Comparative Study of Mineral fertilizer and Cassava peel Compost on seed yield and quality attributes and nutrient use efficiency of Soybean

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ABSTRACT

Nigeria generated approximately 3.75 million tonnes of cassava peel annually as waste. This constitutes major source of pollution to the environment. The major concern is how to convert this waste to useful product to support crop production. A field experiment was carried out to determine effect of cassava peel compost (CPC) and mineral fertilizer on yield attributes, grain yield, seed quality and nutrient use efficiency of soybean. The experimental design was a randomized complete block design with three replicates and each replicate contained all the six treatments. The six treatments consist of control, mineral fertilizer (15-15-15), cassava peel compost and their combination. Data collected on soybean yield attributes, seed quality and nutrient use efficiency were subjected to analysis of variance and significant means compared using Duncan Multiple Range Test (DMRT) at 5% probability level.

The highest yield attributes were recorded with combined application of mineral fertilizer and cassava peel compost. 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC had highest total pods per plant and the highest percent pod setting was record with 150 kg NPK ha^{-1}+1.25 t ha^{-1} CPC. All treatment had significant effect on mineral components of soybean seed well as proximate composition. Sole application of mineral fertilizer gave highest nutrient use efficiency. Generally, combined application of mineral fertilizer and cassava peel compost 100 kg and 2.5 t ha^{-1} outperformed other treatments expect with nutrient use efficiency.

Keywords: Mineral fertilizer, cassava peel compost, percent pod setting, mineral components, nutrient use efficiency

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INTRODUCTION

Soybean is referred to as 'meat of the field' or 'meat without bone' (Abraham 2013). It is an annual antioxidant-rich grain legume that contains up to 40% protein content and 20% high quality oil in the seed (Ishaq and Ehirim 2012). Soybean is the primary source of the world's supply of protein and vegetable oil. Increased production of soybean has been observed to increased world's population growth and reduced demand for protein and edible oil in future (Ishaq and Ehirim 2012)

Abraham (2013) reported that over 80 percent of the world's soybean crop is processed into meal and vegetable, which are used in the production of animal feeds. Soybean is the largest source of oil in the world seed trade with approximately 95 percent consumed as edible oil (Kolapo 2011). The by-products of soybean serve as industrial raw materials in the production of paints, varnish, linoleum and other valuable products (Kolapo 2011). It is also used in the production of biodiesel (Kolapo 2011; Abraham 2013). Studies have proofed that population that eat diet rich in soy products are immune or protected against malnutrition and cardiovascular diseases (Adisa and Balogun, 2013, Abraham, 2013, Williams, 2013). Adisa and Balogun, (2013) reported that soybean products serve as buffers to food insecurity in Southern guinea of Nigeria.

Nigeria is the largest producer of soybean in Africa and eleventh largest producer in the world ((Abraham, 2013). Sanginga *et al.* (2002) and Coulibaly et al. (2009) reported that soybean contributes to the enhanced sustainability of intensified cropping systems by improving soil fertility through nitrogen fixation, permitting a longer duration of ground cover in the cropping sequence, protect soil from recurrent erosion, in-situ decay of root residues enrich soil with nutrients.

Numerous research findings have revealed that the plant produce from organic system such use of composts have higher dry matter content, higher mineral concentration, lower nitrate concentration, higher vitamin C concentration, high phytonutrient content, less water and better taste (Worthington, 2001, Heaton, 2001, Rosen and Allan, 2007). Akanbi *et al*. (2007a) observed that application of 2 t /ha CPC + 187.5 N kg/ha had significant effect on cumulative nutritional values of *celosia argenta* while both 100% NPK and combination of 75% NPK+ 25% CPC had highest crude protein, iron and ascorbic acid content. Cassava peel is one of the several unused organic resources packed from smallholder farms and gaari processing industries. It has relatively high nutrient concentration, but little is known about its potential as nutrient source to improve soil fertility and crop yields (Akanbi et al., 2007b). Many studies have shown that Nigeria soil is general low in organic matter and the supply of all through fertilizer is becoming increase, fertilization practice that maintain or increase production level and consequently decrease water pollution potential should be employed. However, excessive application of fertilizer usually results in high nitrate level in soil after crop harvest (Akintoye and Olaniyan, 2012; Dormaar and Chang, 1995). Akintoye and Olaniyan (2012) confirmed that the use of organic fertilizer as a source of nutrients for plant can greatly reduce environmental problems associated with use of inorganic fertilizer.

Fixen (2009a) reported that nutrient use efficiency is an important indicator of the success of nutrient management in agricultural system. It is one of the basic issues in farming and fertilizer application. Nutrient use efficiency is defined as ability of plant to absorbs, translocates or uses of a specific nutrient better than another plant under conditions of relatively low nutrient availability in the soil or growth media (Soil Science Society of America, 1997; Baligar and Fageria, 2015). Hawkesford *et al*. (2014) defined it as a plant yield per unit of nutrient supply. Nutrient loss to the environment occurs only when fertilizer or manure are applied at the above agronomic need (Roberts, 2008). (Baligar *et al*., 2001) reported that the reclamation of applied inorganic fertilizer is low in many soils with approximately 50% or lower for nitrogen, less than 10% for phosphorus and close to 40% for potassium. Roy *et al*. (2006) reported that the importance of nutrient use efficiency is to meet world food demand, fulfill the nutritional requirements of crops, high yield, resistance to pest and diseases and environmental protection. (Baligar *et al*., 2001) observed that higher nutrient use efficiency by plant could help reduce fertilizer input costs, decrease the rate of nutrient losses and enhanced crop yield. Best management practices such as addition of crop residues, green manure, compost, animal manure use of cover crops, reduce tillage and avoiding burning of crop residues can significantly improve the level of soil organic matter and contribute to the sustainability of

cropping systems and higher nutrient use efficiency. Nutrient use efficiency is affected by soil, crop and environmental factors and fertilizer management and technology (Baligar *et al*., 2001). Rakshit, (2002) and Helmers *et al*. (2014) reported that maintaining manure nitrogen application below grain nitrogen remove the quantity of nutrients sufficient to keep soil nitrate level below the concentrations obtained from the non-manure sites. Many studies revealed that applying manure at greater nitrogen rates than needed for maximum soybean yield increase nitrate level in the soil (Helmers *et al*., 2014; Schmidt *et al* 2000). Adisa and Balogun (2013), reported that most research activities on soybean in Nigeria are majorly on both increasing production and maximizing impact to benefit to poor people and alleviate poverty. However, there is limited information on yield attributes, nutrition composition and nutrient use efficiency of soybean in response to cassava peel compost and mineral fertilizer. The objective of this study was to investigate effect of cassava peel compost, mineral fertilizer and their combination on seed yield attributes, seed quality and nutrient use efficiency.

MATERIALS AND METHODS

An experiment was conducted at Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo State (Latitude 80 10'N, Longitude 40 10'E and 700 m above sea level) within the Southern Guinea Savannah of Nigeria. During the period of the experiment, the monthly rainfall ranged from 8mm to 271.5 mm with an average of 118.90 mm while minimum and maximum temperature is 19^0 C and 24.3^0 C respectively. Prior to the initiation of this trial, the site had been under 2-years secondary bush fallow comprising mostly of guinea grass and *Chromolaena odorate* (L). Pre- planting soil sampling following land preparation was performed and the collected representative surface (0-15 cm) soil sample was subjected to routine physical and chemical analysis. The soil contained 0.15% N, 14.45 mg P kg^{-1} and 0.68Cmol kg^{-1} of exchangeable K. The experimental site soil belongs to Alfisols (USDA, 1998).

The compost was made from cassava peel and cured poultry manure. Both materials were air dried before composting and non-biodegradable materials sorted out of them. They were combined in ratio of 3:1 (cassava 3:1poultry manure) and both were composted in concrete pit (Akanbi et al., 2007a). The compost heap was turned every fortnight. At every turning the heaps watered while pH and temperature measurement. At maturity, the compost was evacuated, air dried pulverized and sub-sample was taken and used for nutrient analysis.

The soybean seed TGX 1448-2E, a promiscuous and low phosphorus varieties were obtained from International Institute Tropical Agriculture (IITA) Ibadan Nigeria. The trial consisted of six nutrient sources as treatments namely:

T_1 = Unfertilized (control)

T2 = 200 kg NPK ha^{-1}(NPK 15-15-15)

T3 = 5 t ha^{-1} CPC,

T4 = 150 kg NPK ha^{-1} + 1.25 t ha^{-1} CPC,

T5 = 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC, and

T6 = 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC.

The treatments were arranged in a randomized complete block design with three replications. Soybean seeds were drilled at inter-row spacing of 30 cm and intra-row of 10 cm. The compost treatments were applied a week before seed sowing while the entire dose of NPK was applied two weeks after sowing. Weed was controlled by application of pre-emergence herbicide Stomp at the rate of 2.5 L a.i /ha and supplemented with one- weeding between 6 week after planting. Insect pest was controlled by applying karate at the rate of 2 ml/litre. Spraying which started from 4 weeks after planting and was applied every fortnight until two weeks to harvesting.

Data were collected on yield attributes (number of pods per plant, % pod setting, total pods per plant, mean pod weight, 1000-seed weight, husk weight, and grain yield). Soybean was harvested when 85% of pods have turned brown to prevent shattering. The number of pods per plant was counted on randomly selected and harvested five plants per plot while the percent pod set was) using below formula:

$$\%Podsetting = \frac{Numberof\ pods/plant}{Numberof\ flower/plant} X \frac{100}{1}.$$

After harvesting, 30 pods were randomly selected per treatment/plot to assess pod and seed characteristics such as total number of filled and empty pods, pod length, girth and dry weight and plant biomass. The number of fully filled pods/plant was counted and recorded as number while the number of empty pods/plant were also counted and registered as the number of empty pods. The numbers of filled and unfilled pods were added to obtained total number of pods/plant. Pods dry weight /plant was obtained by weighing air-dried pods. Mean pod length was taken with aid of measuring tape. The plant biomass was obtained by weighting each plant after detaching the ripped pods. Seed sample for each fertilizer treatments were dried at 65 ^{0}C for 72h, ground and processed for proximate and nutritional content analysis. Proximate composition of nutrients content was determined as described by (A.O.A.C., 1984) while seed N was determined by a semi micro-kjeldahl procedure (Ulger *et al*., 1997). Seed protein was calculated from the kjeldahl N using a conversion factor of 6.25. Lipid content was estimated by exhaustively extracting a known sample weight with petroleum ether (BP 60°C) using a Tecator Soxhlet apparatus as described by AOAC (1984). Fibre content was estimated as described by AOAC (1984). The content of K, Fe, Cu and Zn were measured on atomic absorption spectrometer while total phosphorus (P) was determined using vanadomolybdate yellow method procedure (Murphy and Riley, 1962). Nutrient use efficiency was calculated using below formula as by described (Craswell and Godwin, 1984):

$$Nutrient\ use\ efficiency - \frac{Plant\ yield}{Nutrient\ Supply}$$

Data generated were subjected to analysis of variance (ANOVA) and differences between treatments mean were tested at 5% level of probability while significant means were separated using Duncan Multiple Range Test.

RESULTS

Effects of Cassava peel compost and Mineral fertilizer on Seed Yield attributes of soybean

The variability in number of pods per plant and percent pod set across all treatments was similar with the least value for both parameters obtained in the control treatment. The mean total pods per plant varied from 34.3 in control to 56.3 in 150 kg NPK ha^{-1} + 1.25 t ha^{-1} CPC. The order of increase in the mean number of pods per plants across the various treatments were 150 kg NPK ha^{-1} +

1.25 t ha^{-1} CPC > 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC > 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC > 200 kg NPK ha^{-1}> 5.0 t ha^{-1} CPC > control. In case of pod filling, the plants treated with 150 kg NPK ha^{-1} + 1.25 kg CPC had highest mean number (51.3/ plant) of filled pods. Cassava peel compost alone applied at the rate of 5.0 t ha^{-1} and the combined application of 150 kg NPK + 1.25 t ha^{-1} CPC gave the highest pod length. Sole application of 200 kg NPK ha^{-1} had highest pod weight (7.6 g) and was significantly different from all other treatments (Table 1).

Effect of Cassava peel Compost and Mineral fertilizer on soybean seed and husk parameters

Combined application of 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC gave the highest 1000 – seed weight and followed by 150 kg NPK ha^{-1} + 1.25 t ha^{-1} CPC (Fig 1i). Application of 100 kg NPK ha^{-1} + 2.5 t ha^{-1}CPC had significant and highest husk weight (6.00 g) and least husk weight (1.2 g) was recorded in the plots supplied with 200 kg NPK $ha^{-1.}$. Fertilizer treatment had significant effect on soybean grain: husk 200 kg NPK ha^{-1} gave highest grain; husk (1:7) and followed by application of 5.0 t ha^{-1}CPC. The mean value is 1:35 and range value is between 1:7 and 1:2. There is significant difference between control and 150 kg ha^{-1} NPK+ 1.25 t ha-1 CPC ha^{-1}CPC (Fig 1, ii-iii).

Effect of Cassava peel Compost and Mineral fertilizer on Soybean seed elemental Composition

Analysis of variance showed significant difference among the treatments applied with respect to soybean seed N, K and Cu content (Table 2). Seed N content was highest with non –fertilized plant followed by sole application of cassava peel compost while the least was obtained with use of 150 kg NPK ha^{-1} + 1.25 t ha^{-1} CPC. The seed K content varied significantly with applied fertilizer types but do not take any definite pattern. The K content obtained with 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC treatment was not differed from those of 200 kg NPK ha^{-1} and 100 kg NPK ha-1 + 2.5 t ha^{-1} CPC treatments. The pattern of variability in seed Zn as response to applied fertilizer sources was almost the same observed for K; with application of 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC producing the highest value.

Effect of Cassava peel Compost and Mineral fertilizer on Soybean seed proximate contents

Soybean seed moisture, dry matter, crude protein, crude fiber, fat and ash contents were all significantly affected by applied treatments (Fig 2). The highest crude protein content (32.1%) was recorded with control treatment followed by the 5.0 t ha^{-1} CPC and 200 kg NPK ha^{-1}. The least value was obtained with application of 150 kg NPK ha^{-1} + 1.25 t ha^{-1} CPC (29.4%). Seed treated with sole application of 200 kg NPK ha^{-1} gave the least value (18.75). Sole application of 200 kg NPK ha^{-1} had highest value of crude fibre and the least value was obtained at 5.0 t ha CPC. Seed ash content ranged from 3.5% in unfertilized control to 2.67% in 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC treatment. The highest seed moisture was obtained with application of 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC.

Table 1: Effect of cassava peel compost and inorganic fertilizer on seed yield attributes of parameters of soybean plants

Treatment	Number of pods /plant	% pod set	No./of filled pods /plant	No of unfilled pods/plant	Total pods /plant	Mean Pod length (cm)	Mean pod weight (g)
T1	14.1c	39.6b	20.3c	14.0a	34.3d	4.0c	5.8c
T2	53.0ab	78.0ab	40.3ab	8.0b	48.3ab	4.5ab	9.2a
T3	41.3b	68.8ab	38.0c	4.0c	42.0b	4.6a	7.6b
T4	50.0ab	70.0ab	51.3a	5.0c	56.3a	4.6a	4.7ab
T5	66.5a	83.8a	50.7a	5.0c	55.7c	4.5a	6.9b
T6	39.7bc	73.4ab	46.3ab	3.3c	49.7ab	4.3b	5.3ab
Mean	**41.17**	**73.43**	**41.17**	**6.56**	**47.72**	**4.43**	**6.58**

Values along column with the same letter are not significantly different using DMRT at P ≤ 0.05 (CPC = Cassava Peel Compost; T1 = 0 kg ha^{-1} (control); T2 = 200 kg NPK ha^{-1}; T3 = 5 t ha^{-1} CPC; T4 = 150 kg NPK ha^{-1} + 1.25 t ha^{-1} CPC; T5 = 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC, and T6 = 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC).

Table 2: Effect of cassava peel compost and inorganic fertilizer on selected mineral components of soybean seed

Treatment	Nitrogen	Phosphorus	Potassium	Copper	Zinc
	←		%		→
T1	5.13a	0.24a	0.83b	0.10c	0.16a
T2	4.99b	0.18a	1.35a	0.13ab	0.20a
T3	5.02b	0.20b	0.93b	0.11ab	0.18
T4	4.69c	0.20a	0.98b	0.10c	0.20a
T5	4.74d	0.24a	1.27a	0.13ab	0.18a
T6	4.83c	0.18b	1.40a	0.14a	0.22a

Mean along the same column with the same letter are not significantly different using DMRT at P≤ 0.05 (CPC = Cassava Peel Compost; T1 = 0 kg ha^{-1} (control); T2 = 200 kg NPK ha^{-1}; T3 = 5 t ha^{-1} CPC; T4 = 150 kg NPK ha^{-1} + 1.25 t ha^{-1} CPC; T5 = 100 kg NPK ha^{-1} + 2.5 t ha^{-1} CPC, and T6 = 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC. 100% NPK = 200 kg NPK ha^{-1} NPK 15-15-15; 100% Compost = 5.0 t ha^{-1} compost; CP Compost contained 2.01% N).

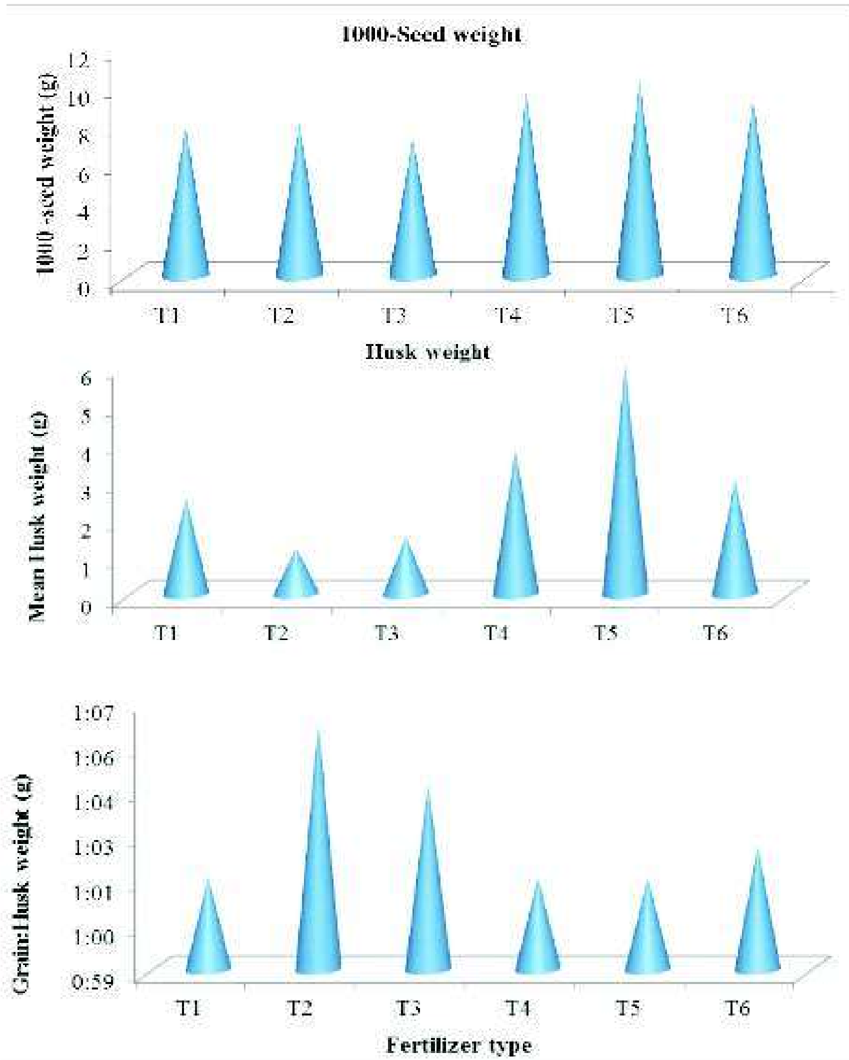

Fig 1: (i-ii): Effect of applied treatments on soybean seed, husk and grain to husk ratio weights

Bars with the same letter are not significant (P 0.05) Where: CPC = Cassava Peel Compost T1 = 0 kg ha-1 (control); T2 = 200 kg NPK ha^{-1}; T3 = 5 t ha-1CPC; T4 = 150 kg NPK ha^{-1} + 1.25 t ha^{-1}CPC; T5 = 100 kg NPK ha^{-1} + 2.5 t ha^{-1}CPC, and T6 = 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC

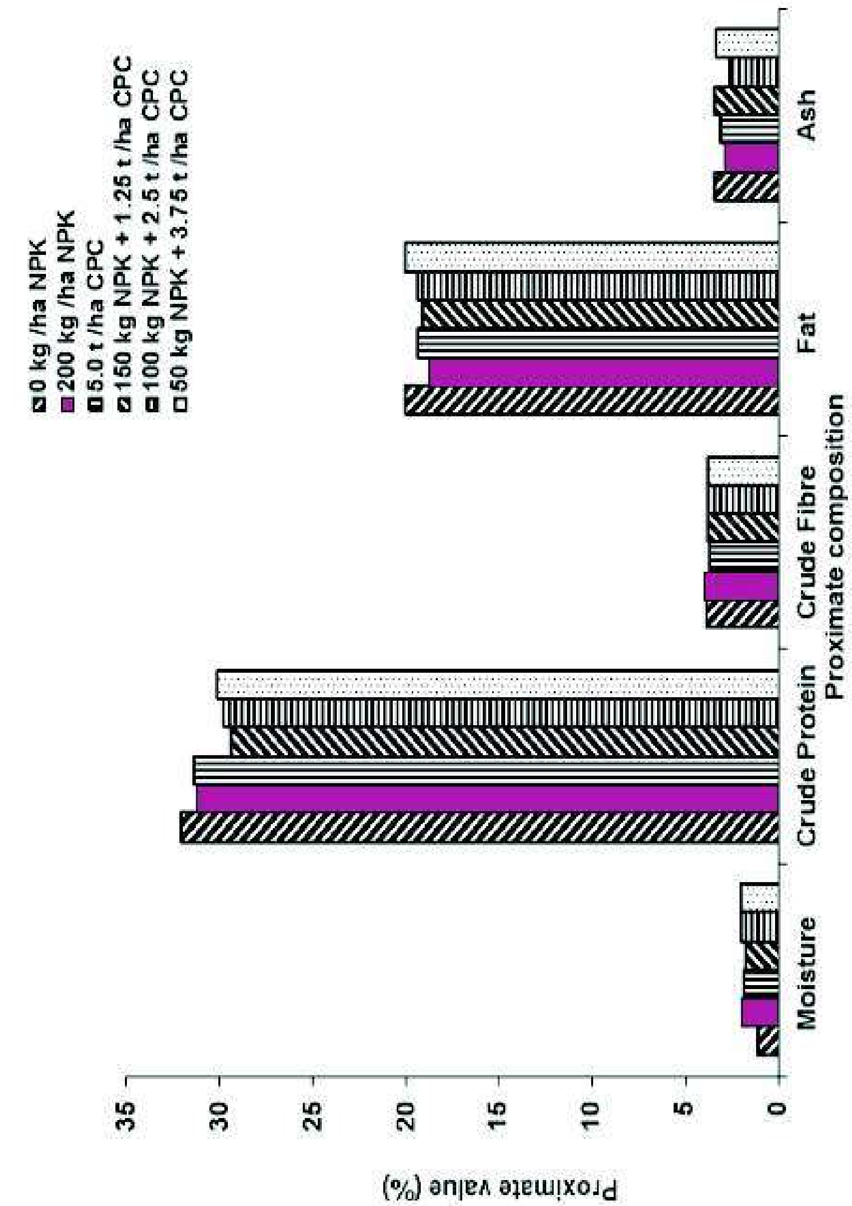

Fig. 2: Effects of fertilizer types on proximate composition of soybean seeds

CPC = Cassava Peel Compost

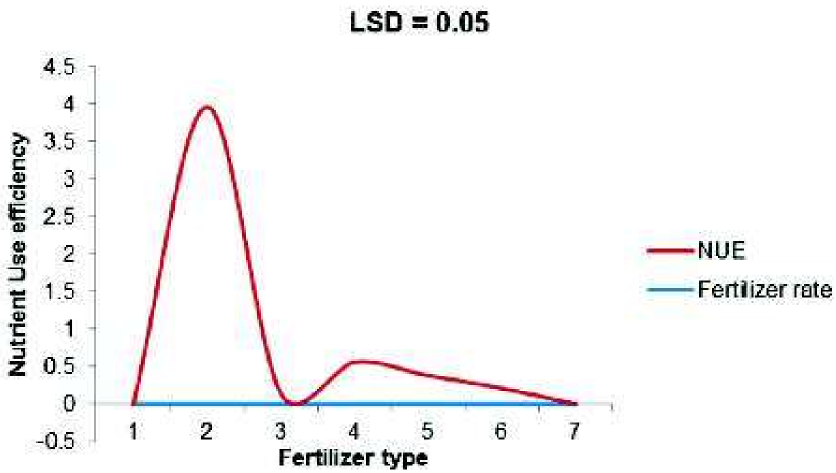

Fig 3: Effect of fertilizer type on Nutrient Use Efficiency

T1 = 0 kg ha-1 (control); T2 = 200 kg NPK ha^{-1}; T3 = 5 t ha-1CPC; T4 = 150 kg NPK ha^{-1} + 1.25 t ha^{-1}CPC; T5 = 100 kg NPK ha^{-1} + 2.5 t ha^{-1}CPC, and T6 = 50 kg NPK ha^{-1} + 3.75 t ha^{-1} CPC

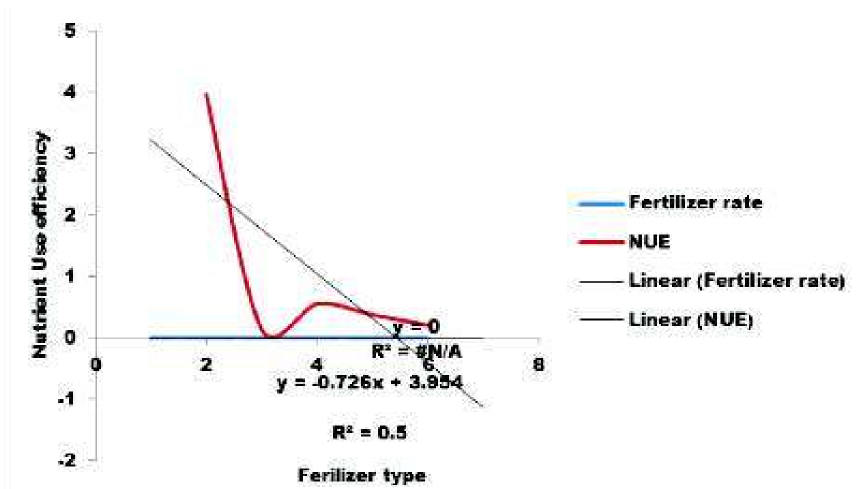

Fig 4: Relationship between Nutrient Use Efficiency and Fertilizer type.

Influenced of cassava peel compost and Mineral fertilizer on Nutrient use efficiency

The nutrient use efficiency (NUE) varied significantly across the applied treatments (Fig 3). Nutrient was found to be better utilized under combined application of NPK + 50% CPC and this was closely followed by NUE of 200 kg NPK ha^{-1}. The mean NUE value ranged between 0.21 to 3.95 ha^{-1} with application of 100% NPK having the highest value of 3.95 ha^{-1}. The order of increase in nutrient use efficiency followed 200 kg NPK ha^{-1}> 150 kg ha^{-1} 1.25 t ha^{-1} CPC 200 kg NPK ha^{-1}> 5.0 t ha^{-1} CPC > 0 kg NPK ha^{-1} + 0 t ha^{-1} CPC fertilizer. The relationship between nutrient use efficiency and fertilizer types showed positive and significant relationship (R = 0.5*) (Fig 4).

DISCUSSION

Total pod per plant was highest with application of cassava peel compost and inorganic fertilizer as well as percent pod setting. This was in agreement with report by (Jaanpaul and Gananesaraja, 1990, Manral and Saxena, 2003). At three month after planting when harvesting was carried out there more shattered pod among the soybean plants treated with 200 kg NPK ha^{-1} compared with others. This could have been cause by early maturity due to ready-made nutrient supply thereby ready for harvest before other while its subsequent staging on field may lead to wastage. There was increase in soybean yield attributes and grain yield with application of both cassava peel compost and inorganic fertilizer. This was similar with work of Tripathi and Shrestha (2000) reported the effect of combine use of urea and farmyard manure on seed yield. (Manral and Saxena, 2003) reported that increased in the seed per pod and 1000- seed weight, implied that nitrogen plays important role in the synthesis of chlorophyll and amino acids. The same to what was reported by (Akanbi *et al*., 2007a) who observed that combined application of cassava peel compost and inorganic fertilizer gave highest weight per pod in *Telfaria occidental* plant.

Application of 100 kg ha^{-1} NPK +2.5 t ha^{-1} CPC gave the highest grain yield. This is early reported by other researchers (Ramamurthy and Shivashankar, 1996), (Kimetu *et al.,* 2004, Sawyer et al., 2006, Akanbi *et al*., 2007a, Helmers et al., 2014) and (Pirdashti *et al*., 2010) . The soybean crop, crude protein, fat, crude fibre and moisture content were improved with application of cassava peel compost and inorganic fertilizer and mineral component followed the same trend. This is in agreeing with report of (Akanbi and Togun, 2002; Rosen and Allan, 2007; Olaniyi and Akanbi, 2007; Akanbi *et al*., 2007b and Olaniyi and Ajibola, 2008). Nutrient use efficiency is same as earlier reported by (Fixen, 2009b) and (Roberts, 2008) right application rate of fertilizer enhanced nutrient use efficiency. The relationship indicated that fertilizer types had strong influence on nutrient use efficiency of plant.

CONCLUSION

This experiment results indicate that combined application cassava peel compost and inorganic fertilizer had significant effect on yield attributes, seed quality and nutrient use efficiency and performed better than when sole application of either compost and inorganic fertilizer is applied. The use of 100 kg NPK + 2.5 t. ha^{-1} CPC produced the most significant yield attributes and grain yield. Inorganic fertilizer had highest nutrient use efficiency followed by application of 150 kg NPK ha + 1.25 t ha^{-1} CPC inorganic fertilizer. Therefore, combined application of cassava peel compost and inorganic fertilizer 100 kg + 2.5 t ha^{-1} is suitable for better seed yield and quality. Inorganic fertilizer 200 NPK ha^{-1}is best for nutrient use efficiency of soybean and 150 NPK + 1.25 t ha^{-1} can be substitute for it in Southern guinea savanna of Nigeria.

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