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Comparative Evaluation of Burnt and Unburnt Agro-wastes on Soil Properties and Growth Performance of Cocoyam in a Humid Environment

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ABSTRACT

Field studies were carried out in 2011 and 2013 planting seasons at the Teaching and Research Farm of Federal University of Technology, Owerri Imo State to evaluate the effect of burnt and unburnt agro-wastes on soil properties, growth and yield of cocoyam (*Colocasia esculenta*) in a Typic-Haplustult. Treatments consisted of saw dust, rice mill waste, cocoa pod waste each applied at 10 t ha^{-1} and saw dust ash, rice mill waste ash and cocoa pod ash each applied at 5 t ha^{-1} and control. The treatments were laid out in a randomized complete block design and replicated four times. Data collected from soil analyses and growth performances of cocoyam were subjected to analysis of variance, while, significant means among treatments were separated using least significant difference at 5% probability level. Results obtained showed that plots amended with 10 t ha^{-1} cocoa pod waste significantly ($p<0.05$) reduced soil bulk density from 1.55-1.37 g cm^{-3} in 2011 and 1.49-1.36 g cm^{-3} in 2013, while, plots amended with 10 t ha^{-1} rice mill waste increased soil moisture content from 128.6-158.7 g kg^{-1} in 2011 and 113.3-150.8 g kg^{-1} in 2013. Plots amended with 10 t ha^{-1} cocoa pod waste significantly ($p<0.05$) increased soil organic carbon from 9.2-17.6 g kg^{-1} in 2011 and 7.15-16.73 g kg^{-1} in 2013, total nitrogen from 1.21-5.38 g kg^{-1} in 2011 and 1.38-4.88 g kg^{-1} in 2013, available P from 15.70-29.75 mg kg^{-1} in 2011 and 13.22-28.43 mg kg^{-1} in 2013. Plots amended with 10 t ha^{-1} cocoa pod increased the growth parameters of cocoyam more than other treatments with the highest cocoyam yield of 4.33 and 8.94 t ha^{-1} obtained in 2011 and 2013, respectively. About 10 t ha^{-1} cocoa pod waste was recommended for improvement of soil fertility, growth and yield of cocoyam in acidic soils of Owerri, Southeastern Nigeria.

Key words: Soil fertility, mineralization, ashes, ultisol, decomposition

INTRODUCTION

The proliferation of agro-based industries in recent time has resulted to an increase in the production of agricultural wastes. Presently, improper disposal strategy of these wastes has led to environmental hazards such as water pollution, proliferation of plants and animal diseases and global warming (Karim *et al*., 2013). However, these agro-wastes contain essential nutrients needed for improvement of soil fertility, plant growth and yield (Oladipo *et al*., 2005). Many researchers have demonstrated the efficacy of some of these agro-wastes in improving soil physico-chemical properties and yield of tropical crops (Ayeni and Adeleye, 2011; Akanni and Ojeniyi, 2007; Mbah and Nkpaji, 2010).

However, the utilization of these organic wastes by farmers is still poor despite their nutrient composition (Ayeni and Adeleye, 2011). The relative neglect of these wastes as soil amendment has partly been attributed to its bulkiness, low nutrient quality, high Carbon: Nitrogen and lignin/N ratios, high cellulose and pectin content and these make them comparatively longer to decompose and release nutrients to crops (Moyin-Jesu, 2008). These organic wastes, therefore, demand appropriate utilization in view of its plant nutrient potentials through scientific investigation. Based on this, the best approach in the utilization of these carbonaceous wastes is either converting them into ashes (Ojeniyi *et al*., 2001) or complementing them with high nitrogen source materials to increase their mineralization process (Motavalli *et al*., 2001). This will prevent temporary nitrogen drain by microbes (Ogbodo, 2009). The impact of saw dust, rice mill waste and cocoa pod waste in comparison with their ashes has not been fully investigated in all tropical crops in Southeastern Nigeria. The major objective of this study was, therefore, to investigate the effects of burnt and unburnt agro-wastes on soil physico-chemical properties, growth and yield of cocoyam in an acidic soil of Owerri, Southeastern Nigeria.

MATERIALS AND METHODS

Study area: The study was carried out at the Teaching and Research Farm of Federal University of Technology Owerri, Imo State, Southeastern Nigeria. The area lies between Latitude “5°21'N” “5°27'N” and Longitude “7°02°E” “7°15'E”. The area has an average annual rainfall range of 1950-2250 mm and annual temperature range of 27-29°C with average relative humidity of 79%. The geological material of soil in the study area is an ultisol and classified as Typic-Haplustult (FDALR., 1985), derived from Coastal Plain Sands (Benin formation) of the Oligocene-Miocene geological era and are characterized by low organic matter, low cation exchange capacity and are highly leached (Onweremadu *et al*., 2011). Tropical rainforest is the dominant vegetation of the area, though with remarkable ecological diversity caused by anthropogenic activities, especially farming and deforestation resulting into depleted vegetation as a result of demographic pressure. Farming at subsistent level is a major socio economic activity of people in the area and fertility restoration in the area is by bush fallow and application of inorganic fertilizers. The location map of the study area is shown in Fig. 1.

Land preparation: The study area, which was under three year, dominated by shrubs and grasses was mapped out, manually cleared using cutlass and hoe and mapped out into experimental plots. Composite soil samples were randomly collected for pre-planting soil analysis using soil auger at 0-30 cm depth. The samples were air dried for a period of one week and sieved using 2 mm mesh sieve and then subjected to routine laboratory analysis.

Field layout and experimental design: The study area was mapped out into 28 experimental plots. Each plot measured 4×4 m with inter plot and inter replicate distances of 1 m each. The experimental plots were manually tilled into 25 mounds, each separated by 1 m apart. The treatments were laid out in a Randomized Complete Block Design (RCBD) with four replications. Treatments: In both 2011 and 2013 studies, the treatments consisted of the following: 10 t ha^{-1} Saw Dust (SD), 5 t ha^{-1} Saw Dust Ash (SDA), 10 t ha^{-1} Rice Mill Waste (RMW), 5 t ha^{-1} Rice Mill Waste Ash (RMWA), 10 t ha^{-1} Cocoa Pod Waste (CPW), 5 t ha^{-1} Cocoa Pod Waste Ash (CPWA) and Control, which did not receive any treatment.

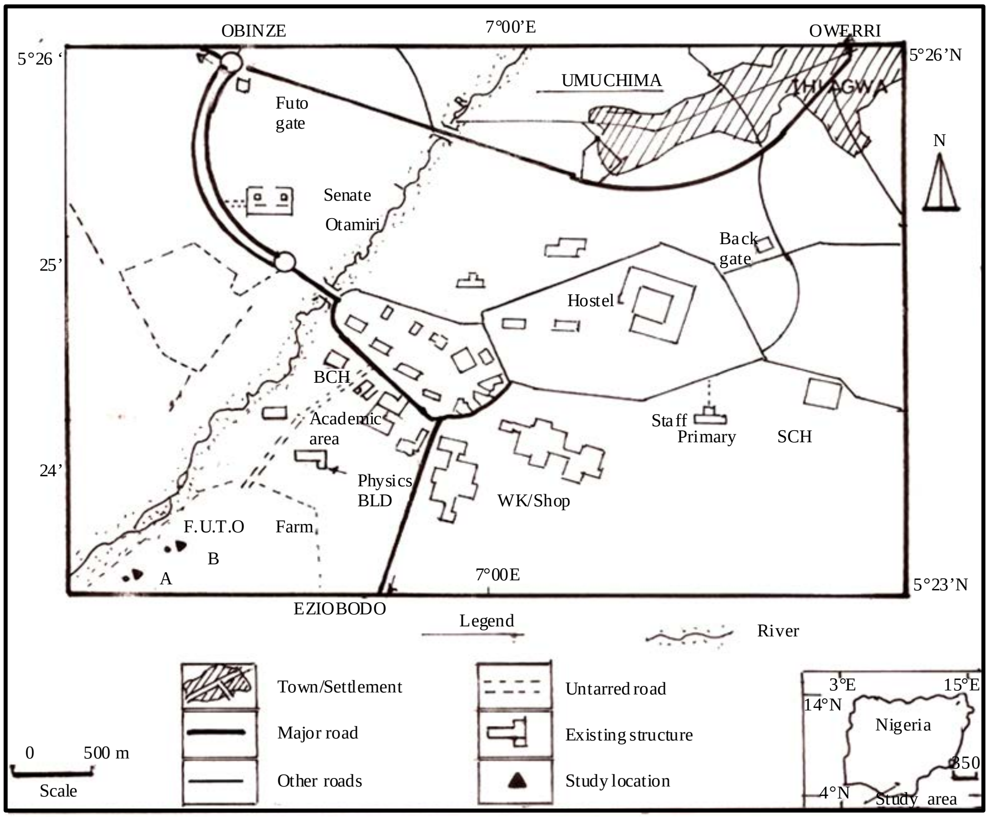

Fig. 1: Location map of the study area

Application of treatments and planting of test crops: The treatments were carefully applied on the mounds using an empty can which was used to measure equal amount of 0.4 t ha^{-1} of the organic wastes and 0.2 t ha^{-1} of the ashes before working them into the soil. These amounts gave a total weight of 10 t ha^{-1} of unburnt wastes and 5 t ha^{-1} of the ashes per experimental plot. The treatments were allowed to incubate for one week before planting the test crops. Cocoyam (*Colocasia esculenta*, cultivar; NCe 001) were planted on the mounds at a depth of 5 cm given a plant population of 5,625 plant ha^{-1}.

Measurement of growth parameters and weeding: After three weeks of planting, the crops have attained 95% germination; nine plants were selected and labeled specifically for data collection. An *in-situ* measurement of plant height and leaf area was measured weekly. Plant height was measured using a meter rule from the surface of the soil to the tip of the tallest leaf (Nwafor *et al*., 2010). Leaf area was calculated using the formula adopted by Nwafor *et al*. (2010). Shoot dry matter was determined using standard procedure while weight of corms and cormels were determined using weighing balance. Number of corms and cormels were counted during harvest.

Laboratory analysis: Particle size distribution was determined by hydrometer method according to the procedure of Gee and Dr (2002). Bulk Density was determined by core methods according to Grossmans and Reinsch (2002). Total Porosity (TP) was calculated from the result of bulk density using the equation:

$$TP = 1 - (\frac{BD}{pd}) \times 100$$

Where:
pd = Particle density (2.65 g cm^{-3})
BD = Bulk density

Gravimetric Moisture Content (GMC) was determined using the equation:

$$GMC = \frac{WMCs}{WSS} \times 100$$

Where:
WMCs = Weight of the moisture contained in soil sample
WSS = Weight of soil sample

Silt/Clay ratio was calculated by dividing the value of the silt fractions by the clay fractions. Soil pH was determined in water and in KCl using pH meter in soil/liquid suspension of 1: 2.5 according to Herdershot *et al*. (1993). Organic carbon was determined using chromic wet oxidation method according to Nelson and Somers (1982). Total Nitrogen was determined by kjeldahl digestion method using concentrated H_2SO_4 and Sodium copper sulphate catalyst mixture according to Bremner and Yeomans (1988). The C/N ratio was determined by computation of organic carbon and total nitrogen values (Brady and Weil, 1999), while available Phosphorus was determined using Bray II solution method according to Olsen and Somers (1982). Exchangeable Mg and Ca were determined using Ethylene Diamine Tetra Acetic acid (EDTA) (Thomas, 1982) while exchangeable K and Na were extracted using 1 N Neutral ammonium acetate (NH_4OAC) and then determined using flame photometer (Thomas, 1982). Exchangeable Acidity was measured titrimetrically using 1 M KCl against 0.05 M Sodium hydroxide (McLean, 1982), while, effective cation exchange capacity was calculated from the summation of all exchangeable bases and total exchangeable acidity. The Ca/Mg ratio was calculated by the value of exchangeable Calcium with exchangeable Mg. Percentage Base Saturation (PBS) was calculated by the summation of the total exchangeable bases divided by effective cation exchange capacity and then multiplied by 100.

Results collected are presented in tables and graphs. Data were subjected to analysis of variance (ANOVA). Significant means among treatments were separated using Least Significant Difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Physico-chemical properties of the soil before the study: The properties of soils used in the study are presented in Table 1. Texturally, soil for 2011 and 2013 locations was loamy sand. The soils were low in moisture content, strongly acidic, low in organic carbon and exchangeable bases. These results showed that there is need to improve the fertility status of the soil for better crop performance since the essential nutrients were below the critical levels recommended by FAO (2006). Appropriate management input is, therefore, needed for better crop production in these soils.

Table 1: Physico-chemical properties of soil in the study locations before planting

Soil property	2011	2013
Sand (g kg^{-1})	863	842
Silt (g kg^{-1})	51	48
Clay (g kg^{-1})	86	110
Textural class	Loamy sand	Loamy sand
Silt/clay ratio	0.59	0.44
Bulk density (g cm^{-3})	1.46	1.44
Total porosity (%)	44.9	45.7
Moisture content (g kg^{-1})	139	129.4
pH H_2O (1:2.5)	5.11	5.32
pH KCl (1:2.5)	4.51	4.48
Organic carbon (g kg^{-1})	10.5	8.42
Total nitrogen (g kg^{-1})	1.4	1.71
Available phosphorus (mg kg^{-1})	11.2	14.3
Exchangeable Ca (C mol kg^{-1})	3.6	2.40
Exchangeable Mg (C mol kg^{-1})	1.64	1.23
Exchangeable K (C mol kg^{-1})	0.15	0.12
Exchangeable Na (C mol kg^{-1})	0.07	0.03
Exchangeable acidity (C mol kg^{-1})	1.75	1.56
Effective cation exchange capacity (C mol kg^{-1})	7.21	5.74
Ca/Mg ratio	2.19	1.95
Base saturation (%)	75.7	72.82

Chemical properties of the agro-wastes used in the study: Selected chemical properties of the organic wastes used in the study are presented in Table 2. The organic wastes varied in nutrient composition with values high enough to support plant growth when compared to pre-planting soil properties (Table 1). The materials had pH values with values high enough to increase the pH of the study locations. The ashes had higher pH values than the unburnt wastes and, therefore, could serve as liming materials. Also, burning the wastes reduced the organic carbon content. The agro-wastes are high in available P and in exchangeable K and, therefore, can serve as good soil amendment.

Effect of saw dust, rice mill wastes and cocoa pod wastes and their ashes on soil physical properties: Results of the effects of agro-wastes and their ashes on soil physical properties for 2011 and 2013 planting seasons are presented in Table 3. Results showed that the particle size distribution of soils amended with 10 t ha^{-1} cocoa pod wastes in 2011 was 787 g kg^{-1} for sand, 96 g kg^{-1} for silt and 80 g kg^{-1} for clay while in 2013, particle sizes were 773.8 g kg^{-1} for sand, 104.2 g kg^{-1} for silt and 122 g kg^{-1} for clay. Plots amended with 10 t ha^{-1} saw dust had 795 g kg^{-1} sand, 98 g kg^{-1} silt and 107 g kg^{-1} clay in 2011 while in 2013, the sand fraction was 815.8 g kg^{-1}, the silt fraction was 66.5 g kg^{-1} and clay was 117.8 g kg^{-1}. Plots amended with 10 t ha^{-1} rice mill waste recorded the soil particle sizes of 791 g kg^{-1} sand, 96 g kg^{-1} silt and 113 g kg^{-1} clay in 2011, while in 2013, sand fraction was 813 g kg^{-1}, silt was 74.2 g kg^{-1} and clay was 112.8 g kg^{-1}. Plots amended with 5 t ha^{-1} saw dust ash, 5 t ha^{-1} rice mill waste ash and 5 t ha^{-1} cocoa pod waste ash recorded soil particle sizes close to the values obtained in plots amended with the unburnt waste. The slight changes in the particle size distribution of the soils especially silt and clay fractions might be because application of large quantities of waste in a sandy soil may increase aggregation thus trapping clay particles that reduces the rate of infiltration, thus reducing water movement out of the root zone and causing precipitation of clay. This observation was in line with Mosaddeghi *et al*. (2000), who recorded similar results on soil particle sizes with application of organic wastes. Results showed that the amendment did not change the textural class of the soil.

Table 2: Chemical properties of organic amendments used in the study

Parameter	SD	SDA	RMW	RMWA	CPW	CPWA
2011						
pH H_2O	6.99	9.63	6.84	7.69	6.71	10.49
pH KCl	6.18	8.89	6.16	7.12	6.12	9.76
Organic carbon (g kg^{-1})	34.70	25.40	24.70	20.40	19.90	15.50
Organic matter (g kg^{-1})	59.80	43.80	42.60	55.00	34.30	26.70
Total nitrogen (g kg^{-1})	0.49	0.13	0.98	0.90	1.11	0.97
C:N	70.8	23.10	25.20	22.70	17.90	15.90
Available phosphorus (mg kg^{-1})	5.20	1.50	6.90	3.71	8.40	1.80
Exchangeable potassium (C mol kg^{-1})	2.70	4.10	2.90	4.20	6.90	7.40
ECEC (C mol kg^{-1})	11.20	14.50	13.90	18.60	22.30	20.80
2013						
pH H_2O	6.43	9.77	6.52	7.43	6.36	9.21
pH KCl	5.79	8.28	6.05	6.94	5.75	8.65
Organic carbon (g kg^{-1})	36.40	24.20	29.00	23.50	19.80	17.20
Organic matter (g kg^{-1})	62.80	41.70	49.90	40.50	32.40	29.70
Total nitrogen (g kg^{-1})	0.52	0.42	0.83	0.80	1.41	1.24
C:N	70.0	57.60	34.90	29.40	14.00	13.90
Available phosphorus (mg kg^{-1})	3.60	1.30	5.11	4.12	4.74	2.91
Exchangeable magnesium (C mol kg^{-1})	2.50	2.31	5.03	5.32	4.11	4.14
Exchangeable potassium (C mol kg^{-1})	3.10	2.64	3.06	5.02	6.84	8.23
ECEC (C mol kg^{-1})	8.90	9.37	13.70	17.50	18.20	20.50

SD: Saw dust, SDA: Saw dust ash, RMW: Rice mill waste, RMWA: Rice mill waste ash, CPW: Cocoa pod waste, CPWA: Cocoa pod waste ash

Table 3: Effect of agro-wastes and their ashes on soil physical properties

Treatment	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Textural class	Bulk density (g cm^{-3})	Total porosity (%)	Moisture content (g kg^{-1})	Silt/clay ratio
2011 study								
10 t ha^{-1} SD	795.0	98.0	107.0	LS	1.39	47.5	153.1	0.90
5 t ha^{-1} SDA	861.3	60.0	78.8	LS	1.40	47.2	146.4	0.75
10 t ha^{-1} RMW	791.0	96.0	113.0	LS	1.38	47.9	158.7	0.80
5 t ha^{-1} RMWA	850.0	70.0	80.0	LS	1.40	47.2	143.0	0.85
10 t ha^{-1} CPW	787.0	98.0	115.5	L	1.37	48.3	149.3	0.85
5 t ha^{-1} CPWA	859.3	56.0	84.8	LS	1.40	47.2	141.2	0.65
Control	867.0	57.0	78.5	LS	1.55	41.5	128.6	0.75
F-LSD $_{(0.05)}$	5.95	4.87	8.39		0.04	1.32	2.91	ns
2013 study								
10 t ha^{-1} SD	815.8	66.5	117.8	LS	1.38	47.9	148.1	0.55
5 t ha^{-1} SDA	818.0	67.8	114.5	LS	1.39	47.5	134.7	0.60
10 t ha^{-1} RMW	771.8	109.8	118.5	LS	1.37	48.3	139.7	0.93
5 t ha^{-1} RMWA	813.0	74.2	112.8	LS	1.39	47.5	134.2	0.65
10 t ha^{-1} CPW	773.8	104.2	122.0	LS	1.36	48.7	150.8	0.84
5 t ha^{-1} CPWA	831.5	54.5	114.0	LS	1.42	46.4	132.5	0.48
Control	867.9	59.5	73.3	LS	1.49	43.8	113.3	0.80
F-LSD $_{(0.05)}$	17.65	17.6	3.16		0.27	1.86	4.26	0.17

SD: Saw dust, SDA: Saw dust ash, RMW: Rice mill waste, RMWA: Rice mill waste ash, CPW: Cocoa pod waste, CPWA: Cocoa pod waste ash, L: Loamy, LS: Loamy sand

This observation was in agreement with Troech and Thompson (1993) and Adaikwu *et al.* (2012) who stated that good soil management practices may slightly raise the clay fraction of the soil and improve soil productivity but cannot change the textural class. According to Fitzpatrick (1986), textural class of the soil is a function of weathering in association with parent materials influenced by climate over time.

The amendments significantly ($p<0.05$) reduced the soil bulk density when compared to the control plot in both seasons. Soils amended with 10 t ha^{-1} cocoa pod waste recorded the lowest bulk density of 1.37 and 1.36 g cm^{-3} for 2011 and 2013 studies, respectively. This was followed by soils amended with 10 t ha^{-1} rice mill waste with the value of 1.38 g cm^{-3} in 2011 and 1.37 g cm^{-3} in

2013. Plots amended with 5 t ha^{-1} with either of the ashes recorded equal value of 1.40 g cm^{-3} in 2011. In 2013 study, soils amended with 5 t ha^{-1} SDA or RMWA recorded equal value of 1.39 g cm^{-3}, whereas, plots amended with 5 t ha^{-1} CDWA recorded higher value of bulk density (1.42 g cm^{-3}) when, compared to other ashes. Reduction of soil bulk density through application of agro-wastes agreed with the findings of Tekwa *et al*. (2010), who found out that application of rice mill husk reduced the soil bulk density. Improvement of soil properties, such as; soil aeration, moisture content and soil structure might increase soil microbes, increase soil organic matter that could reduce soil bulk density.

Results of the effects of agro-wastes on soil total porosity showed that soils amended with the agro-wastes significantly ($p<0.05$) increased soil total porosity (Table 3). Results showed that among the wastes, soils amended with 10 t ha^{-1} cocoa pod waste recorded the highest total porosity of 48.3% in 2011. This was followed by plots treated with 10 t ha^{-1} rice mill waste (47.9%) and then plots treated with 10 t ha^{-1} saw dust (47.5%) and the least was on control plot (41.5%). In 2013, increase in soil total porosity among the wastes followed the trend CPW>RMW>SD. Among the ashes, plots treated with 5 t ha^{-1} CPWA proved superior over other ashes by recording the highest soil porosity of 48.3% in 2011 whereas in 2013, 5 t ha^{-1} RMWA recorded the highest total porosity of 48.3%. The wastes improved soil total porosity more than the ashes. Increase in soil total porosity with application of these wastes could be due to an increase in soil aggregates, reduction in soil bulk density and increase in soil organic carbon content which emanated from these wastes. This observation was in concord with Li *et al*. (2011) and Celik *et al*. (2004), who noted that application of organic wastes increases soil macro and mesopore volume due to an increase in organic matter content, better aggregation and water transmission rate.

The amendments significantly ($p<0.05$) increased soil gravimetric moisture content more than the control plot in both seasons. Experimental plots treated with 10 t ha^{-1} rice mill waste recorded the highest gravimetric moisture content of 158.7 g kg^{-1} in 2011 and plots treated with 10 t ha^{-1} cocoa pod waste recorded the highest (150.3 g kg^{-1}) in 2013. Among the ashes, plots treated with 5 t ha^{-1} saw dust ash recorded the highest moisture content of 146.4 g kg^{-1}, followed by plots amended with 5 t ha^{-1} rice mill waste ash (143.0 g kg^{-1}) and plots treated with 5 t ha^{-1} cocoa pod waste ash (141.2 g kg^{-1}) in 2011 while in 2013 application of 10 t ha^{-1} saw dust ash recorded the highest moisture content of 134.7 g kg^{-1}. The least was the control plot (128.3 g kg^{-1}). Increase in soil moisture content with addition of these wastes could be due to an increase in total porosity, reduction in soil bulk density and better soil aggregation. This finding agreed with the report of Mbah and Nneji (2010) that water holding capacity depends on soil total porosity and the size distribution of its pores. From these results, it is certain that application of agro-wastes improved some soil physical properties thereby improving the quality of the soil for better crop growth.

Effect of agro-wastes and their ashes on soil chemical properties: Effects of saw dust, rice mill wastes and cocoa pod waste together with their ashes on soil chemical properties are shown in Table 4. Results in 2011, showed that the treatments significantly ($p<0.05$) increased soil pH when compared to control. Comparing the wastes, experimental plot amended with 10 t ha^{-1} saw dust recorded the highest pH (water) of 6.45 and 5.84 in KCl. This was followed by plot amended with 10 t ha^{-1} cocoa pod waste which had pH in water 6.56 and in KCl 5.88 and lastly on plot amended with 10 t ha^{-1} rice mill waste which had pH in water 5.97 and 5.34 in KCl. The lowest was control plot with pH in water 5.87 and 5.19 in KCl. Comparing the ashes, plot amended with 5 t ha^{-1} saw dust ash recorded the highest pH of 7.39 in water and 6.77 in KCl. This was seconded

Table 4: Effect of agro-wastes and their ashes on soil chemical properties

Treatment	pH (H_2O)	pH (KCl)	Organic carbon	Organic matter	Total N	Avail. P (mg kg^{-1})	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	Exch. acidity	ECEC	Ca/Mg	BS (%)
			----------- (g kg^{-1}) -----------				--------------------------- (Cmol kg^{-1}) -----------------------------							
2011 study														
10 t ha^{-1} SD	6.45	5.84	14.2	24.48	1.21	23.40	1.90	2.92	2.37	0.03	1.22	8.44	0.7	85.5
5 t ha^{-1} SDA	7.39	6.77	13.4	23.10	2.46	27.03	1.54	3.70	3.73	0.01	1.20	10.18	0.4	88.2
10 t ha^{-1} RMW	5.97	5.34	15.3	26.35	1.83	26.6	2.10	4.08	2.81	0.02	1.25	10.26	0.5	87.8
5 t ha^{-1} RMWA	6.14	5.51	13.8	23.77	2.71	27.30	1.21	3.17	4.61	0.01	1.29	10.29	0.4	87.5
10 t ha^{-1} CPW	6.56	5.88	17.6	30.35	5.38	29.75	2.97	4.43	3.15	0.05	1.25	11.85	0.7	89.5
5 t ha^{-1} CPWA	7.24	6.57	15.6	26.88	2.56	26.15	2.59	3.86	4.86	0.02	1.16	12.49	0.6	90.5
Control	5.87	5.19	9.2	15.85	1.21	15.70	0.16	0.81	1.17	0.06	1.38	3.58	0.2	61.4
F-LSD $_{(0.05)}$	0.01	0.01	0.33	2.57	0.05	0.70	0.29	0.23	0.05	0.01	0.04	0.38	0.17	0.57
2013 study														
10 t ha^{-1} SD	6.46	5.91	12.30	21.20	1.62	20.33	2.37	2.21	2.29	0.02	1.30	8.19	1.1	84.05
5 t ha^{-1} SDA	7.29	6.70	12.83	22.12	2.38	27.53	2.28	3.44	3.36	0.02	1.18	10.28	0.65	88.47
10 t ha^{-1} RMW	5.89	5.33	14.67	25.30	1.81	26.70	2.37	4.03	3.67	0.03	1.26	9.92	0.60	89.22
5 t ha^{-1} RMWA	6.80	6.21	13.32	23.00	2.47	24.58	1.48	3.55	3.97	0.03	1.20	11.42	0.43	88.95
10 t ha^{-1} CPW	6.48	5.94	16.73	28.82	4.88	28.43	2.64	4.01	3.25	0.04	1.16	11.70	0.68	89.00
5 t ha^{-1} CPWA	7.09	6.50	15.25	26.28	2.06	24.45	2.42	3.55	4.31	0.03	1.13	10.28	0.78	89.67
Control	4.86	4.29	7.15	12.33	1.38	13.22	1.08	1.00	0.63	0.05	1.47	4.22	0.30	63.65
F-LSD $_{(0.05)}$	0.44	0.61	0.94	1.63	0.21	1.96	0.62	0.42	0.42	0.01	0.16	0.84	0.52	6.02

plot treated with 5 t ha^{-1} cocoa pod waste ash which recorded 7.24 in water and 6.57 in KCl and lastly plot amended with 5 t ha^{-1} rice mill waste ash with pH of 6.14 in water and 6.57 in KCl. The results revealed that application of ashes increased the pH more than the unburnt wastes.

Results in the year 2013 showed that plot amended with 5 t ha^{-1} saw dust ash increased soil pH (water) from 4.86-7.29 and to 6.70 in KCl (Table 4). This was followed by plot treated with 5 t ha^{-1} cocoa pod ash that increased the soil pH (water) from 4.29-7.09 and to 6.50 in KCl. Among the wastes, plot amended with 10 t ha^{-1} cocoa pod increased soil pH more than other wastes. Plots amended with 10 t ha^{-1} rice mill waste and 10 t ha^{-1} saw dust recorded lower pH than other treatments possibly due to the evolution of carbon dioxide during decomposition which when reacted with soil water to produce carbonic acid that reduced the pH of the soil. Increase in soil pH by the ashes more the unburnt wastes could be due to the higher concentration of calcium and magnesium in the ashes and higher pH of the ashes (Table 2). This observation was in line with Ogbodo (2009) who found out that application of burnt rice mill husk raised the pH of the soil more than unburnt rice mill husk and attributed that to the magnesium and calcium content of the waste which ameliorated the acidity of the soil. Also Adesodun and Odejimi (2009) attributed increase in soil pH by organic wastes to the decarboxylation of organic anions on decomposition by microbes. Moyin-Jesu (2008) and Ayeni and Adeleye (2011) made similar observation on the effect of agro-wastes on a degraded soil.

Application of organic wastes significantly ($p<0.05$) increased the organic carbon content of the soil more than the control (Table 4). In 2011, application of 10 t ha^{-1} cocoa pod waste recorded the highest organic carbon of 17.6 g kg^{-1}. This was seconded by plot amended with 5 t ha^{-1} cocoa pod ash, which recorded organic carbon content of 15.6 g kg^{-1}. There was no significant difference between plot amended with 10 t ha^{-1} rice mill waste and that amended with 5 t ha^{-1} cocoa pod ash on organic carbon content. In 2013, the same trend was observed with application of 10 t ha^{-1} cocoa pod increasing organic carbon from 7.15-16.73 g kg^{-1} (Table 4). The sequence of performance was CPW>CPWA<RMW>RMWA>SDA>SD>control. Increase in organic matter with application of these organic wastes could be attributed to increase in moisture retention and reduced bulk density which created a favourable environment for microbial activity for decomposition and mineralization to take place. Organic carbon was higher in plots treated with unburnt wastes when compared with plots that were treated with the ashes; possibly because of the destruction of carbon by heat during burning. These observations agreed with the findings of Akanbi *et al*. (2000) and Belay *et al*. (2001), who observed that application of organic wastes improved soil organic matter and increased moisture retention and burning reduces soil carbon content (Ojeniyi *et al*., 2010).

The nitrogen content of the soil was significantly ($p<0.05$) increased by application of the agro-wastes when compared to control. From the results in Table 4, application of 10 t ha^{-1} cocoa pod waste gave the highest nitrogen of 5.38 g kg^{-1} among the wastes while plot amended with 5 t ha^{-1} rice mill waste ash gave the highest soil nitrogen of 2.71 g kg^{-1} among the ashes. Application of 10 t ha^{-1} saw dust recorded the lowest nitrogen of 1.21 g kg^{-1} among the amended plots.

In 2013 result, plots amended with 10 t ha^{-1} cocoa pod waste increased soil total nitrogen from 1.38-4.88 g kg^{-1} (Table 4). Increase in soil N followed the sequence CPW>RMWA>SDA>CPWA>RMW>SD>control. Comparing the wastes and the ashes, the ashes improved the nitrogen content than the wastes except cocoa pod waste. This variation could be traced from the C/N ratios of the materials (Table 2). Saw dust had the highest C/N ratio than the rice mill waste and cocoa pod waste and hence converting the saw dust and rice mill waste into ashes lowered the C/N ratios. Therefore application of these materials reduced the nitrogen turn over due to immobilization of soil nitrogen by soil microbes. Again, for the fact that poor decomposition of these wastes was observed before the end of the experiment, most of the nitrogen in the wastes was unable to be mineralized. Cocoa pod waste had the lowest C/N ratio than other materials. Increase in the soil nitrogen could be due to an increase in the rate of decomposition and mineralization process. This observation was in accordance with the findings of Olayinka and Adebayo (1989), who reported that application of high lignified materials such as saw dust reduced nitrogen and phosphorus uptake as well as yield of maize. Ayeni *et al*. (2008) noted that C/N ratio greater than 30 causes N and P immobilization.

Effect of agro-wastes on soil available phosphorus as shown in Table 4 revealed that the amendments significantly ($p<0.05$) increased soil available phosphorus when compared to control in both seasons. Among the wastes, plot amended with 10 t ha^{-1} cocoa pod waste recorded the highest value of available P of 29.75 mg kg^{-1}. This was followed by plot treated with 10 t ha^{-1} rice mill waste (26.6 mg kg^{-1}) and then plot treated with 10 t ha^{-1} saw dust (23.40 mg kg^{-1}). The control plot was the least (15.70 mg kg^{-1}). Among the ashes, 5 t ha^{-1} rice mill waste ash recorded the highest available P of 27.30 mg kg^{-1}, followed by plot amended with 5 t ha^{-1} saw dust ash (27.03 mg kg^{-1}) and then plot treated with 5 t ha^{-1} cocoa pod waste ash (26.15 mg kg^{-1}).

In 2013, similar results were obtained except that plot treated with 10 t ha^{-1} cocoa pod waste increased soil available P from 13.33-28.43 mg kg^{-1}. This was followed by plot treated with 5 t ha^{-1} saw dust ash that gave 27.53 mg kg^{-1} available P. These results showed that application of ash improved soil available P than the wastes except cocoa pod, where the opposite was observed. This could be attributed to the high C/N ratio of the wastes (saw dust and rice mill waste) except cocoa pod that had lower C/N ratio than the ash. Increase in the level of available P with application of these amendments could also be as a result of an increase in soil pH and organic matter. Akanni *et al*. (2012) reported that there is positive correlation between soil organic matter and available P. This observation was in line with the findings of Ojeniyi and Adejobi (2002), Ayeni *et al*. (2008) and Nottidge *et al*. (2007) who reported that application of saw dust ash raised the available P level of the soil and P uptake leading to increase in the growth and yield of maize and vegetables. Increase in the level of available P among the ashes could also be attributed to higher P concentration in the ashes than in saw dust or rice mill waste (Table 2). This observation was similar with that of Yusiharni *et al*. (2007) and Owolabi *et al*. (2003) who recorded higher soil available P in soils amended with saw dust ash. Akanni *et al*. (2012) observed that application of 2.5 t ha^{-1} cocoa pod ash increased soil available phosphorus from 1.44-2.39 mg kg^{-1}. Onwuka *et al*. (2010) found out that application of 6 and 8 t ha^{-1} saw dust ash significantly ($p<0.05$) increased available P and soil organic carbon.

Effects of agro-wastes on the exchangeable bases showed that the treatments significantly ($p>0.05$) increased all the exchangeable bases in both seasons. In 2011, application of 10 t ha^{-1} cocoa pod waste recorded the highest exchangeable calcium of 2.97 cmol kg^{-1} when compared with other wastes. This was followed by plot treated with 10 t ha^{-1} rice mill waste (2.10 cmol kg^{-1}) and then plot treated with 10 t ha^{-1} saw dust (1.90 cmol kg^{-1}). The lowest value was on the control plot (0.16 cmol kg^{-1}). Among the plots treated with ashes, plot amended with 5 t ha^{-1} cocoa pod waste ash recorded the highest exchangeable calcium of 2.59 cmol kg^{-1}. This was followed by plot amended with 5 t ha^{-1} saw dust ash (1.54 cmol kg^{-1}) and then plot treated with 5 t ha^{-1} rice mill waste ash (1.21 cmol kg^{-1}). The same trend was observed on exchangeable magnesium with plots amended with 10 t ha^{-1} cocoa pod waste recording the highest exchangeable Mg of 4.43 cmol kg^{-1} among the waste treated plots while plots treated with 5 t ha^{-1} cocoa pod waste ash recorded the highest exchangeable Mg of 3.86 cmol kg^{-1} when compared to plots treated with saw dust ash or rice mill waste ash. The lowest value was from the control plot (0.81 cmol kg^{-1}). Plots amended with 10 t ha^{-1} cocoa pod waste recorded the highest exchangeable K of 3.15 cmol kg^{-1}. This was followed by plot treated with 10 t ha^{-1} rice mill waste (2.81 cmol kg^{-1}) and then plot amended with 10 t ha^{-1} saw dust (2.37 cmol kg^{-1}). Considering plots treated with ash, plot amended with 5 t ha^{-1} cocoa pod waste ash recorded the highest exchangeable K of 4.86 cmol kg^{-1}, followed by plot amended with 5 t ha^{-1} rice mill waste ash (4.61 cmol kg^{-1}) and then plot treated with 5 t ha^{-1} saw dust ash (3.73 cmol kg^{-1}). The lowest among them was the control plot (1.17 cmol kg^{-1}). In 2013, the same trend was observed (Table 4). Application of 10 t ha^{-1} cocoa pod waste increased exchangeable Ca from 1.08-2.64 cmol kg^{-1} and exchangeable Mg from 1.00-4.01 cmol kg^{-1}. It was also observed that conversion of wastes into ashes increased the exchangeable K. On the exchangeable sodium, plot amended with 10 t ha^{-1} cocoa pod waste recorded the highest exchangeable Na of 0.05 cmol kg^{-1}. This was followed by plot treated with 10 t ha^{-1} saw dust (0.03 cmol kg^{-1}). There was no significant effect among the ashes when compared with the control plot in 2011, while in 2013, the amendments significantly ($p>0.05$) increased exchangeable Na when compared to the control. In 2011, application of 10 t ha^{-1} cocoa pod waste recorded the highest exchangeable acidity of 1.25 cmol kg^{-1}. This was followed by plot treated with 10 t ha^{-1} rice mill waste (1.25 cmol kg^{-1}) and then plot amended with 10 t ha^{-1} saw dust (1.22 cmol kg^{-1}). Among the ashes, application of 5 t ha^{-1} rice mill wastes ash had the highest exchangeable acidity of 1.29 cmol kg^{-1}, followed by plot treated with 5 t ha^{-1} saw dust ash and then plot treated with 5 t ha^{-1} cocoa pod waste ash. Similar trend followed in 2013 result with control recording the highest exchangeable acidity (1.47 cmol kg^{-1}) followed by plot treated with 10 t ha^{-1} saw dust (1.30 cmol kg^{-1}).

Increase in exchangeable cations with application of these agro wastes could be attributed to an increase in the pH of the soil which promotes the availability and uptake of these nutrient elements by plants. Also, increase in soil organic matter, improved soil porosity and gravimetric moisture content due the application of the amendments could be responsible an increase in exchangeable cations. Higher exchangeable K observed with the ashes than the wastes could be attributed to high K content in the ashes (Table 2). These observations agreed with the findings of Adu-Dapaah *et al*. (1994) who recorded an increase in the exchangeable K with application of cocoa pod waste ash. Onwuka *et al*. (2010) made similar observation when application of 8 t ha^{-1} cocoa pod waste ash significantly increased exchangeable K and other basic cations. Odedina *et al*. (2003) and Owolabi *et al*. (2003) confirmed an increase in exchangeable Mg by application of agro-wastes ashes.

The amendments significantly ($p<0.05$) increased the effective cation exchange capacity of the soil with application of 10 t ha^{-1} cocoa pod waste recording the highest ECEC of 11.85 cmol kg^{-1} among the wastes. This was followed by plot treated with 10 t ha^{-1} rice mill waste (10.26 cmol kg^{-1}) and then plot amended with 10 t ha^{-1} saw dust (8.44 cmol kg^{-1}). Among the ashes, application of 5 t ha^{-1} cocoa pod waste ash recorded the highest ECEC of 12.49 cmol kg^{-1}. This was followed by plot treated with 5 t ha^{-1} rice mill wastes ash (10.29 cmol kg^{-1}) and then plot treated with 5 t ha^{-1} saw dust ash (10.18 cmol kg^{-1}). In 2013 result, increase in the ECEC followed the trend CPW>RMWA>CPWA>SDA>RMW>SD>control. In the two results, ashes recorded higher ECEC than the wastes except cocoa pod. This could be due to the higher concentration of basic cations in the ashes than in the wastes as well as faster mineralization of the wastes due to reduced C/N ratio by burning. Also, higher exchangeable bases and effective cation exchange capacity recorded with cocoa pod waste and its ash was due to high organic matter in them since organic matter acts as a reservoir in storing basic cations and making them available for plant uptake (Ayeni *et al*., 2008). Lal and Kang (1982) recorded higher ECEC with an increase in organic matter, while, Lombin *et al*. (1991) have reported that organic matter content of the soil is a major contributor to the ECEC of the soil.

The same trend was observed under percentage base saturation. Plots amended with 5 t ha^{-1} cocoa pod ash recorded the highest base saturation of 90.5%, followed by plot amended with 10 t ha^{-1} cocoa pod waste (89.5%) and the least was the control plot (61.4%) in 2011. In 2013 result, plot amended with 5 t ha^{-1} cocoa pod ash recorded the highest base saturation of 89.67%. This was followed by plot treated with 10 t ha^{-1} rice mill waste (89.22%) and then plot treated with 10 t ha^{-1} cocoa pod waste (89.0%). Increase in base saturation could be due to an increase in the organic matter content, exchangeable bases and rise in soil pH.

Effect of agro-wastes and their ashes on the growth and yield of cocoyam: Results of the effect of agro-wastes on the height of cocoyam are presented in Table 5. Results showed that the amendments significantly ($p<0.05$) increased the height of cocoyam starting from five weeks after planting when compared to control in 2011 planting season. At 19 WAP, plots treated with 10 t ha^{-1} cocoa pod waste recorded the highest height of 49.2 cm. Plots amended with 5 t ha^{-1} cocoa pod ash recorded cocoyam height of 43.2 cm while the least was from the control plot that recorded 12.6 cm height. Comparing the wastes, the sequence of performance was cocoa pod waste>rice mill waste>saw dust>control. Comparing the ashes, the sequence was cocoa pod waste ash>rice mill waste ash>saw dust ash>control. In 2013 result, the amendments significantly ($p<0.05$) increased cocoyam height when compared to the control. At 19 WAP, taller plants were found in plots amended with 10 t ha^{-1} cocoa pod waste with the highest height of 36.83 cm and the sequence of performance starting from the highest was CPW>CPWA>RMWA>RWM>SDA>SD> control.

The results of the amendment on the leaf area of cocoyam are presented in Table 6. Results showed that the amendments significantly ($p<0.05$) increased the leaf area of cocoyam when compared to the control. Among the wastes, soils amended with 10 t ha^{-1} cocoa pod waste recorded the highest leaf area of 275.5 cm^2. This was followed by plots amended with 10 t ha^{-1} rice mill

Table 5: Effect of agro-wastes and their ashes on the height of cocoyam (cm)

	Weeks after planting (WAP)									
Treatments	3	5	7	9	11	13	15	17	19	Mean
2011 study										
10 t ha^{-1} SD	3.2	9.2	20.0	26.2	30.4	31.9	33.8	34.3	34.6	24.8
5 t ha^{-1} SDA	3.7	9.9	24.2	29.2	33.1	34.6	36.4	38.1	38.7	27.5
10 t ha^{-1} RMW	3.5	12.1	26.3	32.5	37.5	39.1	40.6	41.3	41.7	30.5
5 t ha^{-1} RMWA	3.5	12.1	26.1	33.5	36.1	37.8	40.1	41.4	41.7	30.2
10 t ha^{-1} CPW	3.0	12.9	28.9	40.2	43.1	45.4	47.7	48.8	49.2	35.4
5 t ha^{-1} CPWA	3.8	13.6	25.9	35.2	40	41.6	42.7	43.1	43.3	32.1
Control	3.2	5.1	6.5	8.8	9.7	11.2	11.9	12.5	12.6	9.05
LSD(0.05)	NS	1.06	1.15	1.83	1.77	1.84	1.85	2.18	2.50	
2013 study										
10 t ha^{-1} SD	3.00	9.9	18.9	26.6	28.9	32.0	32.0	33.6	33.5	24.3
5 t ha^{-1} SDA	3.75	10.3	24.4	29.6	36.6	36.4	37.1	38.4	38.4	28.3
10 t ha^{-1} RMW	3.60	11.5	25.7	30.3	32.6	35.5	38.6	40.9	40.9	28.9
5 t ha^{-1} RMWA	3.55	10.9	26.9	35.2	37.1	39.2	42.5	42.1	42.1	31.1
10 t ha^{-1} CPW	3.53	13.1	29.1	41.9	45.9	47.2	48.5	51.1	51.1	36.8
5 t ha^{-1} CPWA	3.68	13.5	25.9	36.7	39.9	42.2	46.4	47.6	47.6	33.7
Control	3.08	4.9	7.2	9.57	10.5	11.8	13.4	13.7	13.	9.74
LSD(0.05)	NS	1.26	2.12	1.53	2.12	1.48	2.24	2.48	2.48	

NS: Not significant at 0.05 probability level, SD: Saw dust, SDA: Saw dust ash, RMW: Rice mill waste, RMWA: Rice mill waste ash, CPW: Cocoa pod waste, CPWA: Cocoa pod waste ash

Table 6: Effect of agro-wastes and their ashes on the leaf area of cocoyam (cm^2)

	Weeks after planting (WAP)								
Treatments	3	5	7	9	11	13	15	17	Mean
2011 study									
10 t ha^{-1} SD	12.07	35.18	63.45	117.5	126.78	129.98	132.13	138.4	94.4
5 t ha^{-1} SDA	12.12	36.28	116.3	180.4	195.17	198.75	201.1	205.85	143.3
10 t ha^{-1} RMW	17.85	61.55	99.5	265.7	283.2	288.5	293	295.55	200.6
5 t ha^{-1} RMWA	11.35	41.4	80.0	181.5	200.57	206.05	209.12	212.42	142.8
10 t ha^{-1} CPW	12.42	84.13	182.9	336.9	368.62	381.35	415.47	422.3	275.5
5 t ha^{-1} CPWA	12.3	76.15	162.2	233.6	265.42	270.92	274.5	277.87	196.6
Control	8.17	12.8	16.98	22.85	26.95	23.45	26.75	29.6	20.9
F-LSD $_{(0.05)}$	NS	12.11	32.34	19.56	19.43	22.77	29.93	30.65	
2013 study									
10 t ha^{-1} SD	11.80	34.9	64.2	108.9	127.7	134.4	136.0	152.0	96.24
5 t ha^{-1} SDA	12.23	37.0	115.9	181.5	193.9	238.1	246.5	262.7	161
10 t ha^{-1} RMW	18.52	34.9	101.1	242.5	278.0	288.8	320.1	328.8	201.6
5 t ha^{-1} RMWA	11.72	42.0	82.5	189.8	202.1	216.6	227.8	232.9	150.7
10 t ha^{-1} CPW	12.1	83.6	184.9	331.7	357.3	383.9	411.5	417.5	272.8
5 t ha^{-1} CPWA	12.30	74.6	163.4	231.5	259.9	265.8	284.8	296.3	198.6
Control	7.4	11.9	15.9	23.7	27.2	30.5	37.4	42.1	24.51
F-LSD $_{(0.05)}$	NS	11.49	32.90	32.36	17.86	30.17	43.88	51.95	

NS: Not significant at 0.05 probability level, SD: Saw dust, SDA: Saw dust ash, RMW: Rice mill waste, RMWA: Rice mill waste ash, CPW: Cocoa pod waste, CPWA: Cocoa pod waste ash

wastes (200.6 cm^2) and then plots treated with 10 t ha^{-1} saw dust (94.4 cm^2) while the control plot recorded the lowest value of 20.9 cm^2. Comparing the ashes, application of 5 t ha^{-1} cocoa pod ash recorded the highest leaf area of 196.6 cm^2, followed by application of 10 t ha^{-1} saw dust ash (143.3 cm^2) and then plots amended with 5 t ha^{-1} rice mill waste ash (142.8 cm^2). The sequence of performance was cocoa pod waste>rice mill waste>cocoa pod waste ash>saw dust ash>rice mill waste ash>saw dust>control. In 2013 result, application of 10 t ha^{-1} cocoa pod recorded the highest value of 272.8 cm^2 and the trend was CPW>RMW>CPWA>RMWA>SDA>SD>control.

Results of the effects of agro-wastes on the yield of cocoyam are shown in Table 7. Results showed that there were significant increases ($p<0.05$) in the shoot dry matter, number of cormels,

Table 7: Effect of agro-wastes and their ashes on the yields of cocoyam

Treatments	Shoot dry matter (t ha^{-1})	No. of cormels/plant	Corm yield (t ha^{-1})	Cormel yield (t ha^{-1})	Corm+cormel yield (t ha^{-1})
2011 study					
10 t ha^{-1} SD	0.18	1.07	0.58	1.81	2.39
5 t ha^{-1} SDA	0.23	1.38	0.72	2.36	3.06
10 t ha^{-1} RMW	0.25	1.21	0.70	1.86	2.61
5 t ha^{-1} RMWA	0.25	1.78	0.76	2.75	3.47
10 t ha^{-1} CPW	0.56	2.14	1.14	3.19	4.33
5 t ha^{-1} CPWA	0.23	1.71	0.97	2.19	3.17
Control	0.13	0.62	0.44	0.67	1.11
LSD $_{(0.05)}$	0.12	0.02	0.26	0.56	0.64
2013 study					
10 t ha^{-1} SD	0.33	1.62	1.30	2.66	3.96
5 t ha^{-1} SDA	0.40	1.71	2.09	3.98	6.07
10 t ha^{-1} RMW	0.38	1.63	2.28	3.11	5.38
5 t ha^{-1} RMWA	0.40	1.97	2.98	4.05	7.04
10 t ha^{-1} CPW	0.68	2.37	3.36	5.58	8.94
5 t ha^{-1} CPWA	0.52	2.13	2.78	4.24	7.01
Control	0.15	0.96	0.98	2.98	3.05
LSD $_{(0.05)}$	0.09	0.05	0.60	0.75	0.84

SD: Saw dust, SDA: Saw dust ash, RMW: Rice mill waste, RMWA: Rice mill waste ash, CPW: Cocoa pod waste, CPWA: Cocoa pod waste ash

yield of corms and cormels as well as the total yield of corms and cormels in both seasons. Among the wastes in 2011 result, soils amended with 10 t ha^{-1} cocoa pod waste recorded the highest shoot dry matter of 0.56 t ha^{-1}. This was followed by the plot amended with 10 t ha^{-1} rice mill waste (0.25 t ha^{-1}) and then the plots treated with 10 t ha^{-1} saw dust (0.18 t ha^{-1}) with control which recorded the lowest value of 0.13 t ha^{-1}. Among the ashes, soils amended with 5 t ha^{-1} rice mill waste recorded the highest shoot dry matter yield of 0.25 t ha^{-1}, while plots amended with 5 t ha^{-1} cocoa pod waste ash and plots treated with 5 t ha^{-1} saw dust ash recorded equal weight of 0.23 t ha^{-1}. In 2013, plots amended with 10 t ha^{-1} cocoa pod increased shoot dry matter from 0.15-0.65 t ha^{-1}. The sequence of performance was CPW>CPWA>RMWA = SDA>SD> control.

In 2011, plots amended with 10 t ha^{-1} cocoa pod recorded the highest number of cormels of 53.5/plots and the sequence of performance was cocoa pod>rice mill waste ash>cocoa pod ash>saw dust ash>rice mill waste>saw dust>control. Soils amended with 10 t ha^{-1} cocoa pod waste recorded the highest corm yield of 1.14 t ha^{-1} and the trend of performance was cocoa pod waste>cocoa pod waste ash>rice mill waste ash>saw dust ash>rice mill waste>saw dust>control. Plots treated with 10 t ha^{-1} cocoa pod waste also recorded the highest cormel yield of 3.19 t ha^{-1} and the sequence of performance was cocoa pod waste>rice mill waste ash>saw dust ash>cocoa pod waste ash>rice mill waste>saw dust>control. The highest total yield (corm+cormel) of 4.33 t ha^{-1} was recorded from plots amended with 10 t ha^{-1} cocoa pod waste and the sequence of performance was cocoa pod waste>rice mill wastes ash>cocoa pod waste ash>saw dust ash>rice mill waste>saw dust>control. In 2013, plot amended with 10 t ha^{-1} cocoa pod waste recorded the highest number of cormels (59.25/plot), corm yield (3.36 t ha^{-1}), cormel yield of 5.58 t ha^{-1} and total yield (corm+cormel) of 8.94 t ha^{-1}. In these parameters, the sequence of performance was the same with the trend CP>CPA>RMWA>SDA>RMW>SD>control. Apart from cocoa pod waste, the soils amended with ashes produced better yield than plots amended with the wastes. Uwah *et al*. (2011) recorded total yield of 6.16 t ha^{-1} of cocoyam. However, the 2011 yield (4.33 t ha^{-1}) was lower than the above record, while, 2013 was above the value.

Application of these agro-wastes increased the growth and yield of cocoyam more than the control plots. This confirmed there usage as good source of soil amendment. These findings are in line with the observations of Mbah and Nkpaji (2010) and Mbah and Nneji (2010), who reported an increase in crop height with application of unburnt and burnt rice mill husk. Apart from cocoa pod waste, conversion of saw dust and rice mill wastes into ashes produced taller cocoyam than the wastes. This could be as a result of immobilization of nitrogen in the soil caused by unburnt waste application due to their high C/N ratio. Eneje and Uzuokwu (2012) made similar observation on maize height with application of rice mill husk.

Higher values of leaf area recorded with application of cocoa pod waste could be due to higher nitrogen and organic matter content in the cocoa pod. The immobilization of nitrogen due to saw dust application affected the leaf area development when compared with other amendment. Similar observation was noted by Adekayode and Olojugba (2010) who recorded 4% increase with application of 4 t ha^{-1} saw dust ash on the growth of maize.

Higher yield recorded in 2013 could be attributed to early planting which took place on 1st May, 2013 against 2011 planting season that took place on June 18th, 2011. Also, longer fallow period in 2013 experimental site against 2011 location could contribute to variations in the yields. Chikere-Njoku *et al*. (2011) has reported that increase in fallow period improves soil physico-chemical properties and increased crop yield. Increase in shoot dry matter with the amendment was in line with Uwah *et al*. (2011) who observed that application of agro-wastes increased the shoot dry matter of cocoyam by 51% and the number of corms and cormels by 40%. Adekayode and Olojugba (2010) made similar observation with application of 4 t ha^{-1} saw dust ash on maize growth.

CONCLUSION

Results of these investigations have shown that agro-wastes contain plant nutrient elements that can improve soil fertility status and increase crop yield. Carbonaceous materials, such as; saw dust and rice mill wastes should best be used in ash form. We therefore recommend application of 10 t ha^{-1} cocoa pod waste for improvement of soil fertility, growth and yield of cocoyam in acidic soils of Owerri, Southeastern Nigeria.

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