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Influence of cassava peels and poultry manure-based compost on soil properties, growth and yield of waterleaf (*Talinum triangulare* Jacq) in an *ultisol* of south-eastern Nigeria

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Effects of cassava peels and poultry manure based compost and their sole applications on soil properties, growth and yield of waterleaf were investigated at the University of Calabar Teaching and Research Farm during 2013 and 2014 cropping seasons. The experiment was laid out in a randomized complete block design (RCBD) with three replications. There were seven treatments consisting of mixture of cassava peels and poultry manure (compost), sole application of composted cassava peels and poultry manure each applied at two rates (4 and 8 t/ha) and control (without amendment). The results obtained showed that soil pH, total nitrogen (N), available phosphorus (P), exchangeable potassium (K), magnesium (Mg) and calcium (Ca) were significantly increased with levels of application of treatments compared to control with plots fertilized with compost at 8 t/ha having a higher significant influence on most of the soil chemical properties. There were significant differences ($P < 0.05$) among treatments in plant height, leaf area, number of leaves, number of branches, stem girth and fresh yield of waterleaf. Generally, application of compost irrespective of the rate of application, enhanced waterleaf growth and yield better compared to other treatments. Compost applied at 8 t/ha had the best mean fresh yield of 17.86, 22.92 and 22.34 t/ha at 4, 7 and 10 weeks after planting (WAP) which out yielded the control by 66.41, 77.53 and 77.44%, respectively. This study has demonstrated that the use of cassava peels in the preparation of compost for crop production would be more economical and will also be a useful development in sustainable food production as well as in promoting environmental safety.

Key words: Waterleaf, poultry manure, cassava peels, compost, Ultisol.

INTRODUCTION

Waterleaf *(Talinum triangulare* Jacq*)* is a dicotyledonous plant belonging to the family Talinaceae (Nyananyo and Olowokudejo, 1996). It is a cosmopolitan weed common throughout the humid tropics and commonly found in several countries of West and Central Africa where it is eaten as vegetable. Waterleaf is extensively grown in

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Southern Nigeria, particularly in Cross River and Akwa Ibom States and is used in soups and other delicacies in combination with other vegetables such as African joint or afang *(Gnetum Africana),* bush apple or atama *(Heinsia crinata),* editan *(Lasienthera bulchozianum)* and fluted pumpkin *(Telfaria occidentalis)*.

The valuable parts of the crop are the leaves and succulent stems (Rice et al., 1987). Waterleaf grows best under humid conditions with a mean temperature of about 30°C. Growth is most profuse when water content of the soil is close to field capacity (Schippers, 2000). High temperature (>35°C) and drought negatively affect the number of leaves, leaf area, stem size and number of branches. It is considered medicinal in Southern Nigeria as it is used as herb treatment for measles and stomach upsets. In India, waterleaf is used to treat diabetes (Slakin and Shadeque, 1994). In experiments, waterleaf performs well as a fodder for raising giant snails. However, in the western part of Nigeria, waterleaf is largely regarded as a weed (Akobundu, 1984).

Continuous cultivation which had replaced the traditional shifting cultivation causes soil nutrient depletion, soil structure degradation, reduced water infiltration, increased run off and erosion, thus crop production is not profitable without additional soil nutrient. In Nigeria, farmers realize the need for soil amendments by using available resources such as crop wastes, farmyard manure and animal wastes. However, the quantity and quality required of these materials limit their use. Poor and reckless use of inorganic fertilizer changes physical, chemical and biological properties of the soils as well as reduces the fertility status of the soils (Omisore et al., 2009). Also the use of inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced crop yield, soil acidity and nutrients imbalance. Heavy application of inorganic fertilizers can also build up toxic concentrations of salts in the soil. Moreover, the extent to which farmers depend on this material is constrained by the unavailability of the right type of inorganic fertilizer at the right time, lack of technical know- how and lack of access to credit facility. This necessitates research into organic wastes that are cheap, readily available and environmentally friendly that can be used as fertilizers.

The importance of organic matter in conserving soil physical, chemical and biological properties with implications on nutrient cycling, erodibility, water storage, plant vigor and resultant soil productivity has been well established (Brady and Weil, 1999). Availability of materials for compost preparation, gradual release of nutrients without being wasted through leaching and being environmentally friendly has made compost application popular among farmers. However, effectiveness of compost depends primarily on source and type of organic material, method of composting and compost maturity. Mature compost (finished compost) provides a stabilized form of organic matter and has the potential to enhance nutrient release in the soil more than the raw organic waste (Adediran et al., 2003). Finished compost is generally more concentrated in nutrients than the initial combination of raw materials used and can serve as an effective means of building soil fertility (Brady and Weil, 1999).

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). Most often cassava peels are commonly found in farm locations and processing sites as heaps that are generally perceived as hazard to the environment. These materials, however, could be utilized more effectively and sustainably through recycling. Cassava peels like many organic waste materials 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). The abundance, as well as cheapness of cassava peels had necessitated a research in its use by composting either solely or in combination for waterleaf production. Composting cassava peels eliminate the problem of waste disposal and increase the manurial value of the materials (Adediran et al., 2003; Akanbi et al., 2007). Poultry manure contains nutrient elements that can support crop production and enhance the physical and chemical properties of the soil (Omisore et al., 2009; Iren et al., 2011b; John et al., 2011).

This study, therefore, evaluates the effects of cassava peels and poultry manure based compost on soil properties, growth and yield of waterleaf.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Teaching and Research Farm of the University of Calabar, Calabar, and Southeast Nigeria. Calabar lies between latitude 5° 32' and 4° 27' N and longitude 7° 15' and 9° 28' E in Nigeria. The town is characterized by a bimodal rainfall pattern with a long rainy season (March- July) and a short rainy season from September to early November after a very short dry spell in late August. The total amount of rainfall within this period ranges from 2000 to 3500 mm annually while the mean temperature ranges between 23 and 33°C. The mean relative humidity is 60 to 90%.

Land preparation, experimental design and treatments

The experimental site was manually cleared, tilled and plots measuring 3 m × 1.5 m marked out. An alley of 1.2 m was left between blocks and 0.60 m between plots. The experiment was laid out in a randomized complete block design with three replications.

Compost was prepared using dry cassava peels and well –cured poultry manure in the ratio of 1:1 (dry weight basis). Cassava peels alone were also composted. The materials were allowed to decompose for a period of 12 weeks. There were seven treatments consisting of mixture of cassava peels and poultry manure

Table 1. Properties of the soil before treatment application.

Parameter	Value	
	2013	**2014**
Sand (g/kg)	830	911
Silt (g/kg)	113	56
Clay (g/kg)	57	33
Textural class	Sandy loam	Sandy loam
pH (H_2O)	4.2	4.4
Organic carbon (g/kg)	7.98	7.82
Total nitrogen (g/kg)	0.54	0.62
Available P (mg/kg)	20.00	25.70
Exchangeable K (cmol/kg)	0.09	0.10
Exchangeable Ca (cmol/kg)	2.00	1.84
Exchangeable Mg (cmol/kg)	1.40	1.44
Exchangeable Na (cmol/kg)	0.06	0.06
Exchangeable acidity (cmol/kg)	2.43	2.20
ECEC (cmol/kg)	5.98	5.64
Base saturation (%)	59.36	60.99

(compost), composted cassava peels and poultry manure each applied at two rates (4 and 8 t/ha). There was also a control (without amendment).

Field studies

Prior to land preparation, one composite soil sample was collected from 0 to 15 cm depth using soil auger for physico-chemical analysis. The treatments were evenly distributed and incorporated into the soil one week before planting (WBP) as recommended by Iren et al. (2011a). Waterleaf was planted manually at a spacing of 5 cm × 5 cm using stem cuttings of 10 cm length with leaves still attached. Weeding was done manually by hand pulling within the plots and using hoe to weed around the plots.

Twenty plants were randomly selected, tagged and used in growth measurements. Growth parameters measured were plant height, number of leaves per plant, number of branches per plant, leaf area and stem girth. These parameters were assessed after 4 weeks of planting (WAP) and subsequently at three weeks intervals. Weights of freshly harvested waterleaf were taken from an area of 50 cm × 50 cm within each experimental plot at 4, 7 and 10 WAP. At the end of the experiment, composite soil samples were taken per plot for chemical analysis.

Laboratory studies

The composite soil samples collected before and after experiment were air-dried and sieved through a 2 mm mesh. The following analyses were carried out on the samples using standard procedures: Particle size distribution was determined by the Bouyoucous hydrometer method, using sodium hexametaphosphate as a dispersant. Soil pH was determined using a ratio of 1:2 in soil-water medium and read with a digital pH meter. Organic carbon content was determined by Walkley-Black dichromate oxidation method. Organic matter was obtained by multiplying total carbon by a factor of 1.724. Total nitrogen (N) was determined by the micro-kjeldahl method. Available phosphorus (P) was extracted by the Bray 1 extraction method, and the content of P was determined colorimetrically using a Technico AAII auto analyser (Technico, Oakland, Calif). Determination of exchangeable bases was by neutral ammonium acetate extraction and read with an atomic absorption spectrophotometer (AAS). Exchangeable acidity was determined by the 1 N potassium chloride (KCl) extraction method and titrated with 1 M sodium hydroxide (NAOH) using phenolphthalein as an indicator. The effective cation exchange capacity (ECEC) was the summation of total exchangeable bases and exchangeable acidity. Percentage base saturation (%BS) was obtained by calculation using the formula:

$$\% \text{ BS} = \frac{\text{Sum of exchangeable bases}}{\text{ECEC}} \times 100$$

Samples of poultry manure, composted cassava peels and compost (cassava peels + poultry manure) were also subjected to chemical analysis using standard procedures.

Data analysis

Data were analyzed statistically and means were compared using Fisher's Least Significant Difference (FLSD) at 0.05 probability level (Wahua, 1999).

RESULTS AND DISCUSSION

Properties of the soil before experiment

The physicochemical analysis of the soils used for the experiment during 2013 and 2014 cropping seasons revealed that the soils were extremely acid (pH < 4.5) and sandy loam in texture (Table 1). Acid soils can reduce plant growth and yield by increasing soil concentrations of Al, Fe and Mn to toxic levels and decreasing the availability of Ca, Mg and P. The soils were low in organic carbon, total nitrogen, exchangeable cations and effective cation exchange capacity (ECEC) but high in available phosphorus. Low organic matter in the soil lowers the soil water holding capacity (Mbagwu, 1988) which in turn increases the soil temperature (Mbagwu, 1992). Organic matter increases the amount of soil water and the proportion of available water for plant growth (Brady and Weil, 1999). The soils had total nitrogen values of 0.54 and 0.62 g/kg in 2013 and 2014 cropping seasons, respectively. These values were less than the critical level of 1.50 g/kg given by Aduayi et al. (2002) for soils of the humid tropical region. The low nitrogen level could be attributed to high rate of mineralization and subsequent high rate of leaching that accompanies the heavy rains associated with the forest zone of Southeastern Nigeria (Osodeke, 1996).

The low levels of nutrients obtained in the experimental soils indicate low fertility status and may be attributed to high temperature, high rainfall and leaching losses which characterize the tropical areas (Parnes, 1990). The low fertility status could also be attributed to continuous cropping which necessitates the need for additional

Table 2. Nutrient content of poultry manure, cassava peels and compost used for the experiment.

Treatment	pH (H_2O)	Organic carbon (%)	Total nitrogen (%)	C/N Ratio	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
Poultry manure	7.4	8.52	1.89	4.51	1.47	0.37	2.24	0.87	0.016
Cassava peels	5.4	12.57	1.47	8.55	0.79	0.11	1.89	0.81	0.012
Compost	7.8	7.48	2.10	3.56	2.13	0.65	2.68	1.08	0.019

Compost = cassava peels and poultry manure

Nutrient contents of the amendments used for the study

Table 2 shows the nutrient content of the amendments used. Poultry manure had a slightly alkaline pH (7.4), while compost (5.8) and cassava peels (5.4) were acidic in reaction. Compost had the highest values for total N (2.10%), P (2.13%), K (0.65%), Ca (2.68%), Mg (1.08%) and Na (0.019%) followed by poultry manure which had corresponding values of 1.89, 1.47, 0.37, 2.24, 0.87 and 0.016%. Cassava peels however, had higher organic carbon content (12.57%) than other treatments indicating lower rate of decomposition and mineralization.

The higher values obtained from compost is in agreement with those reported by Adediran et al. (2003) and Akanbi et al. (2007) that composting cassava peels eliminate the problem of waste disposal and increases the manurial value of the materials.

Changes in soil chemical properties after experiment

Changes in soil chemical properties after experiment are presented in Table 3. The amendments used significantly ($P < 0.05$) improved the pH, organic carbon, total nitrogen, available P, exchangeable K, Mg, Ca and base saturation of the soil compared to the control (without amendment). Increasing the levels of application of the amendments increased soil pH significantly in both years, except the soil treated with cassava peels alone, with the highest pH values obtained from the soils treated with 8 t/ha of compost. Increasing the levels of application of all the amendments increased soil organic carbon, N, P, K, Mg, Ca and base saturation compared with the control, with the 8 t/ha of compost treated soils recording the highest values in both years. These observations are in agreement with the findings of Nwadialo (1991) and Eneje and Uzoukwu (2012), who reported that increasing rates of poultry manure resulted in increasing values of soil pH and exchangeable bases. The improvement in most of the soil chemical properties by the compost (poultry manure and cassava peels) treatment is in line with the findings of Eneje and Nwosu (2012), who observed highest improvement in exchangeable Ca and ECEC with the admixture of cow dung and cassava peels. The organic amendments increased soil chemical properties is also in agreement with the findings of Giwa and Ojeniyi (2004) and Olatunji and Oboh (2012), who reported that manure increased soil organic matter, N, P, exchangeable K, Ca and Mg.

However, the values obtained for total nitrogen and exchangeable K in the amended soils were still below the critical levels of 1.5 g/kg N and 0.2 cmol/kg K. This could be as a result of higher nutrient uptake by crops and/or loss through leaching (Ayoola, 2006). Increase in available P content in the treated soils could be due to the incorporation of organic amendment which was observed to have also increased the amount of soluble organic matter thereby increasing the rate of desorption of phosphate, thus improving the available P content in the soil (Zsolnay and Gorlitz, 1994; Brady and Weil, 1999).

Influence of cassava peels and poultry manure based compost on waterleaf growth

Table 4 shows significant increases in heights of waterleaf at different growth stages as influenced by the amendments applied. At 4 and 7 WAP, there were significant increases in plant height by all the amendments compared with the control, except the plants treated with 4 t/ha of cassava peels, while at 10 WAP all the amendments significantly increased waterleaf height relative to control. Significant increases were observed as the rate of application of the amendments increased. Taller plants were obtained from plots treated with 8 t/ha of compost across all the growth stages and were significantly higher than other treatments.

There were significant increases in leaf area of waterleaf amongst treatments at 4 WAP with the highest leaf area obtained from plants treated with 8 t/ha compost (11.69 cm^2), followed by 4 t/ha compost treated plants (10.62 cm^2) and 8 t/ha poultry manure treated plants (9.20 cm^2) (Table 5). Similar trend was obtained at 7 and 10 WAP, except that there was no significant increase among 4 t/ha compost, 8 t/ha cassava peels and 8 t/ha poultry manure treated plants at 10 WAP.Number of leaves per waterleaf plant was significantly increased by all the treatments across all growth stages relative to control (Table 6), with the highest value (28.57)

Table 3: Influence of cassava peels with poultry manure based compost on soil properties

Treatments	Soil pH (H_2O)	Org. C (g/kg)	Total N (g/kg)	Av. P (mg/kg)	Exchangeable cations (cmol/kg) K	Na	Mg	Ca	E. A. (cmol/kg)	ECEC (cmol/kg)	BS (%)
					2013						
Control	4.0	9.7	0.40	19.61	0.07	0.06	0.63	0.80	2.20	3.76	41.49
4 t/ha poultry manure	4.5	13.1	0.70	36.02	0.08	0.05	0.60	1.03	1.70	3.46	50.87
8 t/ha poultry manure	4.8	18.3	0.80	36.12	0.10	0.06	0.61	1.20	1.80	3.77	52.25
4 t/ha cassava peels	4.1	13.8	0.50	20.66	0.07	0.05	0.80	1.42	2.20	4.54	51.54
8 t/ha cassava peels	4.2	19.6	0.70	28.13	0.11	0.06	1.10	1.40	1.80	4.47	59.73
4 t/ha compost	4.9	19.2	0.90	40.11	0.13	0.06	1.33	2.26	1.40	5.18	72.97
8 t/ha compost	5.3	18.9	1.10	43.00	0.15	0.08	1.60	2.60	1.20	5.63	78.69
LSD (0.05)	**0.2**	**3.2**	**0.02**	**6.19**	**0.01**	**NS**	**0.10**	**0.45**	**0.87**	**NS**	**7.33**
					2014						
Control	4.1	10.7	0.50	20.46	0.06	0.04	0.60	1.00	2.26	3.96	42.93
4 t/ha poultry manure	4.4	17.2	0.90	30.60	0.08	0.06	0.60	1.50	1.80	4.04	55.45
8 t/ha poultry manure	5.2	19.2	1.00	35.30	0.13	0.05	1.60	1.70	1.80	5.28	65.91
4 t/ha cassava peels	4.0	15.1	0.50	22.20	0.13	0.04	1.55	1.10	1.80	4.62	61.04
8 t/ha cassava peels	4.1	19.7	0.70	25.00	0.15	0.05	1.60	1.23	2.00	5.03	60.24
4 t/ha compost	5.3	15.2	1.10	34.10	0.17	0.07	1.66	2.64	1.70	6.24	72.76
8 t/ha compost	5.6	21.8	1.12	36.80	0.18	0.07	1.70	2.72	1.40	6.07	76.94
LSD (0.05)	**0.4**	**4.1**	**0.06**	**5.81**	**0.02**	**NS**	**0.11**	**0.32**	**NS**	**NS**	**6.46**

Compost = cassava peels with poultry manure

obtained from plants treated with 8 t/ha compost at 7 WAP followed by plants treated with 8 t/ha poultry manure (27.15). As the growth stage advanced to 10 WAP, there was a drop in the number of leaves with the highest number of leaves (24.57) obtained from both the plants treated with 8 t/ha of compost and 8 t/ha poultry manure though not significantly higher than the plants treated with 4 t/ha of compost (22.83) and 4 t/ha poultry manure (22.67).

The highest number of branches (9.70) was obtained from plants treated with 4 t/ha of compost at 10 WAP (Table 7), while the biggest stem girth (2.27 cm) was obtained from plants treated with 8 t/ha compost at 10 WAP, though not significantly different from other treatments except control (Table 8). The responses of waterleaf growth to fertilizer application in an *Ultisol* of Southeastern Nigeria have also been reported by Ndaeyo et al. (2013).

Influence of cassava peels and poultry manure based compost on waterleaf yield

Fresh yield of waterleaf was significantly ($P < 0.05$) increased by all treatments at all growth stages compared with control (Table 9). The highest mean fresh yield of 17.86 t/ha obtained at 4 WAP from plants treated with 8 t/ha compost did not differ significantly from 4 t/ha compost and poultry manure (irrespective of rate of application) treatments, but differed significantly from cassava peels treatments and control. At 7 and 10 WAP, the highest mean fresh yield of 22.92 and 22.34 t/ha obtained from plants treated with 8 t/ha compost, respectively were significantly higher than all other treatments. The best mean fresh yields of 17.86, 22.92 and 22.34 t/ha obtained at 4, 7 and 10 WAP, respectively by 8 t/ha compost treated soil out yielded the control by 66.41, 77.53 and 77.44%, respectively. Significant growth and

Table 4. The mean plant height (cm) of waterleaf as influenced by cassava peels and poultry manure based compost.

Treatment	4 WAP	7 WAP	10 WAP
Control	10.30	10.70	8.23
4 t/ha Poultry manure	13.10	13.30	11.27
8 t/ha Poultry manure	14.80	16.00	11.87
4 t/ha Cassava peels	10.33	11.70	10.90
8 t/ha Cassava peels	12.60	15.84	12.33
4 t/ha Compost	15.93	16.33	15.33
8 t/ha Compost	17.53	18.87	16.03
LSD (0.05)	**1.13**	**1.45**	**0.6**

Table 5. The mean leaf area (cm^2) of waterleaf as influenced by cassava peels and poultry manure based compost.

Treatment	4 WAP	7 WAP	10 WAP
Control	5.36	5.01	4.07
4 t/ha Poultry manure	8.86	9.11	6.39
8 t/ha Poultry manure	9.20	10.27	7.50
4 t/ha Cassava peels	6.20	7.14	5.89
8 t/ha Cassava peels	7.08	8.30	6.66
4 t/ha Compost	10.62	10.88	7.72
8 t/ha Compost	11.69	14.55	12.43
LSD (0.05)	**0.52**	**1.12**	**1.10**

Table 6. The mean number of leaves of waterleaf as influenced by cassava peels and poultry manure based compost .

Treatment	4 WAP	7 WAP	10 WAP
Control	9.23	8.80	9.70
4 t/ha Poultry manure	14.37	24.60	22.67
8 t/ha Poultry manure	16.50	27.15	24.57
4 t/ha Cassava peels	10.83	12.70	12.33
8 t/ha Cassava peels	11.23	14.90	13.90
4 t/ha Compost	16.53	25.97	22.83
8 t/ha Compost	16.50	28.57	24.57
LSD (0.05)	**1.21**	**1.33**	**1.97**

Table 7. The mean number of branches per plant of waterleaf as influenced by cassava peels and poultry manure based compost.

Treatment	4 WAP	7 WAP	10 WAP
Control	3.57	4.83	4.16
4 t/ha Poultry manure	5.87	6.90	7.30
8 t/ha Poultry manure	6.20	7.60	8.17
4 t/ha Cassava peels	4.30	4.80	5.86
8 t/ha Cassava peels	4.20	5.30	6.10
4 t/ha Compost	6.83	8.87	9.70
8 t/ha Compost	6.08	7.90	8.23
LSD (0.05)	**0.98**	**1.2**	**1.6**

Table 8. The mean stem girth (cm) of waterleaf as influenced by cassava peels and poultry manure based compost.

Treatment	4 WAP	7 WAP	10 WAP
Control	1.11	1.10	1.18
4 t/ha Poultry manure	1.57	1.82	1.76
8 t/ha Poultry manure	1.69	2.10	2.18
4 t/ha Cassava peels	1.45	1.58	1.58
8 t/ha Cassava peels	1.57	2.07	1.61
4 t/ha Compost	1.56	1.87	1.73
8 t/ha Compost	1.75	2.17	2.27
LSD (0.05)	**0.24**	**0.18**	**0.81**

Table 9. The mean fresh yield (t/ha) of waterleaf as influenced by cassava peels and poultry manure based compost.

Treatment	4 WAP	7 WAP	10 WAP
Control	8.00	7.15	7.04
4 t/ha Poultry manure	16.60	17.20	13.55
8 t/ha Poultry manure	16.68	17.48	14.84
4 t/ha Cassava peels	8.80	10.49	11.40
8 t/ha Cassava peels	15.20	16.68	13.40
4 t/ha Compost	17.40	18.03	15.88
8 t/ha Compost	17.86	22.92	22.34
LSD (0.05)	**2.03**	**3.19**	**5.34**

Yield increases with the use of compost have been reported by Akanbi et al. (2007) and John et al. (2011 and 2013).

The yields obtained from this study were relatively lower than the yield (56.03 and 54.36 t/ha in 2009 and 2010, respectively) obtained by Ndaeyo et al. (2013) that used 100 kg/ha of NPK + 3.75 t/ha of poultry manure in the cultivation of waterleaf in Akwa Ibom State but falls within the yield they obtained by the application of 5 t/ha of poultry manure (23.33 and 22.96 t/ha in 2009 and 2010, respectively).

They, however, stressed that it would be more rewarding to apply 5 t/ha poultry manure alone compared to sole application of 400 kg/ha mineral fertilizer for waterleaf production in an *Ultisol*. The disparity in yield could be accounted for by a number of factors, including the original status of the soil with respect to the nutrient elements, other edaphic factors and climatological variability. It could also be due to the fact that integrated use of organic and inorganic fertilizers promotes higher positive effect on microbial biomass and hence soil health (Chen, 2008).

However, the increasing awareness by consumers in western and tropical countries on illnesses such as diabetes, hypertension, cancer and obesity associated with consumption of food produced with chemical fertilizers, has shifted their focus to safe eating habits by consuming food crops produced with organic fertilizers (Moyin-Jesu, 2007). Similar results were reported by Hodges (1982), that acceptance of a crop can be influenced by the type and source of nutrients used in its production.

Generally, in developed countries, a kilogram of vegetable produced using organic fertilizer attracts higher prices than the same quantity produced using inorganic fertilizers because it is believed that the former is devoid of synthetic chemicals. This is in line with the findings of Ater et al. (2011) whereby greater proportion of students (76 %) paid higher prices for roasted cobs harvested from poultry waste treated plots than those from inorganic fertilizer treated plots in Benue State, Nigeria.

The consistent increases in growth and yield of waterleaf by plants treated with compost, poultry manure and cassava peels over the control in this study is an indication that the amendments are able to supply the required nutrients for good growth and yield of waterleaf. This is in line with the findings of Iren *et al*. (2011b, 2014) 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; Iren et al., 2014) also contributed to its ability to supply nutrient to the waterleaf plant throughout the growth period.

The results of this study have shown that the addition of poultry manure and cassava peels solely or in combination improved soil chemical properties. The improvement compared with the control increased as the rate of application increased. The amendments also improved growth and yield of waterleaf. The use of cassava peels in combination with poultry manure gave better improvement in soil chemical properties, growth and yield of waterleaf and is therefore recommended for sustainable production of waterleaf as well as in promoting health and environmental safety.

Conflict of Interest

The authors have not declared any conflict of interest.

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