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Influences of Cassava Peels on Some Soil Physical Properties, Maize Growth and Yield in an Ultisols

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ABSTRACT
Experiment on the effects of cassava peel (CP) on soil physical properties, maize growth and yield was conducted at Teaching and Research Farm of Ambrose Alli University, Ekpoma, Edo State. Five levels of CP; 0, 10, 15, 20 and 25 t/ha were administered to cultivated maize Swan-1 variety in a randomized complete block design, replicated thrice. Results showed that CP increased maize leaf area at 3 weeks after planting (WAP) and plant height at 6 and 9 WAP significantly. The highest maize cob and grain weights of 20.24 t/ha and 6.75 t/ha were obtained from the application of CP at 25 t/ha. Cassava peels at 25 t/ha also resulted in significant moisture content 23.49% on mass basis; CP at 20 t/ha and 25 t/ha reduced soil bulk density significantly from 0.92 g/cm^3 to 0.82 g/cm^3 and 0.79 g/cm^3 respectively. It however, had had no significant effects on soil particle density, moisture content on volume basis and porosity but they increased with rates of cassava peel applications. Cassava peel mulch as an organic manure increases soil organic matter, soil physical fertility that may increase crop growth and yield.
Keywords: bulk density, cassava peels, growth, Maize, yield

INTRODUCTION
Cassava processing produces large amounts of waste and is generally considered to contribute significantly to environmental pollution (FAO, 2001). A cassava starch production unit processing 100 tons of tubers per day has an output 47 tons of fresh by-products, which may cause environmental problems when left in the surroundings of processing plants or carelessly disposed off (Aro *et al*., 2010). In Nigeria, for example, cassava wastes are usually left to rot away or burnt to create space for the accumulation of yet more waste heaps. The heaps emit carbon dioxide and produce a strong offensive smell (Adebayo, 2008). Cassava peels (large amounts of cyanogenic glucosides) and pomace (large amounts of biodegradable organic matter) may cause surface water pollution especially if they are stored under heavy rain or simply disposed of in surface waters (Pandey *et al*., 2000; Cereda *et al*., 1996; Barana *et al*., 2000). The presence of a large processor or several small processors can cause the eutrophication of slow moving water systems, notably during the dry season (FAO, 2001). However, cassava processing does not seem to affect groundwater supply, except occasionally in the immediate surroundings of processing units, due to leaching through the soil (FAO, 2001). Cassava processing generates solid and liquid residues including cassava peels. Cassava peels which are regarded in many areas in Nigeria as waste are rich in crude protein (5.29%) and fat (1.18%) (Oyenuga, 1968). Iren *et al*. (2015) asserted that most cassava peels are commonly found in farm locations and processing sites as heaps that are generally perceived as hazard to the environment. That it could be utilized more effectively and sustainably through recycling and are potential source of organic matter and plant nutrients.
Management of cassava peels includes direct incorporation into the soil, feeding them to livestock, burning or processing them into a more stable organic fertilizer called compost (Rogers and Milner, 1983). An important factor in soil reclamation using organic matter derivable from organic residues is its

role in improving the soil physical properties, by forming stable aggregates to improve soil structure; buffer the soil, improve aggregate stability, the population of soil microorganisms and enhance water retention capacity (Spaccini *et al.,* 2002; Ogunlade *et al.,* 2006; Olatunji *et al.,* 2006). Repeated application of organic residues on soils has long lasting positive effects on soils, (Adeniyan and Ojeniyi, 2005). Okonkwo *et al.* (2011) found that soils amended with different forms of cassava peels were high in organic matter relative to the control. Higher organic matter was recorded in plots treated with dried ground cassava peel + dried cassava peel. Mbah and Mbagwu (2006) and Nnabude and Mbagwu (2001) reported similar results when they used cassava peel wastes as soil amendments.

Mbagwu (1992) showed that the decrease in bulk density obtained with rice shaving and poultry manure treated soils were directly related to increased organic matter which played a significant role in reducing compaction of soil. A source of organic matter, the organic amendment promotes soil fauna activity and plays a major role in the buildup and stabilization of soil structure. The significant decrease in soil bulk density could be attributed to the direct and indirect effect of soil organic matter levels. Directly, organic matter due to its low bulk density and ability to increase soil aggregate stability results in lower soil bulk density and soil compatibility. Indirectly the decrease in bulk density is as a result of improved structure as it is partly sustained by increased porosity. Erden *et al.* (2006) and Ogbodo (2011) reported better pepper root growth under tillage methods due to reduction in soil bulk density. Mulch application increases leaf nitrogen, phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). Some studies earlier revealed that mulches of *Chromolaena* and *Gliricidia* pruning increased soil and plant nutrients (N, P, K, Ca, Mg) content in cowpea, cassava and maize (Ojeniyi and Ighomorore, 2004; Awodun *et al*., 2007; Akanbi and Ojeniyi, 2007). Al-rawahi (2011) found that mulch resulted in higher growth parameter and yield of sorghum. On decomposition and mineralization of mulches, nutrients were released (Nottidge *et al*., 2005 and 2008). Iren *et al*. (2015) found that cassava peels at the rate of 8 t/ha produced fresh water leaf yield that was not different significantly from that of poultry manure while compost of both additives were better significantly. The consistent increase in growth and leaf yield of water leaf plants treated with compost, poultry manure and cassava peels over the control as reported by Iren *et al.* (2015) was due to the amendments that were able to supply the required nutrients for good growth and yield of waterleaf. Iren *et al*. (2014) also reported that application of organic manure increased crop growth and yield. The long-term residual effects of organic manure coupled with slow release pattern of its nutrient (Adediran *et al*., 1999; Isitekhale *et al*., 2014) also contributed to its ability to supply nutrient to the waterleaf plant throughout the growth period.

MATERIALS AND METHODS

The study was conducted at the experimental site of Teaching and Research Farm of Ambrose Alli University, Ekpoma, Edo State. Soil samples were randomly collected at 0-15 cm depth with the aid of soil auger. The samples were thoroughly mixed to obtain a composite sample after which it was air dried at room temperature, sieved using a 2mm mesh sieve and bagged into polyethylene bag in readiness for laboratory analysis before planting.

The experimental site was manually cleared, packed and delineated into plot sizes. Cassava peel (CP) was applied at the rate of (0, 10, 15, 20 and 25 tons/hectare) to the plots and allowed to equilibrate for two weeks before planting. The experiment was laid out in a randomized complete block design (RCBD) with five treatments and replicated three times. Maize variety (SWAN 1) seeds were used as a test crop and was planted two seeds per hole at a spacing of 25 cm x75 cm. Weeds were controlled manually with hoe at an interval of three weeks.

Soil samples were analyzed at the Nigerian Institute for Oil Palm Research (NIFOR), near Benin City for routine soil analysis. Soil samples were analyzed for particle size distribution; which was determined by the hydrometer method (Okalebo *et al*., 2002), soil pH was measured in a 1:1 (soil-water) by glass electrode pH meter (Maclean, 1982), organic carbon was done by wet dichromate acid oxidation method (Nelson and Sommers, 1996), total nitrogen was determined by the micro Kjeldahl method (IITA, 1989). Available phosphorus was extracted by Bray II solution and determined by the molybdenum blue method on the technician auto-analyzer as modified by Bray and Kurtz (1995), Al^{3+} and H^+ were extracted with 1N KCl (IITA, 1989), Ca, Mg, Na and K were extracted with 1N NH_4OAC pH 7.0 (ammonium acetate). Potassium and sodium were determined with flame emission photometer while calcium and magnesium were determined with automatic adsorption spectrophotometer (IITA, 1989). ECEC was calculated by the summation of exchangeable bases and exchangeable acidity (IITA, 1989).

Physical parameters: The physical parameters determined at harvesting were soil moisture on mass and volume basis, soil particle density, soil bulk density and porosity.

Growth parameters: The plant growth parameters measured were plant height (cm), leaf area (cm^2), number of leaves per plant at three (3) weeks intervals after planting.

Yield parameters: The yield parameters recorded were cob weight and grain yield.

All data collected were analyzed statistically using analysis of variance (ANOVA) at 5% probability level and the means separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

The properties of the soil of the study area are shown in Table 1. It was of sand texture, pH was acidic in nature, had total nitrogen content of 0.06 g/kg and organic carbon of 0.80 g/kg. Based on established critical levels, the soil was high in available phosphorus, exchangeable calcium, exchangeable potassium and Magnesium but low in organic carbon and total nitrogen.

Table 1: Properties of soil of the study area

Parameters	Value
Soil pH(H_2O)	5.50
Organic Carbon (g/kg)	0.80
Total Nitrogen (g/kg)	0.06
Available Phosphorus (mg/kg)	21.30
Exchangeable cations (cmol/kg)	
Ca	4.16
Mg	1.36
K	2.05
Na	0.54
H^+	0.30
Al^{3+}	-
ECEC	8.41
Particle Size Distribution (g/kg)	
Sand	879.00
Silt	30.00
Clay	97.00
Textural class	Sand

The effects of cassava peels (CP) on soil physical properties are shown in Table 2. Moisture content on mass basis and volume basis ranged from 10.19 % to 23.49 % and 11.35 % to 31.51 %, respectively. Moisture content on mass basis was increased significantly with CP when compared to the control while on volume basis; there was no significant increase with CP rates. Application of 25 kg/ha CP resulted in the highest moisture content on mass and volume basis of 23.49 % and 31.51 % respectively. Conversely, the control resulted in the lowest moisture content on mass and volume basis of 10.19 % and 11.53 % respectively. It was also observed that other levels of CP treatments; 10 t/ha, 15 t/ha and 20 t/ha increased soil moisture on mass basis relative to the control. Cassava peel rates resulted in significant ($P < 0.05$) effect on soil bulk density; soil bulk density reduced significantly with increasing rates of CP from 0.92 g/cm^3 in the untreated soil to 0.82 g/cm^3 and 0.79 g/cm^3 as a result of 20 t/ha and 25 t/ha CP treatments, respectively. It was observed that though 10 t/ha and 15 t/ha CP treatments effect reduced soil bulk density relative to the control; the effects were not different significantly. Also, both treatments had similar bulk density of 0.88 g/cm^3. The favourable soil bulk density of 0.79 g/cm^3 obtained from the application of 25 t/ha CP was not different from that obtained from CP at 20 t/ha. Differences in soil bulk density between the control and plots amended with CP may be may be because the decomposed CP helped to increase the soil matrix thereby reducing soil bulk density. Similar finding 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, encourages downward movement of water through old root channels (Obi, 2000). Plant root ramification and penetration are favoured by low soil bulk density and this in turn increases plant growth and yield since more nutrients are made available to the plant (Isitekhale, 2010).

Particle density of the soil ranged from 2.52 g/cm^3 to 2.67 g/cm^3 after CP treatment and maize harvest (Table 2). The particle density values did not show definite pattern; the lowest particle density of 2.50 g/cm^3 was obtained from 20 t/ha CP treatment while the highest particle density of 2.67 g/cm^{3}was obtained from CP treatment at 25 t/ha. This was followed by the control with particle density of 2.57 g/cm^3. Soil particle density is assumed to be 2.65 g/cm^3 (Brady and Weil, 1999; Foth, 1975); application of 15 t/ha CP resulted in similar particle density of 2.64 g/cm^3 while the 25 t/ha CP treatment resulted in particles that were higher than the assumed soil particle density. Application of CP to the soil at the various rates had no significant effect on soil porosity. Soil porosity ranged from 63.13 % to 69.76 %, the pattern showed increase with increasing rates of CP. The highest soil porosity of 69.76 % was obtained by CP treatment at 25 t/ha. Though not significantly different, all rates of CP resulted in higher particle density relative to the control. Isitekhale and Osemwota (2010) reported that poultry manure which improves soil organic matter usually gave higher soil porosity, air filled porosity, bulk density and void ratio when compared to the control. Akinrinde (2006) stated that any organic sources improves soil organic matter and contributes to the maintenance of soil physical fertility. These results support bulk density reduction observed in response to increased organic inputs by Albadejo *et al*. (2008) as cited by Armin *et al*. (2013). This they suggested was due to dilution effect of the dense mineral fraction of the soil caused by the increase in organic matter in the plow layer (soil layer) and the increase in porosity due to the improvement in soil structure (Hayes and Naidu, 1998). Repeated application of organic residues on soils has long-lasting positive effects on soils (Adeniyan and Ojeniyi, 2005). Application of cassava peels therefore increases soil organic matter favourably in order to bring about bulk density reduction and soil matrix. This is in line with Mbagwu (1992) who reported that the decrease in bulk density obtained with rice shaving and poultry manure treated soils were directly related to increased organic matter which played a significant role in reducing compaction of soil.

Table 2: Effect of cassava peels on soil moisture, bulk density, particle density and porosity

Cassava Peel (CP) (t/ha)	Bulk Density g/cm^3	Particle Density g/cm^3	Porosity (%)	Moisture content (%)	
				Mass Basis	Volume Basis
0	0.92	2.57	63.13	10.19	11.35
10	0.88	2.52	64.73	11.99	13.62
15	0.88	2.64	66.38	11.52	13.05
20	0.82	2.50	67.04	19.93	22.05
25	0.79	2.67	69.76	23.49	31.50
LSD	0.07	NS	NS	6.86	NS

The matrix of correlation shows that soil moisture on mass basis correlated significantly and positively with soil moisture on volume basis and porosity with r^2- values of +0.982 and +0.895, respectively (Table 3). Soil moisture on volume basis correlated positively with soil porosity (r^2 = +0.915). However, bulk density correlated negatively and significantly with soil moisture on volume basis (r^2 = -0.978) and mass basis (r^2 = -0.958) but was not significant with soil porosity (r^2 = +0.945). The significant and negative correlation between bulk density and soil moisture is favorable for crop growth as compacted soils may limit moisture retention and rooting and thereby reduce plant nutrient absorption. This is in agreement with Foth (1975) who stated that bulk density influences root ramification and proliferation and thereby increase in moisture and nutrient absorption.

Table 3: Matrix of correlation between moisture content, bulk density and porosity

	Soil moisture mass basis	Soil moisture volume basis	Bulk density	Porosity
Soil moisture mass basis	0	0.982	-0.978	0.895
Soil moisture volume basis	0.982	0	-0.958	0.915
Bulk density	-0.978	-0.958	0	-0.945
Porosity	-0.895	0.915	0.945	0

Cassava peel treatments had no significant effect on maize plant height and number of leaves at 3 WAP (Table 4). However, CP at the rate of 25 kg/ha gave the highest maize leaf area 186.80 cm^2 that was significant when compared to the control, 10 t/ha and 15 t/ha CP but was not significantly different from 152.60 cm^2 obtained from 20 t/ha CP. Cassava peels application had no significant effects on maize leaf area and number of leaves at 6 WAP (Table 5). However, application of 25 t/ha CP resulted in the highest mean leaf area 327.00 cm^2 and number of leaves 10.00. This was followed by plants treated with 20 t/ha CP. At 9 WAP, 15, 20 and 25 t/ha CP increased maize plant height significantly to 208.00 cm, 216.00 cm and 238.00 cm respectively, relative to 181.00 cm in the control (Table 6). The effect of 10 t/ha CP on maize plant height at 9 WAP was not significant when compared to the control and was comparable to the effect of CP at 15 t/ha. Cassava peels had no significant effects on maize number of leaves and leaf area.

Table 4: Effects of cassava peel on maize growth at 3 weeks after planting (WAP)

Cassava peels (CP) (t/ha)	Plant Height (cm)	Leaf Area (cm^2)	Numbers of Leaves
0	37.36	116.02	8.00
10	40.40	131.10	9.00
15	46.93	98.85	8.60
20	37.30	152.60	8.60
25	50.43	186.80	9.60
LSD (0.05)	Ns	40.00	Ns

Table 5: Effects of cassava peel on maize growth at 6 weeks after planting (WAP)

Cassava peels (t/ha)	Plant Height (cm)	Leaf Area (cm^2)	Numbers of Leaves
0	60.00	202.00	8.60
10	60.00	264.00	8.60
15	71.00	240.00	9.00
20	67.00	285.00	9.00
25	94.00	327.00	10.00
LSD (0.05)	16.00	Ns	ns

Table 6: Effects of cassava peel on maize growth at 9 weeks after planting (WAP)

Cassava peels (t/ha)	Plant Height (cm)	Leaf Area (cm^2)	Numbers of Leaves
0	181.00	407.00	12.00
10	195.00	436.00	12.00
15	208.00	396.00	13.00
20	216.00	507.00	13.00
25	238.00	522.00	13.30
LSD (0.05)	19.24	Ns	ns

Maize cob and grain weights showed similar pattern of increase with increasing CP rates (Table 7). The highest maize cob and grain weights of 20.24 t/ha and 6.75 t/ha were obtained from the application of 25 t/ha CP. Maize grain yield was higher significantly when compared to other rates of application. The need to apply higher doses of CP was justified by the fact that 10 t/ha CP resulted in non-significant effect compared to the control. The effectiveness of CP to increase maize yield and even above 5 t/ha reported by Remison (2005) in southern Nigeria may be attributed to both the improvement of soil physical properties and plant nutrient release. Agbim (1985) reported that higher maize grain yield with organic wastes relative to the control. Nnabude and Mbagwu (2001), Mbah *et al.* (2004), Mbah and Onweremadu (2009) reported that the use of organic wastes as soil amendments have resulted in higher maize yield in eastern Nigeria.

Table 7: Effects of cassava peel on maize cob weight and grain yield

Cassava peels (t/ha)	Cob weight (t/ha)	Grain Yield (t/ha)
0	10.09	1.68
10	13.99	1.98
15	14.35	3.14
20	19.05	4.22
25	20.24	6.75
LSD(0.05)	3.53	0.44

CONCLUSION

Based on this study, it was concluded that cassava peel mulch as an organic manure can increase soil organic matter, soil physical fertility that may increase crop growth and yield.

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