Original Research Article

Effects of Cassava Peel Compost on Selected Properties of Soil

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Abstract

An experiment was carried out to determine the effects of cassava peel compost on some chemical properties of soil: soil pH, CN, selected soil nutrients (N, Ca, Mg and P), and selected heavy metals (Pb, Ni and Cd). Locally - sourced cassava peels were fermented for two weeks and reduced in size. Various proportions of cassava peels compost in soil, 10%, 20%, 30%, 40% and 50% corresponding to C10, C20, C30, C40 and C50, respectively were used. The mixtures were placed in plastic buckets, and placed in a greenhouse. Samples were collected in triplicate from each bucket weekly for four weeks, for analysis. Two way ANOVA and DMRT (5% significance level) were carried out on the data obtained, both for various compost mixes and over time. Results showed that soil pH increased with an increase in compost content. Cyanide values dropped to negligible levels. Nitrogen and lead values increased, but not significantly. Phosphorus values dropped significantly, while there were highly significant increases in soil calcium and magnesium contents as the compost mix ratio increased. Nickel and cadmium values also dropped insignificantly. Soil pH and cadmium levels increased over time, while cyanide, nitrogen, phosphorus, calcium, magnesium, lead and nickel reduced over time, but not significantly. It was concluded that the disposal of large quantities of cassava peels in agricultural soils should be discouraged as it increases soil alkalinity and reduces soil phosphorus, which are likely to have adverse effects on plant growth.

Keywords: Cassava peel, Compost, Soil, pH, Soil nutrients, Heavy metals.

Introduction

Cassava (*Manihot esculenta*) is a heat-loving, drought-resistant plant which is home to Africa, South America, and Asia. It is cultivated for its starchy roots, and is a staple food material in many developing countries, including Nigeria, where it is eaten as *garri*, *fufu*, or other products.

Given the large scale on which cassava processing is carried out, large volumes of solid and liquid wastes are produced (Oboh, 2006), and it is estimated that with processing for industrial use, such wastes will continue to increase (Afuye and Mogaji, 2015). The major waste products are wastewater and cassava peels. Very often, cassava peels are thrown away after removal from the edible part of the root during processing. The peel eventually decays in the soil. This study aims to determine the effect of the decayed peels (compost) on the important chemical conditions of soil. Knowing these effects, recommendations can be made as to the disposal of cassava peels.

Materials and Methods

Compost Preparation and Soil Mixing

Fresh cassava peels were collected from various sources within Ozoro, Delta State, Nigeria, and thoroughly mixed. Thereafter, the peels were soaked in water for two weeks in order for fermentation to occur. The fermented cassava peels were subjected to size reduction using a burr mill, forming a thick paste.

Bulk soil was collected from the irrigation station of the Department of Agricultural and Bio-Environmental Engineering Technology, Delta State Polytechnic, Ozoro, Nigeria, and mixed thoroughly to form a homogenous mass. A sample of soil was taken to the laboratory for moisture content determination by gravimetry. By Craig (2004),

$$MC_{pdb} = \frac{w_i - w_f}{w_f} \times 100 \quad [1]$$

where:

MC_{pdb} = moisture content, % dry basis

w_i = initial soil weight, g

w_f = oven dry soil weight, g.

The moisture content was determined as 68.4% (dry basis). The soil was then mixed by hand with the compost in predetermined ratios by weight to form five different soil-compost mixtures. The mix ratios and soil-compost contents are given in Table 1.

Table 1: Soil-compost mixtures

Mixture label	Soil mixed (%)	Compost mixed (%)
C10	90	10
C20	80	20
C30	70	30
C40	60	40
C50	50	50

The containers used for mixing were 4-litre plastic buckets. Three buckets were prepared per mix ratio. Ratios were mixed such that the contents of each bucket weighed 3,333.3g. Table 2 shows the actual weights of soil and compost for each of the five mixtures prepared.

Table 2: Soil-compost mixtures (percentages and weights)

Mixture label	Soil (%)	Soil weight (g)	Compost (%)	Compost weight (g)
C10	90	3,000	10	333.3
C20	80	2666.6	20	666.6
C30	70	2333.3	30	999.9
C40	60	1999.9	40	1333.3
C50	50	1666.6	50	1666.6

All buckets were placed in a greenhouse previously constructed. Soil samples were taken at 8am every Tuesday for four weeks and sent to the laboratory for analysis. Water (200ml) was added to each bucket once in two days to simulate precipitation.

Greenhouse

A greenhouse of dimensions 3m ×1m × 2m was constructed at the irrigation station of the Department of Agricultural and Bio-Environmental Engineering Technology, Delta State Polytechnic, Ozoro, Nigeria. Wood and transparent polyethylene sheets were the main materials of construction. The roof was sloped gable style to prevent water accumulation atop it, and a door of width 1m (with a latch for locking) was created, as shown in Figure 1. The temperature and relative humidity within the greenhouse were taken daily using a digital thermometer and a digital hygrometer, respectively. Readings were taken thrice daily: at 8.00am, 12.00pm, and 4.00pm.

Procedures for Chemical Analyses

Chemical analyses of soil samples were carried out at Thermosteel Nigeria Limited, Warri, Delta State, Nigeria. The procedures are given below.

pH

A 10g weight of soil sample was taken and placed in a clean beaker to which 20ml of distilled water was added and thoroughly mixed. Thereafter, the mixture was placed in a calibrated Hanna® in-situ pH meter and the pH read.

Cyanide

Cyanide content was determined using the American Public Health Association (APHA) 4500-CN method. A 1g weight of soil sample was weighed into a 25ml centrifuge vial, to which was added 10ml of 1N sodium hydroxide (NaOH). The mixture was shaken for 10 minutes, and centrifugation carried out. Immediately after, the mixture was filtered into a 200ml volumetric flask. The distillate was then diluted to the mark with reagent water, mixed thoroughly, and protected from light.

The distillate was then titrated using standard silver nitrate ($AgNO_3$) solution to form the soluble cyanide complex $Ag(CN)^{2-}$. As soon as all CN^- had been complexed, the addition of a small quantity of Ag+ was detected by the indicator, p-dimethylaminobenzalrhodanine, resulting in a colour change from yellow to salmon. Total true cyanide was then determined according to APHA (1992):

$$C_{CN} = \frac{A-B}{C} \times D \times \frac{E}{F} \quad [2]$$

where:

C_{CN} = total true cyanide (mg/L)

A = volume of $AgNO_3$ used for titration of sample (ml)

B = volume of $AgNO_3$ used for titration of blank (ml)

C = volume of sample titrated (ml)

D = actual normality of $AgNO_3$ (unitless)

E = volume of sample extracted (ml)

F = weight of sample used (g).

Total Nitrogen

A soil sample was digested; 25ml of the digest was taken and made up to 50ml using distilled water. Five millilitres (5ml) of 12N potassium hydroxide (KOH) was then added. Thereafter the solution was filtered. To 25ml of the filtrate was added 1ml of 10% sodium tartrate ($Na_2C_4H_4O_6$)

and 5ml of Nessler's reagent. The solution was allowed to stand for 15 minutes for colour change, and the absorbance read at 460nm.

Phosphate

A 2g sample of soil was weighed and mixed with a spoonful of carbon black; 20ml of Olsen's solution was added, and the mixture was shaken for 30 minutes. The mixture was then filtered, and 5ml of the extract was poured into a 25ml measuring cylinder, to which 4ml of Reagent B was added, and the solution was made up to the 25ml mark by adding 6ml of distilled water. The solution was left undisturbed for 15 minutes, and then the absorbance was read off at 882nm.

Calcium, Magnesium, Lead, Nickel and Cadmium

These elements were determined using the Direct Flame Absorption Spectrometry method (using an atomic absorption spectrophotometer, AAS). The procedure is as follows.

A sample of soil was air-dried, then crushed in a crucible and weighed. Digestion was then carried out using a concentrated solution of hydrochloric acid (HCl), after which the volume was made up with distilled, deionized water to 200ml. The digests were then analyzed using the atomic absorption spectrophotometer. The atomic absorption spectrophotometer was configured to detect one metal at a time. The metal being tested for determined the lamp, slit width and wavelength to be used. The concentration of the metal was extrapolated from the product of absorbance and the graph factor. The graph factor was determined when the AAS was calibrated.

Data Analysis

The data obtained from the chemical analyses were subjected to two-way analysis of variance (ANOVA) using SPSS version 20, 2011. Significantly different means were separated using the Duncan's Multiple Range Test at 5% significance level.

Results and Discussion

Environmental Conditions

The environmental conditions observed during the experiment are given in Figure 2 (dry bulb temperature) and Figure 3 (relative humidity).

Dry bulb temperature varied from 30.8^{o}C to 38.9^{o}C within the greenhouse during the period, while relative humidity varied from 60% to 90%.

Analysis

Variations in means of measured chemical properties for various soil-compost mixtures are given in Table 3.

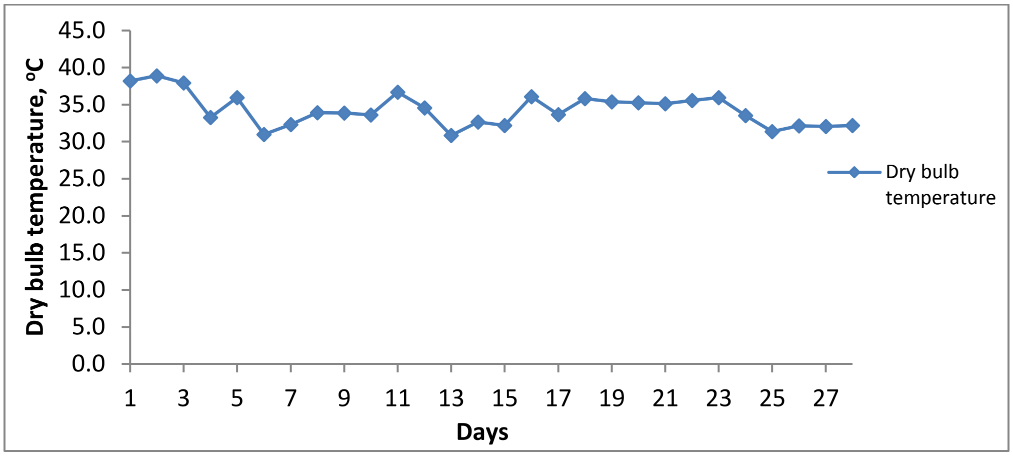

Figure 2: Variations in dry bulb temperature within the greenhouse over the experimental period

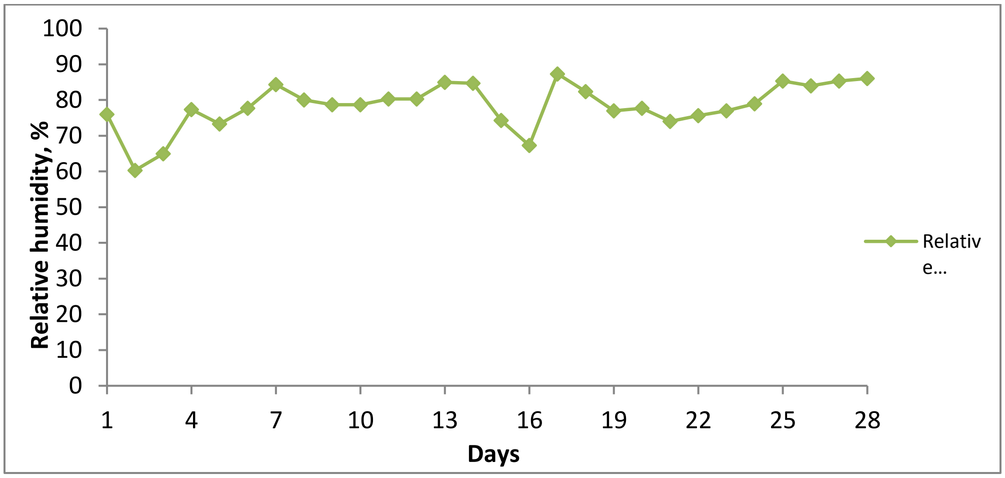

Figure 3: Variations in relative humidity within the greenhouse over the experimental period

Table 3: Mean variations of chemical properties with compost mix ratios

Properties	Control	C10	C20	C30	C40	C50
pH	4.500 ± 0.000[b]	5.475 ± 0.390[a,b]	5.375 ± 0.269[a,b]	5.075 ± 0.320[a,b]	5.500 ± 0.204[a]	5.225 ± 0.409[a,b]
CN	0.001 ± 0.000[a]	0.001 ± 0.000[a]	0.001 ± 0.000[a]	0.001 ± 0.000[a]	0.001 ± 0.000[a]	0.001 ± 0.000[a]
N	0.002 ± 0.000[a]	0.009 ± 0.001[a]	0.027 ± 0.021[a]	0.007 ± 0.003[a]	0.130 ± 0.126[a]	0.003 ± 0.001[a]
P	3.057 ± 0.000[a]	0.261 ± 0.136[b,c]	0.186 ± 0.090[b,c]	0.419 ± 0.080[b]	0.263 ± 0.036[b,c]	0.125 ± 0.051[c]
Ca	67.614 ± 0.000[b]	19.688 ± 6.335[c]	36.608 ± 4.402[b,c]	40.707 ± 11.927[b,c]	64.698 ± 10.909[b]	111.711 ± 23.439[a]
Mg	43.346 ± 0.000[d]	69.287 ± 14.713[c,d]	97.104 ± 11.307[b,c]	91.850 ± 12.054[b,c]	109.182 ± 17.102[b]	150.411 ± 9.699[a]
Pb	0.002 ± 0.000[a]	1.771 ± 1.196[a]	1.555 ± 0.909[a]	1.171 ± 0.683[a]	1.558 ± 1.048[a]	1.724 ± 1.226[a]
Ni	4.088 ± 0.000[a]	1.389 ± 0.535[b]	1.011 ± 0.426[b]	1.021 ± 0.371[b]	1.594 ± 0.539[b]	1.562 ± 0.311[b]
Cd	0.725 ± 0.000[a]	0.260 ± 0.147[b]	0.131 ± 0.073[b]	0.213 ± 0.129[b]	0.201 ± 0.115[b]	0.174 ± 0.098[b]

[a,b,c,d,]within the same row, means with different superscripts are significantly different ($P<0.05$)

As shown in Table 3, the acidity of soil samples mixed with the compost reduced. The most significant difference was observed for a 40-60 compost-soil mixture (C40). This is similar to results obtained by Iren *et al*. (2015), who observed an increase in soil pH when cassava peel compost was mixed with soil. A similar result was also obtained when Eneje and Nwosu (2012) mixed cow dung and cassava peel compost with soil. A different result was however obtained by Osunbintan (2012) when the effects of wastewater from cassava processing were analyzed: a significant reduction in pH was immediately observable. This is an indication that cassava peel compost is alkaline.

Cyanide values appeared constant for all samples because the cyanide concentrations at the time of testing were below the sensitivity detectable by the APHA 4500-CN system for cyanide testing. All cyanide values were reported as being <0.001mg/kg. This is in agreement with results obtained by Izonfuo *et al*. (2013) and Obodai *et al*. (2014), who reported that cyanide quickly falls to negligible levels when cassava peel compost is added to soil.

The nitrogen content of the soil was increased by the addition of the compost, but not significantly. Again, the most obvious difference was observed for a 40-60 compost-soil mixture (C40). This is similar to results obtained by Izonfuo *et al*. (2013) and Iren *et al*. (2015).

Soil phosphorus content was significantly reduced by addition of the compost. With the exception of the 10-90 compost-soil mixture (C10), phosphorus content was found to reduce with an increase in added compost. This is not in agreement with the results of Izonfuo *et al*. (2013) and Iren *et al*. (2015), who reported a significant increase in soil phosphorus due to the addition of cassava peel compost.

There were significant differences in soil calcium and magnesium contents, clearly increasing with amount of compost mixed, similar to results obtained by Osunbintan (2012) and Iren *et al*. (2015). Afuye and Mogaji (2015) also reported an increase in calcium content of shallow wells into which cassava effluents had been allowed to flow.

The addition of cassava peel compost to the soil caused an increase in the soil lead content. The increase was however not directly proportional to the amount of compost mixed. All compost mix preparations did not cause significant increases in soil lead content at the 5% significance level, consistent with results by Obodai *et al*. (2014). At 1.72mg/kg, which was the highest value observed (C50), up from 0.002mg/kg, lead content was found to be way below the 10mg/kg limit set by the World Health Organization (WHO, 1982).

The concentrations of nickel and cadmium in the soil dropped when the compost was added. Reductions were not directly proportional to the amount of compost mixed. All compost mix preparations did not cause significant reductions in soil nickel and cadmium content at the 5% significance level.

Variations in means of measured chemical properties over the four weeks are given in Table 4.

Table 4: Mean variations of chemical properties over the four-week test period

Properties	Week 1	Week 2	Week 3	Week 4
pH	4.983 ± 0.201[b]	5.867 ± 0.291[a]	4.933 ± 0.208[b]	4.983 ± 0.135[b]
CN	0.001 ± 0.000[a]	0.001 ± 0.000[a]	0.001 ± 0.000[a]	0.001 ± 0.000[a]
N	0.008 ± 0.002[a]	0.019 ± 0.014[a]	0.003 ± 0.000[a]	0.088 ± 0.084[a]
P	0.731 ± 0.467[a]	0.746 ± 0.468[a]	0.650 ± 0.488[a]	0.737 ± 0.468[a]
Ca	61.119 ± 10.308[a]	40.817 ± 8.460[a]	68.840 ± 23.385[a]	56.574 ± 15.428[a]
Mg	102.049 ± 22.354[a]	103.087 ± 14.959[a]	82.662 ± 14.761[a]	86.322 ± 14.917[a]
Pb	2.669 ± 0.759[a]	2.514 ± 0.712[a]	0.002 ± 0.000[b]	0.002 ± 0.000[b]
Ni	1.992 ± 0.662[a]	1.154 ± 0.588[a]	1.937 ± 0.480[a]	2.027 ± 0.419[a]
Cd	0.420 ± 0.070[a,b]	0.466 ± 0.069[a]	0.125 ± 0.120[b]	0.125 ± 0.120[b]

[a,b]within the same row, means with different superscripts are significantly different ($P<0.05$)

From Table 4, it is evident that time had no significant effect on the concentrations of soil cyanide, nitrogen, phosphorus, calcium, magnesium, lead and nickel at the 5% significance level. Reductions in these chemical parameters were generally recorded over time. Soil pH however increased significantly in the second week and dropped, again significantly, in subsequent weeks, as was also observed for cadmium concentration.

Conclusion

Dry bulb temperature in the greenhouse during the experimental period varied from 30.8^{o}C to 38.9^{o}C, while relative humidity varied from 60% to 90%. The data analysis results indicated that soil pH, hence alkalinity, increased with an increase in compost content. Cyanide values dropped to negligible levels. Nitrogen and lead values increased, but not significantly. Phosphorus values dropped significantly, while there were highly significant increases in soil calcium and magnesium contents as the compost mix ratio increased. Nickel and cadmium values also dropped, but not significantly.

Results of time-based analysis revealed that soil pH and cadmium levels increased significantly over time, while cyanide, nitrogen, phosphorus, calcium, magnesium, lead and nickel reduced over time, but not significantly.

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