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# CHANGES IN CHEMICAL PROPERTIES OF AN ACID SOIL AMENDED WITH AGRICULTURAL WASTES AND THE YIELD OF (BAMBARA GROUNDNUT) *Vigna subtenuinea I verde* IN ABAKALIKI SOUTH EAST NIGERIA

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**ABSTRACT:** A study was conducted in the 2008 and 2009 raining seasons to investigate the effect of some organic wastes on some soil chemical properties and the yield of Bambara groundnut in a typic haptstult at Abakaliki. The treatments comprised of municipal waste, unburnt rice husk and burnt rice husk dust at the rates of 5t/ha respectively. An untreated soil was used as the control. The experiment was laid out in a randomized complete block design with four treatments and five replications. The test crop was bambara groundnut (*Vigna subtenuinea I verde*). The results showed that the soil chemical properties were superior on organic wastes treated plots than the untreated plots. The chemical properties of the organic waste treated soils differed significantly depending on type of waste applied. The crop yields on the amended plots were significantly higher than the untreated plots .The influence of the amendments on soil chemical and crop yield were in the order; burnt rice husk dust>municipal waste>unburnt rice husk>untreated soil. The results showed that organic wastes could be used to improve the soil productivity and consequently increase the yield of bambara groundnut in the study area.

**KEY WORDS:** Chemical Properties, Acid Soil, Amendments, Agricultural wastes, Bambara groundnut.

## INTRODUCTION

Owing to the dynamic nature of the soil, human activities and changing climatic conditions, most soils in the tropics suffer from soil nutrient poverty and chemical degradation. Applications of inorganic manure (fertilizer), organic wastes are some of the measures to combat the ugly situations. The beneficial effect of organic wastes in restoring soil productivity and in improving crop productivity is generally recognized through the improvement of soil nutrient status and the soil physical conditions, hence influencing the yield of crops (Dudai,1991) .Incorporation of organic materials and their use as mulch could influence the soil, resulting in improved soil physical conditions and in root penetration (Anikwe *et al*.,2003). Alofe and Egolum,(1995) reported that the application of organic wastes to the soil significantly increased the yield of bambara groundnut.

Bambara groundnut (*Vigna subtenuinea L Verdc*) is a tropical legume indigenous to Africa. It ranks third in importance after Groundnut and cowpea. Yields as high as 3t/ha have been reported under favorable conditions. However yield in Africa is between 0.5 to 2.2t/ha (Anon, 2004).The low yield may not be unconnected to poor chemical properties of most tropical soils. It is hoped that the practice of recycling of organic wastes into the soil could boost the production of bambara groundnut in Abakaliki area of the derived savannah zone of Nigeria. This study is necessary in order to restore the waving interest of the farmers in bambara groundnut production. Most of these farmers in this ecological zone are small-scale farmer who can not afford inorganic manure such fertilizer owing to its high cost. There are abundant rice husk dust and municipal waste in the study area, constituting environmental hazards. It is necessary to determine the agricultural benefits of these wastes for crop production. The aim of this study therefore was to determine the effect of the organic wastes application on soil chemical properties and the yield of bambara groundnut in Abakaliki.

## MATERIALS AND METHODS

The study was conducted at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki during the 2008 and 2009 raining seasons. Abakaliki is located within latitude $06^{o}\ 4^{1}$ N and longitude $08^{o}\ 5^{1}$ E. The rainfall pattern is bimodal with peaks in july and September and a short dry spell in August. The mean annual rainfall is 1500 to 1800mm. the area had a mean temperature of about $30^{o}C$ during the hottest period while the average temperature between December and January was $21^{o}C$ (EBADEP, 2008, 2009) during the study period. The bed rock geology is of shale residium. The soil is shallow with unconsolidated parent material within 1m of soil surface, of the order Ultisol and classified as Typic Haplustult. The vegetation is primarily of derived savannah. The study site was a field that was left fallow for 4 years.

The treatments comprised of burnt rice husk dust, unburnt rice husk dust and municipal wastes at the rates of 5t/ha respectively. The municipal wastes were collected from an urban refuse dump site whereas the rice husk dusk was sourced from the Abakaliki rice mills. The treatments were represented as T1=control; T2=municipal waste; T3=unburnt rice husk and T4=burnt rice husk dust a variety of bambara groundnut (*Vigna subterranean L Verdc)* was used as the test crop.

The experiment was laid out in a randomized complete block design (RCBD) with 4 treatments and 5 replications. A total land area of 14 X 14 m ($196m^2$) was used for the experiment. Each block measured 2X14 m while each experimental plot measured 2 X 3m ($6m^2$). The blocks were separated from each other by 1m ally while the

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experimental pots were separated by 0.5 m alley.The experimental site was cleared manually with cutlass and plant residues removed. The tilling operations were manually carried out with a hand hoe. Twenty soil samples for determination of pre-planting chemical properties) were randomly collected with soil auger at the depth of 0-20cm and mixed into a composite. Another set of auger soil samples were collected from each treatment plot after harvesting and bagged according to plots for the determination of post harvest soil chemical properties. The analyses of the samples were done in the Soil and Environmental Management Laboratory of the University.

The treatments were incorporated into the appropriate seedbeds and allowed to equilibrate for a period of 2 weeks before planting the test crop. Two seeds per hole were planted at a depth of 3cm with a spacing of 75 X 30 cm and later thinned down to 1 plant per stand giving a plant population of 44,444 stands /ha.

**Laboratory Analyses of Soil Chemical Properties**

Soil pH in 1:2.5 soil water solution was determined with pH meter, total nitrogen was determined using the macro- kjeldahl procedure described by Jackson (1958); Available phosphorus was determined by Bray2 (Bray and Kurtz,1945); organic matter percentage was determined by walkly and black method (1945) the value was corrected to organic carbon by multiplying the percent organic matter by a factor of 1.724 ;the exchangeable bases potassium(K),calcium(Ca) and sodium(Na) were determined by extracting with 1 N ammonium acetate; the amount of K, Ca, and Na in the filtrate were determined using Corning flame photometer with appropriate filter, and Mg determined using a Perkin-Elmer atomic absorption spectrometer (IITA,1979);CEC was determined by distillation with $NH_4OAC$ according to IITA,(1979); trace elements Zinc, iron boron and molybdenum, were determined according to I.I.T.A. (1979) method.

The plots were kept weed free by weeding frequently as the need arose with a small hand hoe. Harvesting was done at dry maturity.

In the field observation 10 plants from the net plot were tagged and harvested for pod and grain yield measurements. The net plot measured 2 x 2m.The harvested pods were air dried and weighed; then threshed and reweighed as grain yield. The grain was adjusted to 14% moisture content and converted to tons per hectare.ata was collected and analyzed using analysis of variance (ANOVA) and separation of means using the Fisher Least Significant Difference (F-LSD) as described by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

The pre planting soil analysis showed that the soil was acidic with low CEC and poor in general chemical properties.(Table 1).

**Table 1: The Result of the Pre-Planting Soil Analysis**

| Soil Chemical Properties | Values |
|---|---|
| pH (H2O) | 5.3 |
| % organic matter | 2.56 |
| % organic carbon | 1.48 |
| H + (Me/100g soil) | 1.60 |
| Al +(Me/100gsoil) | 0.60 |
| % nitrogen | 0.11 |
| Phosphorus (Me/100gsoil) | 53.2 |
| Cation Exchange Capacity (Me/100gsoil) | 5.60 |
| Calcium Me/100g soil | 4.60 |
| Patassium me/100g soil | 0.06 |
| Magnesium Me/100g soil | 2.40 |
| Sodium Me/100g soil | 1.25 |

**Effect of Organic Treatment on Soil Chemical Properties**

The changes in soil chemical properties as a result of the organic amendments are presented in table 2.

**Calcium**

Organic amendments significantly (p=0.005), improved soil calcium content when compared with the untreated soil. There were also significant variations in soil calcium content owing to the different organic amendments. The level of improvement in soil Ca contents were 1.7,1.8 and 2.6 Me/100g soil for urban waste ,unburnt rice husk and burnt rice husk dust respectively compared to untreated soil. The municipal waste treated soil produced 0.1 Me/100gsoil more calcium than unburnt rice husk dust treated soil whereas it had 0.8 Me/100gsoil of Ca less than the burnt rice husk dust treated soil. Treating the soil with burnt rice husk dust produced 0.8Me/100g soil significantly higher Ca than unburnt rice husk. The partially burnt rice husk dust with its large surface area could release more calcium to the soil though faster decomposition rate. This is supported by the finding of Müller-Samänu and Kotishi, (1984) who stated that partially burnt rice husk dust is used as lime alternative owing to its high calcium content.

**Potassium**

Potassium content of the organic waste treated soils was significantly higher than the control. There were also significant variations in levels of K content of the soil owing to the organic wastes. The unamended soil had 0.03; 0.02 and 0.13 Me/100gsoil significantly less potassium compared to municipal waste, rice husk dusk and burnt rice husk dust treated soils respectively. Municipal waste treated soil also had 0.01 Me/100g soil significantly higher potassium than the rice husk dust treated soil, while burnt rice husk dust treated soil produced 0.10 Me/100g soil significantly higher potassium content compared with municipal waste treated soil.

**Phosphorus**

The soils amended with organic wastes had significant improvement on soil available phosphorus compared with the unamended soils. The different organic waste showed significant variations in their improvement on soil available phosphorus. The levels of organic wastes improvement in the soil available phosphorus relative to the control were 50.8, 30.7 and 58.9 Me/100gsoil respectively for municipal waste, unburnt rice husk and burnt rice husk dust. Municipal waste treated soil had 58.8 mg/1Kg significantly more available phosphorus than rice husk dust treated soil whereas burnt rice husk dust treated soil had 9.0 Me//100g soil significantly more available phosphorus than municipal waste treated soil. The burnt rice husk dust treatment soil also significantly had 31.0 Me/100gsoil high available phosphorus than unburnt rice husk dust treated soil. The results is supported by Nwabude and Mabagwu (1999), who reported that burnt rice husk increased soil phosphorus in Abakaliki agroecological zone of Nigeria..

**Magnesium**

There were significant improvement in soil exchangeable Mg in the soils amended with organic wastes compared to the unammended soils, and also significant variations in soil Mg among the soils treated with the different soil ammendements.The values of the increase of soil Mg owing to waste ammendement compared to the control were 1.4, 1.2 and 1.6 Me/100g soil for municipal waste, unburnt rice husk dust and burnt rice husk dust respectively. Municipal waste treated soil had 0.2 mg/1Kg soil significantly more soil magnesium than the unburnt rice husk dust treated soil, whereas the burnt rice husk dust treated soil had 0.2Me/100g soil significant improvement in soil magnesium over the municipal waste treated soil. Burnt rice husk dust treated soil also had 0.4 Me/100g soil significantly more magnesium than the unburnt rice husk dust treated soil. This result is owing to the fact that burnt rice husk has finer particles which are easily mineralized. Therefore the mineralized substance may release more magnesium to the soil owing to further increased decomposition associated with very high surface area exposed to microbial and chemical activities and reactions respectively.

**Sodium:**

Soils amended with organic wastes showed significant improvement in soil sodium content. There were also variations in the level of soil Na content owing to the different organic amendment sources. The rates of increase in soil sodium content were 0.10, 0.12 Me/100g soil for the municipal waste and burnt rice husk dust treatment respectively compared with the control. Municipal waste increased soil Na by 0.20 Me/100g compared to the unburnt rice husk dust treated soil, whereas the burnt rice husk treated soil had 0.22 mg/1Kg of sodium significantly higher than the unburnt rice husk dust treated soil.

**% Total Nitrogen**

The soil total nitrogen values were significantly higher in the organic waste treated soil compared with the control. The different organic amendment sources had variations in their levels of N contribution to the soil.There contributions were 10.71, 9.01 and 20.63 per cent for municipal waste, unburnt rice husk dust and burnt rice husk dust treated soils respectively compared to the control. The municipal waste treated soil had 1.82% significantly more total nitrogen compared with unburnt rice husk dust treated soils, whereas burnt rice husk dust significantly improved soil total nitrogen by 11.40% compared with municipal waste treated soil. The partially burnt rice husk dust treatment improved the soil total nitrogen by 12.70% compared to the unburnt rice husk dust treatment. There levels of improvements of soil total nitrogen however are less than the quantity of soil N rated as adequate for crop production (Landon 1991).

**% Organic Matter:**

The soil organic waste amendments increased the levels of soil organic matter when compared with the unamended soil. The organic matter levels of the treated soils varied depending on the source of organic amendment. Municipal waste, unburnt rice husk dust and partially burnt rice husk dust treatments significantly increased soil organic matter by 4.17, 5.4 and 15.34% respectively when compared with the control. The municipal waste treated soil had 2.05% significantly more organic matter than the unburnt rice husk treated soil. while burnt rice husk dust amendment significantly improved organic matter by 11.66% compared to unburnt rice husk dust. Furthermore burnt rice husk dust treated soil produced significantly 12.88% more organic matter than the unburnt rice husk dust treated soil.

**Exchangeable Aluminum**

The level of exchangeable aluminum in the organic waste treated soil is significantly different from the untreated soil. Also the organic waste treated soils were significantly different when compared with one another. The control contained 0.20, 0.30 and 0.50 mg/1Kg soil less exchangeable aluminum than municipal waste, unburnt rice husk dust and burnt rice husk dust treatments respectively. Municipal waste treated soil significantly differed by 0.10 mg/1Kg soil when compared with unburnt rice husk dust treated soil. Whereas burnt rice husk dust treated soil had 0.30 mg/1Kg significantly more exchangeable aluminum than the unburnt rice husk dust treatment soil. Also the partially burnt rice husk dust treated soil had 0.20 mg/1Kg significantly more exchangeable aluminum than the unburnt rice husk dust. The presence of high concentration of exchangeable aluminum in the soil replaces the cation on the exchange site, thereby enhancing the quantities of calcium, magnesium, sodium and potassium in the soil. These releases can be seen in this work were burnt rice husk dust release of cation is improving the soil reaction significantly. The burnt rice husk dust has consistently produced better soil nutrient than the municipal waste and rice husk dust treatments.

**Soil pH**

There was a reduction in acidity of the organic waste treated soil when compared with the untreated soil. There were also variations in acidity of the different soil amendments. Municipal waste treatment raised soil pH by 0.8 units, unburnt rice husk dust by 0.5 units and burnt rice husk by 1.2 units compared to the untreated soil. Among the amended soils burnt rice husk dust increased pH by 0.6 and 0.7 units compared to municipal waste and unburnt rice husk treatments respectively. The acidity reduction capabilities of the amendments were in the order burnt ricr husk dust > municipal waste > unburnt rice hust. Calcium and Magnesium are the major components of the burnt rice husk. These two elements in acid solution have the capability to replace hydrogen ions on the exchange site. The replaced ions are easily leached beyond the root zone of the crops. This account for liming effect of the burnt rice husk dust recorded.

**Cation Exchange Capacity (CEC)**

The application of the organic wastes significantly raised the cation exchange capacity of the amended soils relative to the unamended soils. The municipal waste amended soil raised soil CEC by 1.0Cmol/100g,but unburnt rice husk by 0.4Cmol/100g,whereas the burnt rice husk dust

**Table 5:** Estimate of the Profitability of using Different Weed Control Methods on Okra Plots: -

2005

| Treatments | Yield (tons/ha) | Cost of Weed (control/ha) | Output($/ha) | Net Gain |
|---|---|---|---|---|
| No Weeding | 1.75 | - | 870.00 | 870.00 |
| 3 Hand-pulling | 3.83 | 450.00 | 1,910.00 | 1460.00 |
| 6 Tons Mulch | 3.05 | 390.00 | 1,520.00 | 1,130.00 |
| 2 Hoe-Weeding | 3.35 | 250.00 | 1,675.00 | 1,425.00 |

2006

| Treatments | Yield (tons/ha) | Cost of Weed (control/ha) | Output($/ha) | Net Gain |
|---|---|---|---|---|
| No Weeding | 2.62 | - | 870.00 | 870.00 |
| 3 Hand-pulling | 3.83 | 450.00 | 1,910.00 | 1460.00 |
| 6 Tons Mulch | 2.88 | 390.00 | 1,935.00 | 1,545.00 |
| 2 Hoe-Weeding | 3.36 | 250.00 | 1,675.00 | 1,425.00 |

The above table assumes all other factors of production to be constant

led to 3.2 Cmol/100g increase in soil CEC. It was observed that among the amended soils municipal waste treatment raised soil CEC by 0.6Cmol/100g compared to unburnt rice husk and was 2.2Cmol/100g less than burnt rice treated soil. Burnt rice husk dust led to an increment of 2.2 and 2.8 Cmol/100g in CEC compared to unburnt rice husk and municipal waste treatments respectively. These rates of CEC recorded in this study fall short of the standard for crop production. With continued enrichment of the soil ,the CEC value is expected to continue to increase. Cation exchange capacity of soils reveals the fertility levels of such soils, This explains the difference in quantities of the exchangeable cations recorded. The burnt rice husk dust recorded higher pH value and higher CEC. This situation explains why the fertility status of the treated soils maintain increasing trend of burnt rice husk dust>municipal waste>unburnt rice husk dust.

**Pod and grain yield of Banabara groundnut**

The effect of organic waste treatment on pod and grain yield of Bambara groundnut is presented in table 3.

**Table 3: Effect of organic waste on pod and grain yield of Bambara Groundnut**

| Treatment | Pod yield t/ha | Grain yield t/ha |
|---|---|---|
| Control | 3.68[a] | 2.99[a] |
| Municipal waste | 4.56[b] | 3.84[b] |
| Rice husk dust | 4.32[b] | 3.55[b] |
| Burnt rice husk dust | 6.76[c] | 4.41[c] |
| FLSD (P=0.05) | 0.62 | 0.74 |

Note: mean yield data of 2007 and 2008.Figures with the same superscript are not statistically significant.

**Pod Yield**

Oils treated with organic wastes produced significantly higher pod yields compared to the ones on the untreated soil. The bambara groundnut growing on There were also variations in the levels of improvement in pod yield owing to the various amendments. The increase in pod yield of the amended soils were 0.86t/ha for municipal waste,0.64t/ha for unburnt rice husk and 3.08t/ha for burnt rice husk amendments.

**Grain Yield**

The amendments of the soil led to significant improvement in the grain yield of the crop. There was significant difference in grain yield of Bambara groundnut when the organic waste treatments were compared with the untreated soil and when the organic waste treatments were compared with one another. There were 0.86 and 1.42 t/ha significant increase in grain yield when the municipal waste treated soil and burnt rice husk dust respectively were compared with the untreated soil. Unburnt rice husk treated soil improved grain yield significantly by 0.55 t/ha over the control. Burnt rice husk dust improved yield by 0.57 and 1.06 t/ha compared to municipal waste and unburnt rice husk treatments respectively. Whereas municipal waste treatment produced significantly more grain than unburnt rice husk dust .Burnt rice husk dust ensured nutrient supply and availability to the crops. Vigorous plants ensure higher photosynthesis, converting product into grains. The role of burnt rice husk dust in ameliorating acidic of ultisols has been highlighted by Ekpe *et al*, 2009 who recorded increased grain yield of partially burnt rice husk dust treated soils in the study area.

## CONCLUSION

An experiment to monitor the fertility contributions of three sources of organic waste (municipal waste, rice husk dust and burnt rice husk dust) was studied in a typic haplustult. The experiment was laid out in a randomized completes block design with four treatments and five replication with Bambara groundnut as a test crop. Analysis of post harvest soil samples revealed significant difference in chemical properties of the organic waste treated when compared with the control. Agronomic parametric measured (pod and grain yield) also revealed significant differences when the organic waste treated soils were compared with the untreated soil.

In conclusion burnt rice husk dust proved more effective in reducing acidity, increasing soil fertility, pod and grain yield of the cast crop.

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