

Influence of different forms of Cassava peel on physicochemical properties of an Ultisol and yield of Maize (*Zea mays L.*) in Abakaliki South Eastern-Nigeria.

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A study to determine the effect of cassava peels on soil properties and yield of maize in an Ultisol was conducted at the Teaching and Research farm of faculty of Agriculture and Natural Resources Management Ebonyi State University, Abakaliki. The experiment was established in a randomized complete block design with six treatments and four replications. The treatments were: fresh cassava peels (FCP), dry cassava peels (DCP), dried ground cassava peels (DGCP), dried ground cassava peels + fresh cassava peels (DGCP+ FCP), dried ground cassava peels + dried cassava peels (DGCP+ DCP) and control with no application of cassava peels. The results showed that application of the treatments significantly ($p > 0.05$) reduced the bulk density and increased total porosity (Tp), saturated hydraulic conductivity and water stable aggregates relative the control. Highest saturated hydraulic conductivity range of $0.0081 - 0.0099 \text{ cm S}^{-1}$ were recorded in the DGCP+ DCP relative to the control ($0.0013-0.0011 \text{ cm S}^{-1}$ in 2006 and 2007 respectively). Significantly higher values of organic carbon (%OC), Available P, Cation exchange capacity (CEC) and Total N were observed in amended plots relative to the control in both seasons. Maize yield showed highest values of 2.77 and 3.01 t ha⁻¹ in the DGCP+ FCP amended plots in 2006 and 2007 seasons, respectively. Cassava peels are efficient in improving soil properties and maize yield.

Key words: Cassava peels, Soil properties, Maize yields, Ultisol.

INTRODUCTION.

Increase in food demand worldwide, has led to progressive transformation of traditional extensive fallow system of land cultivation and management, to a modern fertilizer intensive and continuous cultivation of lands, which has resulted in serious land degradation and consequent decline in soil productivity, Parr and Papendick, (1978). In order to reverse the trend of declining fertility of soils and restore soils to their original fertility status, farmers have since reversed to the traditional bush fallow system and the use of plant residue, house hold refuse, animal manure and other organic manure to maintain soil fertility and enhance soil organic matter contents.

Studies on organic waste as alternative to inorganic fertilizers have been carried out (Anikwe, 2000., Nnabude and Mbagwu, 2001., Mbah and Onweremadu, 2009). It was noted that these research efforts, which were aimed at finding the agronomic values of organic waste were necessitated by the following reasons: the decline in physical and chemical properties of soil as a result of intensive cultivation; and the inability of inorganic fertilizer to check the decline in soil physical and chemical properties as observed by Mbagwu, (1992). According to Hornick and

Parr (1987) organic materials generally differ in their properties and characteristics. Those with higher levels of organic stability such as cereal straws, wood-bark and sewage sludge provide distinct advantages in the initial reclamation of marginal soils.

In Abakaliki agro-ecological zone of the South eastern Nigeria, large quantities of fresh cassava peels accumulate around market areas and refuse dump sites in the urban, sub-urban and rural communities. The soils of Abakaliki have several structural impediments such as high bulk density, extreme consistency conditions, compaction and poor drainage. The ability of organic waste to improve their conditions has been extremely studied (Okonkwo et al. 2008., Nwite et al. 2011). The objective of this study is therefore to determine the effects of the application of different forms of cassava peels on soil properties and yield of maize in Abakaliki agricultural zone of Ebonyi state, Southeast of Nigeria.

Material and Methods.

Field study was conducted in 2006 and 2007 on the experimental farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State

University, Abakaliki (06° 04'N, 18° 65' E). Total rainfall ranges between 1500-2000 mm with a mean of 1800 mm, distributed bimodally. The mean daily temperature range is between 27-31°C. Abakaliki agricultural zone lies within the Asu river group and consists of olive-brown sandy shale, fine grained sand stones and mudstones. The soils are shallow, with unconsolidated parent materials (shale residuum) within 1 m of the soil surface. It belongs to the order Ultisol and classified as typic Haplustult. The study site was manually cleared. Auger soil samples were taken randomly from a depth of 0-20 cm. The soil samples were air-dried at room temperature thoroughly mixed to form a composite sample and was passed through a 2.0 mm sieve for the pre-planting soil analysis. The experiment was established in a randomized complete block design (RCBD) with six treatments and four replications. The treatments applied at the rate of 10 t ha⁻¹ include: fresh cassava peels (FCP), dry cassava peels (DCP), dried ground cassava peels (DGCP), dried ground cassava peels mixed with fresh cassava peels (DGCP+FCP), dried ground cassava peels mixed with dried cassava peels (DGCP+DCP) and a control with no application. The treatments were spread uniformly on each plot measuring 4 m x 4 m and incorporated into the soil during seed-bed preparation. Maize variety Swan-1-Y was planted at a distance of 50 cm x 50 cm after a week of incorporation. The experimental plots were kept weed free.

Observation and Data Collection.

Ten undisturbed core soil samples (for analysis of soil bulk density and hydraulic conductivity) and ten auger samples (for the determination of gravimetric soil water content) were randomly collected from a depth of 0-20 cm in each plot. The core samples, were analyzed separately and mean results used while the auger samples were mixed and the composite soil-sample taken for analysis. Measurements for soil bulk density, total porosity, and gravimetric water content were also made at 8 weeks after planting. Shoot dry weight of maize was taken at teaselling and grain yield was measured at harvest. In each plot, 10 plants were randomly selected, tagged and sampled. The maize grains were dried, shelled, weighed and yield data adjusted to 14 % moisture content (by weight). Post harvest auger-soil samples were taken plot by plot (10 samples per plot) bulked to form a composite.

Laboratory Analysis.

Both pre-planting and post harvest soil samples were analysed separately. Particle size distribution was measured by the hydrometer method of Gee and Bauder(1986). Total nitrogen was determined by the micro-kjeldhal method Bremner and Mulvaney (1986) Soil pH in 1:1 soil-water solution was measured using electrode pH meter, and organic carbon determined by Walkley and Black method (Nelson and Sommers, 1982) and organic matter (OM%)obtained by multiplying OC

value with Vanbammeler factor of 1.734. Available P was measured with Bray-2 method (Page *et al*, 1982) .Soil bulk density and hydraulic conductivity were analysed using core method and constant head methods respectively (Page *et al*. 1982) .Total porosity was calculated from bulk density data as the fraction of total volume not occupied by soil assuming a particle density of 2.65 Mg m⁻³. Available water capacity was determined using a pressure plate apparatus at 10 kPa (field capacity) , Stolte, (1997) Aggregate stability was measured at the macro-level (WSA> 0.05 mm) using the wet sieving technique of Kemper and Rosanou, (1986)

Statistical Analysis.

Data collected from soil physico-chemical study and maize performance, were subjected to analysis of variance according to Steel and Torrie, (1980) and their means compared using least significant difference (FLSD at P < 0.05).

Results and Discussion

Pre-planting soil properties.

The soil texture is sandy loam(Table 1) with pH 4.8 (extreme acid). The soil organic matter (1.78 g kg⁻¹), total N (0.08 g kg⁻¹), available P (7.2 mg kg⁻¹) and the exchangeable cations; K, Ca, Mg and Na were low. However, high soil bulk density of 1.76 Mg m⁻³ was obtained while other soil parameters like total porosity, soil water content and water stable aggregates had low values (Enwezor *et al*. 1988).

Table 1. Pre- planting soil properties (0-20 cm)

Parameters	Soil	Cassava peels
Sand (g kg ⁻¹)	680	-
Silt (g kg ⁻¹)	220	-
Clay (g kg ⁻¹)	100	-
Textural class	sandy loam	-
pH (H ₂ O)	4.8	-
Org C (g kg ⁻¹)	1.03	3.87
Om (g kg ⁻¹)	1.78	6.65
Total N (g kg ⁻¹)	0.08	0.20
Avl.P (mg kg ⁻¹)	7.2	22.43
Exchangeable		
K (c mol kg ⁻¹)	0.20	0.52
Ca (c mol kg ⁻¹)	2.40	3.94
Mg (c mol kg ⁻¹)	1.26	1.98

Na (c mol kg ⁻¹)	0.02	0.08
CEC (c mol kg ⁻¹)	3.88	6.25
Bd (Mg m ⁻³)	1.76	-
Tp (%)	21	-
Mc (%)	28	-
<u>WSA (%)</u>	<u>40</u>	<u>-</u>

Post Harvest Soil Properties.

Effect of cassava peels on soil physical properties.

Table 2 shows that significant changes in soil bulk density occurred in the plots where the different forms of cassava peels were applied in the two years of study. The application of cassava peels significantly ($p < 0.05$) reduced the soil bulk density relative to the control in both seasons. For instance soil bulk density was reduced by 24 % (2006) and 26% (2007) in plots amended with DGCP+ DCP. The order of decrease in soil bulk density was DGCP + DCP < DGCP+ FCP < DCP < FCP < control. Differences in soil bulk density between the control and plots amended with cassava peels may be because the decomposed cassava peels helped to increase the soil matrix thereby reducing soil bulk density. Similar findings were made by Mbagwu,(1992), Mbah *et al.*(2004) and Mbah (2008). Lower soil bulk density is a positive productivity indicator in soil as it helps in easing root penetration and therefore, encourage downward movement of water through old root channels (Obi,2000) Soil bulk density increased by 3% (2006) and 5% (2007)

in the control plots relative to the pre-planting. This may be due to tillage operations and low organic matter content according to Okonkwo *et al.* (2008) as well as other natural factors like the alternate wetting and drying cycles that cause large “effective stresses”, in a tropical climate. Higher total porosity values were obtained in the plots amended with the cassava peels relative to the control. The trend was in the order of DGCP+DCP > DGCP+FCP > DCP > DGCP > FCP > control. The highest total porosity of 59% and 61% were obtained in the DGCP+DCP. These values were higher than higher than the control by 34% (2006) and 38% (2007) in 2006 and 2007 seasons, respectively. Higher saturated hydraulic conductivity ranging between 0.0042 -0.0047 cm s⁻¹ and 0.0081 - 0.0099 Cm s⁻¹ in amended plots were obtained relative to the control (0.0013 Cm s⁻¹ to 0.0011 cm s⁻¹) in 2006 and 2007 respectively. The DGCP+DCP increased saturated hydraulic conductivity by 72% and 80% in 2006 and 2007 respectively relative to the control. Saturated hydraulic conductivity is a measure of how well the soil transmits water under saturated conditions according to Marshal *et al.*, 1996) Higher conductivity implies that soils amended with DGCP+DCP transmitted water better under saturated conditions. According to Nwite *et al.* (2011) and Mbagwu, (1992) incorporation of organic wastes significantly increased soil hydraulic conductivity, but the magnitude of increase depended on the rate of application. The generally higher saturated hydraulic conductivity values implied that run-off and erosion can be checked with the application of different forms of cassava peels. The results also showed that gravimetric soil water content was affected by the different forms of the cassava peels. The highest soil water content of 61% (2006) and 68% (2007) were recorded in the DGCP+DCP amended plots. These values showed increased soil water content of 47% (2006) and 54% (2007) relative to the values obtained in the control . This study corroborates that of Nnabude *et al.* (2000).

Table 2. Effect of different forms of cassava peels on selected soil physical properties

Treatments	Bd (Mg m ⁻³)		SHC(cms ⁻¹)		Tp(%)		GWC(%)	
	a	b	a	b	a	b	a	b
Control	1.87	1.91	0.0013	0.0011	28	27	26	24
FCP	1.40	1.31	0.0042	0.0047	39	45	40	49
DCP	1.22	1.17	0.0056	0.0069	48	50	47	52
DGCP	1.10	1.06	0.0079	0.0093	52	56	54	59
DGCP+FCP	1.12	1.09	0.0076	0.0089	49	53	53	58
DGCP+DCP	1.08	1.03	0.0081	0.0099	56	59	59	61
<u>LSD (0.05)</u>	<u>0.17</u>	<u>0.05</u>	<u>0.0003</u>	<u>0.0005</u>	<u>2.71</u>	<u>3.45</u>	<u>3.45</u>	<u>3.62</u>

FCP= fresh cassava peels, DCP= dry cassava peels, DGCP= dried ground cassava peels, DGCP+ FCP= dried ground cassava peels + fresh cassava peel, DGCP+ DCP= dried ground cassava peels mixed with dried cassava peels (DGCP+ DCP) and control with no application of cassava peels. Bd = Bulk density, SHC = Saturated hydraulic conductivity, Tp = Total porosity, GWC = Gravimetric moisture content, a = 2006, b =2007

Effect of cassava peels on soil chemical properties.

Table 3 shows the result of the chemical properties of soils amended with different forms of cassava peels. Organic matter was very high in all plots receiving amendments relative to the control. The results showed that the highest organic matter level was recorded in the DGCP+DCP amended plot (3.12 and 3.31 g kg⁻¹) for the two years, respectively. These values gave an increase of 44% and 62% relative to the control. Enwezor et al (1988) classified organic matter as follows: less than 2.0% as low (values below critical limits), 2.1-3.0% as medium (values above critical level) and greater than 3.1% as high (values above which response will be unlikely and application uneconomical). The high level of soil organic matter in plots receiving amendment could be attributed to the application of cassava peels. Organic matter is a reservoir of essential and non-essential mineral elements for plant growth and development; hence increased organic matter may lead to increased soil productivity. The total N content of the soil was highest in the DGCP+FCP amended plots (0.21 g kg⁻¹ in 2006 and 0.24 g kg⁻¹ in 2007). These represent increase in N content of

62% (2006) and 78% (2007) relative to the control. Soil N content decreased in the control plots (0.05 g kg⁻¹ in 2006 and 0.03 g kg⁻¹ in 2007). The highest available P of 32.07 mg kg⁻¹ (2006) and 38.68 mg kg⁻¹ (2007) increase were obtained in the DGCP+DCP amended plots representing 62% and 70% (2006) relative to the control. Observe CEC values in amended plots ranged between 5.77-7.21 and 6.37-8.34 c mol kg⁻¹ in 2006 and 2007 seasons, respectively. The CEC values obtained in the DGCP+FCP increased by 87% (2006) and 35% (2007) relative to the control. Similarly the DGCP+DCP amended plots increased CEC by 98% (2006) and 49% (2007) over the control. The high CEC values of the amended plots were likely a result of decomposition of the different forms of the cassava peels which yielded more of the exchangeable bases. The results of the soil chemical properties showed that cassava peels either in a fresh, dried or ground condition raised the fertility status of the amended plots and could be effective in improving of soil properties. The result of this study corroborates those of Mbah and Mbagwu(2006) and Nnabude and Mbagwu(2001) when they used wastes as soil amendments.

Table 3 Effect of different forms of cassava peels on some soil chemical properties.

Treatments	2006				2007			
	Om g kg ⁻¹	Total N g kg ⁻¹	Avl.P g kg ⁻¹	CEC C mol kg ⁻¹	Om g kg ⁻¹	Total N g kg ⁻¹	Avl.P g kg ⁻¹	CEC C mol kg ⁻¹
Control	1.19	0.05	7.61	3.65	0.79	0.03	6.84	3.35
FCP	2.17	0.17	21.34	5.77	2.38	0.19	21.32	6.37
DCP	2.78	0.14	26.07	5.99	2.99	0.16	30.49	6.87
DGCP	2.89	0.15	26.44	6.23	3.10	0.20	32.4	7.32
DGCP+FCP	2.96	0.21	29.62	6.83	3.14	0.24	31.35	7.87
DGCP+DCP	3.12	0.19	32.07	7.21	3.31	0.21	38.68	8.34
LSD (0.05)	0.84	0.03	2.18	1.24	0.91	0.05	3.01	1.41

FCP= fresh cassava peels, DCP= dry cassava peels, DGCP= dried ground cassava peels, DGCP+ FCP= dried ground cassava peels + fresh cassava peel, DGCP+ DCP= dried ground cassava peels mixed with dried cassava peels (DGCP+ DCP) and control with no application of cassava peels

Maize Yield.

Table 4 showed significant treatment effect on maize yield relative to the control (Table 4). However differences in yield observed among the treatments were not significant. Highest maize grain yield of 2.77 and 3.01 t ha⁻¹ were observed in DGCP+ FCP in 2006 and 2007 seasons, respectively. The observed grain yield of 3.01 t ha⁻¹ (2007) in DGCP+FCP amended plots was 6%, 15%, 19%, 2% and 77% higher than values in, DCP ,

DGCP+DCP, DGCP, DCP, FCP and C, respectively. The increase observed in cassava peel amendments could be due to the improvement in soil physical and chemical properties which translated to higher grain yield in both seasons. Similarly improved nutrient conditions of the soil following addition of cassava peel could have also contributed to improvements in yield in amended plots relative to the control. The result of this study is in line

with the observations of Mbah et al.(2004), Mbah and Onweremadu(2009) and Nnabude and Mbagwu (2001) when they used organic wastes as soil amendments.

Table 4. Maize performance under the different forms of cassava peels.

Treatment	Grain yield	
	t ha ⁻¹	
	a	b
Control	0.92	0.70
FCP	2.65	2.96
DCP	2.33	2.45
DGCP	2.46	2.55
DGCP+FCP	2.77	3.01.
DGCP+DCP	2.26	2.84
LSD (0.05)	0.45	0.51

FCP= fresh cassava peels, DCP= dry cassava peels, DGCP= dried ground cassava peels, DGCP+ FCP= dried ground cassava peels + fresh cassava peel, DGCP+ DCP= dried ground cassava peels mixed with dried cassava peels (DGCP+ DCP) and control with no application of cassava peels

Conclusions.

Results from this study showed that application of cassava peel as soil amendment improved soil physical and chemical properties. The improvement in the soil properties led to enhanced maize grain yield relative to the control.

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