (Omueti *et al*., 2000). For the rice bran-based compost, the rice bran was measured by volume and mixed with cattle dung (CD) in ratio 3:1 inside the windrow. The organic waste (rice bran) was piled up in layers with CD, turned manually and sprinkled with water once in a week with moisture content maintained at 60% field capacity (Fadare *et al*., 2000).

The monitoring of the composting commenced immediately after heap building. The temperature build up in each composting bin was measured daily at 11: 00 am with the aid of a mercury thermometer dipped to a depth of about 0.35 m in three different parts of each compost pile and the values averaged to get the average temperature. The pH of the pile was determined fortnightly using a pH meter in aqueous extract of 5g decomposing samples with distilled water at the soil : water ratio of 1:4 (w.v) (Guerra-Rodriguez *et al*., 2000; Banout *et al*., 2008).

At compost stability, when the temperature of the pile dropped to that of ambient temperature and remained relatively constant over a period of two weeks, compost samples were randomly taken from each pile, homogenized and labeled. The compost was applied at 2.5, 5.0, 7.5 and 10 t/ha. A non-fertilized treatment served as the control. The experiment comprises of five treatments replicated four times with two pots per replicate in a Completely Randomized Design (CRD) making forty pots in all. Compost were weighed and mixed with the soil and allowed to mineralize for two weeks. Field capacity of the soil was determined in the laboratory, using 50 g of the experimental soil with a sensitive scale. A funnel was placed on a cylindrical flask. Filter paper was put inside the funnel to prevent soil from pouring out. The 50 g soil was later put inside the funnel and 50 ml of water was poured on the soil in the funnel. Excess water (that could not be retained in the soil pore spaces) drained into flask until it stopped. The volume of drained water in the flask was subtracted from the actual volume (50 ml) of water poured. The amount water held at field capacity of the soil was 1500 ml. The soil inside the 5 kg pots containing each level of rice-bran compost and control were watered to 60% field capacity (FC) and allowed to equilibrate for two weeks.

Soybean seeds of TGX 1740-1F variety sourced from Institute Agricultural Research and Training (IAR&T), Ibadan which was sowed two weeks after compost application. Three seeds were planted into each polythene bags in the green house, thinning was carried out after 9 days of planting, thus ensuring two vigorous seedlings per pot. The first hand weeding operation was carried out at four weeks after planting and other subsequent operations done as necessitated by weed occurrence. Cypermethrin was applied fortnightly at the rate of 2 ml per litre of water to control insect pest attack from two weeks after planting and continued until harvesting. Growth parameters measured were plant height and number of leaves. Biomass yield was also recorded. At final harvest, the soils were moistened for easy removal of roots and the plants were partitioned into leaves, stem, and root. The plant parts were dried in a forced air-tight oven at 70 ^{0}C until constant weight was obtained. They were weighed on an electric top loading balance and their respective weights recorded. Data collected were subjected to Analysis of variance (ANOVA) using GENSTAT Statistical Package (8^{th} Edition) at 5% probability level while treatment means with significant differences were separated using Duncan Multiple Range Test (DMRT) at 5% probability level.

3. Results

3.1 Physical and Chemical Properties of the study soil

The result of the pre-planting soil analysis is shown in Table 1. The Alfisol collected from Parry road at the University of Ibadan was slightly acidic. Organic carbon was below the 20 g/kg considered as critical for soils of Southwestern

Nigeria (FFD, 2012), high in exchangeable calcium and magnesium, sufficient in exchangeable K and Na (Landon, 1984). The textural class is sandy loam.

3.2 Chemical Analysis of the Rice-bran compost.

Sample was taken from rice-bran compost. The sample was subjected to chemical analysis. The pH of the compost was determined in 1:2 sample to water ratio using Electrometric method (Bates, 1954). Organic carbon was determined by dry ashing method (Okalebo *et al.,* 1993). Total N was determined by the micro kjedahl method (Bremer, 1996). The plant sample was digested with mixture of perchloric, nitric and conc. Sulphuric acid. P was determined from the digest by vanado-molybdate yellow colour procedure (Olsen and Dean, 1965), while the bases; K, Ca, Mg and Na, as well as the micronutrients; Fe, Zn, Cu and Mn in digest were read with the Atomic Absorption Spectrophotometer (Model Buck Scientific NV 201/ 211). The result of the proximate composition of the compost (Table 2) showed that rice-bran based compost contained plant nutrients and carbon appreciably.

3.3 *Effects of Compost based treatments on the number of leaves of soybean*

The results of the fertilizer treatment on number of leaves of soybean are presented in Table 3. The result showed that there was significant difference ($p<0.05$) among the treatment. At 3 and 4 WAS, 10 t/ha of compost gave the highest mean number of leaves (15.00, 24.50) which was not significantly different from others except 2.5 t/ha (12.50, 18.88) and control (10.25, 13.88). However, there were significant differences ($p<0.05$) among the treatment means at both 5 and 6 WAS, 10 t/ha of compost gave the highest mean number of leaves (33.50, 47.62) which was significant different from all the various rates of rice-bran compost.

3.4 Effects of Compost based treatments on plant height of soybean

The results of the fertilizer treatment on height of soybean plant are presented in Table 4. The results showed that there was significant difference ($p<0.05$) among the treatments at all successive weeks. At 3 WAS, the 10 t/ha compost gave the highest mean height (27.57) which was not significant different from others except 5.0 t/ha (23.99), 2.5 t/ha (21.99) and the control treatment (15.00). At 4, 5 and 6 WAS, 7.5 t/ha compost gave the highest height (38.62) (49.34) (64.51) which differ significantly from other treatments apart from 10 t/ha compost (38.19) (45.36) (60.54) while the control gave the significantly lowest height (20.45) (25.02) (39.39).

3.5 Effects of Compost based treatments on yield parameters of soybean

The results showed that there were significant differences ($p<0.05$) among treatment means across all the parameters. 10 t/ha compost gave the highest root weight (26.77 g/pot) which was not significantly different from 7.5 t/ha (26.38 g/pot) compost but higher than other treatments. The control gave the lowest significant mean value of root (7.55 g/pot). In terms of shoot weight of soybean, 10 t/ha compost treatment gave the highest mean value (28.31 g/pot) which was significantly different from other treatments. The control gave the lowest significant mean value of shoot (8.15 g/pot). In terms of grain weight, also, 10 t/ha compost gave the highest (6.08 g/pot), which was not significantly different from others except 7.5 t/ha compost (5.67) while the control gave the lowest significant value (3.46 g/pot).

4. Discussion

The soil used was moderately acidic. Total N and the exchangeable K were low (Adeoye, 1986). The compost was high in macronutrient contents but could supply sufficient nutrients due to the high rates of application. The N, P and K applied were as high as would supply by conventional fertilizers. Growth attributes such as plant height and number of leaves was significantly increased by the application of rice-bran compost, an indication that the soybean utilizes the fertilizer applied in growth and development processes.

The significant effects of rice-bran compost over control (as indicated by the various growth parameters including plant height and number of leaves) is an indication that manure is a store house for various nutrient elements essential for plant growth (Agboola, 1982). It confirms the agronomic value and the potential of organic material in soil fertility amendment as reported by Agboola and Obatolu (1990). They studied the effects of optimum use of different organic materials to improve the quantity and quality of organic matter of tropical soil and reported that organic waste material improves water holding capacity, increase organic matter content and also enhances the growth and yield of crops.

The positive response recorded could be as a result of better growth achieved at the applied rates of 7.5t/ha and 10 t/ha. This is because higher vegetative production in crop means higher interception of light and therefore more assimilate production that increase yield. This implied the ability of the rice-bran compost to release its nutrients for plant use. The result was in agreement with the report of Ayeni *et al.* (2008) where compost improved the plant height of maize due to proper mineralization. Lower rates of 2.5 and 5.0 t/ha supplied nutrient to give only better growth and yields than the non-fertilized plants but not comparable with the higher rates of 7.5 and 10 t/ha. Carsky (2003), observed that organic additions substantially increased soybean pod yield. A similar increase in yield with compost had been reported on other vegetables. Akanbi *et al.* (2007a), had reported an increase in yield of *Telfaria spp* and also on *Celosia spp* Akanbi *et al.,* (2007b). Soybean growth and yields were improved with the rice bran and cattle dung compost up till 7.5 t/ha to supply 95 kg N, 169 kg P and 12 kg K.

Conclusion

This study was designed to find the effectiveness of rice bran compost as an alternative to the expensive and not tropical soil friendly mineral fertilizer in soybean production. Lower rates of 2.5 and 5.0 t/ha supplied nutrient to give only better growth and yields than the non-fertilized plants but not comparable with the higher rates of 7.5 and 10 t/ha. The excellent performance of rice bran compost was attributed to its inherent nutrient content and steady increase in nutrient release when applied as a soil amendment

Table 1. Particle size Distribution and Chemical Properties of Soil before cropping

Parameters	Values
pH (H_2O)	6.2
Organic carbon (g kg^{-1})	13.5
Total nitrogen (g kg^{-1})	1.6
Available Phosphorus (mg kg^{-1})	11.8
Exchangeable cations (cmol kg^{-1})	
K	0.6
Ca	2.0
Mg	2.0
Na	0.5
Exchangeable acidity (cmol kg^{-1})	0.5
Micronutrients (mg kg^{-1})	
Fe	55.6
Mn	280
Cu	1.3
Zn	1.8
Particle size distribution (g kg^{-1})	
Sand	772
Silt	94
Clay	134
Textural class	loamy

Table 2. Chemical Analysis of the Compost

Parameters	Values
pH (H_2O)	7.9
Organic carbon (g kg^{-1})	109.7
Total nitrogen (g kg^{-1})	9.5
Available Phosphorus (g kg^{-1})	16.9
Exchangeable cations (g kg^{-1})	
K	1.19
Ca	10.5
Mg	8.1
Na	0.83
Micronutrients (mg kg^{-1})	
Fe	11600
Mn	390
Cu	80
Zn	50

Table 3: Effects of Compost on number of leaves/ plant of soybean

	Weeks after planting			
Treatment (tha^{-1})	3	4	5	6
0	10.25c	13.88c	18.62d	28.12c
2.5	12.50b	18.88b	25.12c	38.12b
5.0	14.00ab	22.00a	27.50bc	39.38b
7.5	14.75a	22.62a	28.38b	40.75b
10	15.00a	24.50a	33.50a	47.62a

Means with the same letter (s) in the same columns are not significantly different from each other, p = 0.05 (DMRT)

Table 4: Effects of Compost on Plant height (cm) of soybean

	Weeks after Planting			
Treatment (tha^{-1})	3	4	5	6
0	15.00d	20.45c	25.02d	39.39d
2.5	21.29c	29.71b	38.58c	53.59c
5.0	23.99bc	35.79a	42.99bc	57.31bc
7.5	25.62ab	38.62a	49.34a	64.51a
10	27.57a	38.19a	45.36ab	60.54ab

Means with the same letter (s) in the same columns are not significantly different from each other, p = 0.05 (DMRT)

Table 5: Effects of Compost on Yield Parameters of soybean

Treatment (tha^{-1})	Root ($gpot^{-1}$)	Shoot	Grain
0	7.55c	8.15e	3.46c
2.5	10.16c	11.82cd	4.92abc
5.0	18.08b	12.82c	5.00abc
7.5	26.38a	20.99b	5.67ab
10	26.77a	28.31a	6.08a

Means with the same letter (s) in the same columns are not significantly different from each other, p = 0.05 (DMRT)

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