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Research Article

Effect of Composted Cassava Leaves and Urea on Soil Chemical Properties, Growth and Yield of Pepper (Capsicum annum) in an Ultisol of Southeastern Nigeria

Azu, Donatus E.O[1], Essien B. A[1] and Nweke Peter[2]
[1]Department of Horticulture and Landscape Technology, Akanu Ibiam Federal Polytectnic, Unwana, Afikpo Ebonyi Nigeria
[2]Department of Agricultural Technology, Akanu Ibiam Federal Polytechnic, Unwana, Afikpo Ebonyi Nigeria

*Corresponding Author
Azu, Donatus E.O

Abstract: This study was conducted to evaluate the effect of composted cassava leaf (CCL) and urea as soil amendments on soil nutrient properties, growth and yield of pepper in an utisol of southeastern Nigeria. The experiment consisted of Green House and Laboratory studies and the treatments comprised of three rates (0, 1 and 2 ton ha^{-1}) CCL and three rates (0, 1 and 2 tonha^{-1}) urea arranged in a factorial pattern in Complete Randomized Design (CRD) in three replications. Results obtained showed that relative to control, the application of the treatments significantly influenced the soil chemical indices. While the increased addition of CCL as lone treatment increased the pH, increased application of urea as single treatment consistently decreased the pH. Combined application of the amendments' better improved the pH. The pH was raised from 4.73 in the control to 6.33 in the pot that had 2ton ha^{-1} CCL and 1ton ha^{-1} urea. The available P, organic carbon and organic matter, basic cations, exchangeable acidity, Effective Cation Exchange Capacity and Base Saturation were similarly improved due treatment application. The plant growth and yield parameters were also significantly improved due to treatment applications and 2ton ha-1 CCL and 1ton ha-1 urea also showed best improvement among the other treatment combinations and is therefore recommended for pepper production in Southeastern Nigeria.
Keywords: Cassava leaves, Urea, soil chemical properties and Pepper.

INTRODUCTION

Capsicum is a crop that is widely cultivated because of its spicy nature and nutritional value. It is a major source of vitamin A and C and is largely cultivated in tropical regions (Shippers, 2000). Nigeria is known to be one of the largest producers of pepper in the world, accounting for about 50% of the African production (Erinle, 1989). This according to Adigun, (2001) can be attributed to the good soils and weather that supports its growth. Due to the good flavor and pungency characteristics of Nigerian pepper, the demand is always very high (Erinle, 1989). It is widely recognized that tropical soils require special management to guarantee their productivity and sustainability of production (Azu *et al.*, 2017). This mainly due to the inherent low fertility status occasioned by acidity, nutrient adsorption and leaching that results from heavy tropical rains (Osodeke, 1999).

Mineral fertilizers have conventionally been used to treat poor nutrient soils to increase and maintain crop production. Even though mineral fertilizers release specific nutrients rapidly to the soil and plant response, studies over the years have shown that the persistent and aggressive use of mineral fertilizers to boost crop production has resulted into soil and environmental degradation including acidification, loss of organic matter, soil erosion and nutrient imbalance (Vanlanwe *et al.*, 2002; Azu *et al.*, 2017).

Organic agriculture is gaining popular attention in recent years. Organic matter improves soil physical, chemical and biological conditions of the soil for long term and sustainable crop production (Ghabbor and Davis, 2009). However, it has been severally reported that organic fertilizers provides slow release of nutrients (Akande *et al.*, 2008) and it is always difficult to obtain large quantities for commercial agricultures.

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To overcome this limitation, soil Scientists have come up with the fertility management programme of combining mineral and organic fertilizers in farming system. Reports have shown that the supplementation of organic manures with mineral fertilizers have proved more superior to the application of either of the fertilizer alone (Adediran *et al.*, 1999; Ano and Asumugha, 2000).

Agronomists have long recognized the benefit of maintaining and increasing soil organic matter and one of the organic fertilizer sources which is relatively underutilized is composted cassava leaves. Cassava leaves have been used in the combat of malnutrition in many societies (Motta *et al.*, 1994). According to Ravindran *et al.*, (1988), cassava leaves are good source of fibre, minerals and vitamins. Several studies have shown that cassava plant is a heavy feeder, removing large amount of nutrients from the soil when cultivated on a long-term bases (Howeler, 2004). These nutrients are partitioned into different parts of the plant including the shoot and the tubers. Unfortunately, only the stored nutrients in the tubers are eventually utilized by human or his animals. The rest are usually lost, since most societies don't consider the leaves as economic part (Howeler, 2002).The high hydrogen cyanide content of the cassava leaves may have been responsible for this assertion.

In view of the above, there are currently limited or no information on the effect of composted cassava leaves and urea on soil fertility properties, growth and yield of pepper in southeastern Nigeria. This information gap informed the decision for this study.

MATERIALS AND METHOD

The pot experiment was carried out in the Green House of Akanu Ibiam Federal Polytechnic Unwana, tropical rain forest zone of Nigeria (coordinates: latitude $5^0$48'N and longitude $7^0$55'E). The soil of the experimental area is a Typic Hapludult (Federal Department of Agriculture and Land Resources, 1985; Nwaogu and Ebeniro, 2009). The air temperature is generally high all year round and the current temperature range is 32°C -21°C with total annual rainfall exceeding 3,500 mm (Njoku *et al.*, 2006).The area has being use for cassava cultivation for more than ten years.

Soil samples were collected with the soil anger from the Polytechnic multi-purpose farm at 0-20cm depth. This was air dried, sieved with 2mm sieve, after which sub-samples of 5kg each were weighed into 12L capacity plastic buckets perforated at the bottom to allow for air and water movement.

The ripe cassava leaves were collected from harvested cassava farms within the Polytechnic community. These were stored inside a deep hole in the ground and covered lightly with soil for two months. Weekly turning and water application were observed to aid microbial decomposition throughout the incubation period.

The experiment consisted of 27 treatments, corresponding to three rates (0, 1 and, 2, ton ha^{-1}) composted cassava leaves (CCL) and three rates (0, 1, and 2 ton ha^{-1}) Urea, arranged factorially in a completely randomized design (CRD) with three replications. Two seedlings of pepper (About two weeks after germination) were transplanted in each pot two weeks after treatments application and later thinned down to one seedling per pot after establishment. Adequate watering, weeding and pest control were observed throughout the growing period.

At 12 weeks after planting (WAP), agronomic and growth parameters data were collected from each pot. Data collected at the early bloom stage (8 WAP) were plant height, and number of leaves. At maturity, the yield component collected was the number of fruits per plant.

Post-harvest soil samples were collected from each pot and the following chemical analysis were carried out according to standard procedure: Soil pH (Udo, *et al.*, 2009), org. C (Pansu and Gautheyrous, 2006), total N (Simmone *et al.*, 1994), Available P (Bray and Kurtz, 1945) ECEC (Udo, *et al.*, 2009)and base saturation was obtained mathematically with:

$$\text{B5 (\%)} = \frac{\text{Total cations}}{\text{ECEC}} \times \frac{100}{1}$$

Statistical analysis was done by the analysis of variance (ANOVA) and the means separated using FlsD.0.05

RESULTS AND DISCUSSION

Physical and chemical properties of the soil used for the study

The soil was a clay loam with high clay content (38.31%) with pH of 4.27 and 3.78 in water and salt respectively indicating acidity (Table 1). Organic carbon and organic matter were relatively moderate (1.90, 3.29% respectively), nitrogen and P content were low, below the critical values proposed by Osodeke (2000) for most crops in southeastern Nigeria. The low P content observed in this study may be related to high P fixation, consequent of the high Fe^{+2} and Al^{+3} in this soil. Azu *et al.*, (20017) have also reported similar observation. Total acidity was high (4.01cmol/kg). However, the total exchangeable bases were high and thus, base saturation was also high. The high carbonate content of the soil, coupled with the shale parent material of the soil must have been responsible for observed high base concentration as previously reported by Azu *et al.*, (2018). The chemical properties of the soil shows that it is low in fertility and therefore require external manure input for profitable crop production.

Table1.1. some physical and chemical properties of the soil and wood ash used for the study.

Properties	Soil	Composted cassava leaves
Sand (%)	40.13	-
Silt (%)	21.56	-
Clay (%)	38.31	-
Texture	Clayey – loam	
pH (H_2O)	4.27	8.18
pH ($Cacl_2$)	3.78	7.23
Org. C. (%)	1.90	2.57
Org. M (%)	3.29	4.43
Total N (%)	0.25	5.50
Av. P (mg/kg)	5.62	13.40
Ca (cmol. /kg)	3.18	10.20
Mg (cmol. /kg)	1.00	20.10
K (cmol. /kg)	0.06	24.44
Na (cmol. /kg)	0.02	7.12
Exc. Acidity	4.01	-
ECEC	8.27	-
B.S%	51.51	

The chemical properties of the composted cassava leaves used for the study wood is shown in Table 1. Results showed that the composted cassava leaves was rich in mineral elements. Nitrogen was high. The pH was relatively alkaline both in water and salt (8.18 and 7.23 respectively). This observation is contrary to earlier reports of acidity in cassava leaves owing to the high hydrogen cyanide content (Awoyinka *et al.*, 1995). The long term microbial decomposition and fermentation of the leaves must have influenced the present result. The organic carbon and organic matter content of the CCL were high (2.57%, 4.43% respectively), indicating their suitability to increase the organic matter base of the soil. The N and P content of the CCL were high (5.50% and 13.4kg/mg respectively). Howeler (2004) has previously reported high N and P content in cassava leaf residues. The result may be attributed to the high nutrient demand of cassava from the soil. The basic cation content in the composted cassava leaves were high occurring in the order of K>Mg>Ca>Na. This study therefore suggests that the cassava leaves especially when composted can serve as rich source of nutrients to soil and if properly applied can serve as suitable replacement to mineral fertilizer use.

Effect of composted cassava leaves and urea on soil chemical properties

Table 2 shows both the main and the interactive effects of CCL and urea on some selected soil fertility properties. From the Table, relative to the control experiment, there was progressive improvement on the soil fertility indices with increased treatments application. Results showed that while the pH increased with CCL application, relatively decline trend on pH was observed with increased urea addition. However, the interactive effects of the treatments showed significant difference ($P<0.05$). The highest pH value of 6.33 was obtained in the experiment that had 2ton ha^{-1} CCL and 1ton ha^{-1} urea Mineral fertilizers such as urea have been reported to increase soil acidity when consistently used (Azu *et al.*, 2017; Awodun, 2007). Significant improvement on soil pH when mineral and organic fertilizers are integrated have also been reported in tropical soils (Ano and Asumugha, 2000; Azu *et al.*, 2018).

Similarly, organic carbon and organic matter increased exponentially with CCL application relative to control, while a decline trend was observed with increased urea. However, the treatments and their interactions showed significant difference. Composted cassava leaf being from plant origin is expected to impact on the soil more carbon (Brady and Weil, 2008). Similarly the increase in soil organic carbon and organic matter as a result of CCL can be a reflection of the high content of this element in the CCL as observed in the study. From the results, it was observed that the highest amount of organic carbon (2.09%) was obtained in the pot that had 2ton ha^{-1} CCL and 1ton ha^{-1} urea, while the least amount (1.00%) was obtained in the experiment that had only 2ton ha^{-1} urea.

Table.2 Mean effect of composted cassava leaves and urea on soil chemical properties

CCL + UREA	pH		Av.P	Org.C	Org.M	TN	TEB	TEA	ECEC	BS
Ton ha^{-1}	H_20	$Cacl_2$	mg/kg		%			Cmol/kg		%
0 + 0	4.73	4.22	4.88	1.52	2.62	0.10	2.00	3.67	5.67	35.27
0 + 1	4.41	4.00	4.56	1.45	2.50	0.19	2.00	3.70	5.70	35.09
0 + 2	4.20	4.00	4.18	1.00	2.24	0.26	1.96	3.74	5.70	34.39
1 + 0	5.00	4.62	5.55	1.44	2.48	0.16	2.55	3.03	5.58	45.70
1 + 1	5.63	5.22	5.71	1.40	2.41	0.30	2.23	3.00	5.23	42.64
1 + 2	5.48	5.18	5.40	1.21	1.91	0.32	2.15	3.44	5.59	38.46
2 + 0	6.00	5.77	6.01	2.00	3.45	0.27	3.90	2.90	6.80	57.35
2 + 1	6.33	6.10	6.28	2.09	3.60	0.30	4.00	2.20	6.20	64.52
2 + 2	6.19	6.00	6.13	2.00	3.45	0.37	3.02	2.61	5.63	53.64
Lsd(0.05)CCL	NS	NS	0.022	0.101	1.376	0.0014	0.011	0.010	0.422	19.221
Lsd(0.05)UR	NS	NS	NS	0.101	1.376	0.0014	0.011	0.010	0.4222	19.221
CCL x UR	0.017	NS	0.113	NS	NS	0.0039	0.032	0.021	1.501	NS

Nitrogen content of the soil was significantly ($P<0.05$) increased as a result of the treating the soils with CCL and Urea both as lone and combined treatments and the improvement increased with application rate. This result may be a reflection of the high N content in both fertilizer materials. Wobeto *et al.*, (2006) has reported high N content in leaves of cassava, while urea is known to contain about 46% N (Brady and Weil, 2008). The highest value of 0.37% N was obtained in the experimental pot that had 2ton ha^{-1}CCL and 2ton ha^{-1}Urea, showing the superior influence of combined treatment of mineral and organic fertilizers over the application of either of them (Ano and Asumugha, 2000).

Phosphorus content of the soil was increased as a result of the treatment application especially, CCL as lone and in combination with urea. At 5% probability level, the lone application of CCL and in combination with urea showed significant differences. The P values ranged from 4.18mg/kg in the pot that had only 2ton ha^{-1} urea to 6.28mg/kg in pot that had 2ton ha^{-1} CCL and 1ton ha^{-1} urea. The reduction in acidity, coupled with the increased organic matter content due to CCL addition may have reduced P sorption and thus, more available P (Osodeke and Ubah, 2005; Azu *et al.*, 2017).

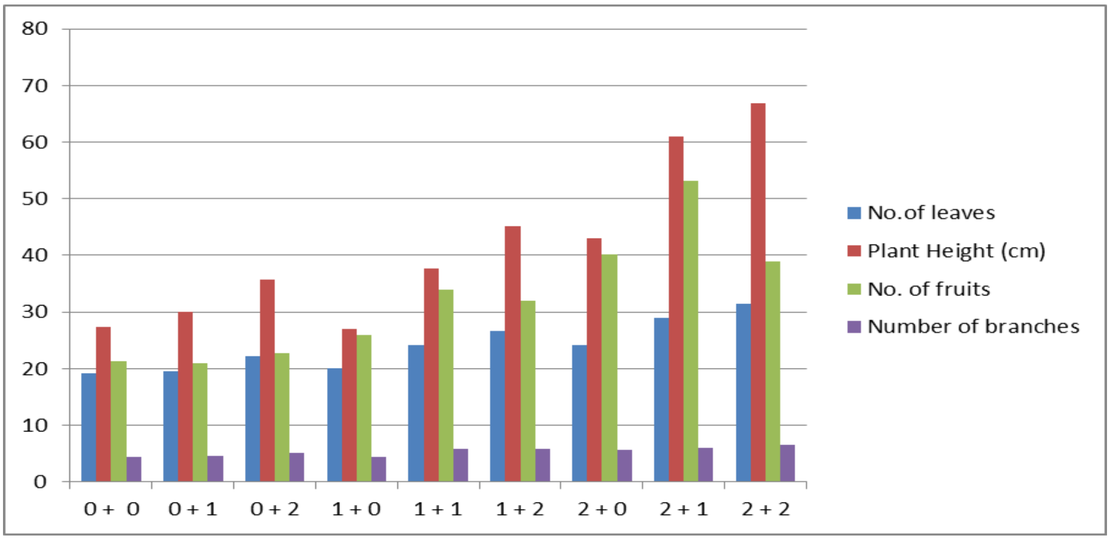
Results showed that while the exchangeable bases increased with CCL addition, increased urea application resulted into decline in the basic cations. In a similar pattern, combined treatments had superior improvement on exchangeable acidity. While the least value of 1.96 Cmol/kg was obtained in the experiment that had only 2ton ha^{-1} urea, the highest value of 4.00 Cmol/kg was obtained in the pot that had 2ton ha^{-1} CCL and 1ton ha^{-1} urea. Studies have shown that mineral fertilizers tend to reduce basic cations in soils, while organic manures have the capacity to not only supply the soil with mineral bases, both also ensure their sustainability (Ghabbour and Davie, 2000; Awodum, 2007).

The exchangeable acidity was drastically reduced by CCL application relative to control and treatments with single urea application. The TEA values ranged from 2.20 Cmol/kg in the pot that had 2ton ha^{-1} CCL and 1ton ha^{-1} urea to 3.74 Cmol/kg in the experimental unit that had 2ton ha^{-1} urea. Urea has been reported to decrease soil pH and therefore exchangeable acidity (Azu *et al.*, 2017).). As a consequence of raised pH, CCL can contribute to lowering Al and Fe toxicity and thus decrease the TEA (Mbah *et al.*, 2010).

The ECEC and BS were significantly improved as a result of the treatment application and the improvements were proportional to treatment addition. Treatment combination of 2ton ha-1 CCL and 1ton ha-1 urea generally showed superior in these parameters to other treatment combinations.

Effect of composted cassava leaves and urea on growth and yield of pepper

Figure 1 shows the effect of CCL and urea on the growth and yield parameters of pepper. Results showed that relative to the control experiment, the application of the treatments as single or combined improved these agronomic variables. The number of leaves was significantly increased as a result of the treatments and the highest number of leaves was observed in the experiment that had 2ton ha^{-1} CCL and 2ton ha-^{1} urea. Similarly, the number of branches and plant height increased with treatment addition with urea showing greater improvement than CCL when applied as lone treatments. Nitrogen is known to favour vegetative phase of crop growth (Brady and Weil, 2008), thus the high N content of these materials may have influenced the results.



Treatments (Composted cassava leaves + Urea)

Fig.1 Number of leaves, plant height number of fruits and number of branches of pepper as affected by the addition of composted cassava leaves and urea fertilizer

However, the number of fruits was consistently higher in the experiments that had combined treatment of CCL and urea than their lone applications and the treatment combination of 2ton ha^{-1} and 1ton ha^{-1} urea gave the highest number of fruits. This observation is in consonant with earlier reports of superior effect of combined organic and inorganic fertilizers compared with the application either of them (Ano and Asumugha, 2000; Azu *et al.*, 2017).

CONCLUSION

The data presented here have shown that the addition of CCL and urea as soil amendments improved the soil nutrient properties, growth and yield of pepper and the improvements were proportional to the amendment rates. From Table 2 and Figure 1, the treatment combination of 2ton ha^{-1} CCL and 1ton ha^{-1} urea relatively had better improvement on both soil fertility properties, plant growth and yield properties and is therefore considered optimum for pepper production and is recommended in southeastern Nigeria.

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