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Performance of Indigenous *Celosia argentea* Variety and Soil Physico-chemical Properties as Affected by Dual Application of Compost and Single N-mineral Fertilizer in Southern Guinea Savanna Vegetation Zone of Nigeria

Peter Akintoye Babajide*[1] and Noah Olugbemiga Olla[2]

1. Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.
2. Department of Agricultural Technology, Oyo State College of Agriculture Igboora, Nigeria.

* E-mail of the correspondence author: akinbabajide@yahoo.com

Abstract

Both the organic and chemical fertilizer materials had been adjudged defective and imperfect, especially while considering some of their embedded attributes, such as 'rapid nutrients-releasing-and-varnishing', residual effects, hoarding and high cost of purchasing the inorganic fertilizers. Also, the organic residues are known to be slow in nutrients dissolving and releasing, apart from their competitive usages, as well the time and drudgery involved in their preparations.

Two consecutive field studies were carried out in the year 2008, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, to assess the effects of combining four levels (0.0, 1.5, 3.0 and 6.0 t ha^{-1}) of composted Tithonia-biomass and three rates (0.0, 20.0, 40.0 kg N ha^{-1}) of urea on growth, yield and nutrient uptakes of *Celosia argentea* and soil physico-chemical properties. Trial was laid out in a randomized complete block design (RCBD) with four replications. Data collected on growth and yield parameters were analyzed using ANOVA at $p < 0.05$. Growth and yield parameters increased significantly with increasing level of the mineral-N fertilizer and compost applications, compared to the control during the experiments. Combined application of 3.0 t ha^{-1} of compost and 20.0 kg N ha^{-1} had significantly highest values of all the growth and yield parameters measured. Data from plants which received combined application of 6.0 tons ha^{-1} compost and 40.0 kg N ha^{-1} were not significantly different from those obtained from combined application of 3.0 t ha^{-1} of compost and 20.0 kg N ha^{-1} but significantly higher than other treatment combinations. Moreso, soil physico-chemical properties significantly improved with increasing application of tithonia-compost. Thus, organic soil amendments such as *Tithonia diversifolia* biomass could favour crop performance and soil quality and that, combined application of 3.0 t ha^{-1} of compost and 20.0 kg N ha^{-1} is recommended for supplying adequate nutrients required for optimum growth and yields of celosia and improved soil quality in the study area.

Key words: Indigenous celosia variety, compost, *Tithonia diversifolia,* soil physico-chemical properties, guinea savanna.

1.0 Introduction

Celosia argentea L. belongs to the pigweed family 'Amaranthaceae'. It is an important leaf vegetable of the southwestern Nigeria, which is well known for its succulent leaves rich in protein, vitamins and minerals (Akanbi *et al*., 2007). *Celosia argentea* is commonly found in the traditional mixed and inter-cropping systems of the tropics as seen on small patches of pure over crowded stands (when drilled) or single plants (when transplanted) at regular or irregular spacing (Akanbi *et al.,* 2007). Its leaves (which are slightly mucilaginous) and young shoots are useful in soup and stew preparations. Boiled shoots are served with carbohydrate foods such as yam or yam flour, rice etc. Moreso, celosia leaves can be dried and preserved against the dry season in India (Aruna, 2009). Its uses beyond dietary and extend to medicinal purposes and treatment of ailments such as abscesses, cough, diabetes, diarrhea, dysentery, eczema, eye problems, gonorrhea, infected sores, liver ailments, menstruation problems, muscle troubles, skin eruptions, snakebites and wounds (Schippers, 2000).

Tithonia diversifolia (Hemsl.) A. Gray. is a common weed, which is also known as Wild flower or Mexican sunflower. It is an annual shrub belonging to the family Asteraceae which grows aggressively to a height of 2.5m or beyond and adaptable to most soils (Consolacion *et al.,* 2006; Olabode *et al.,* 2007). It could be ranked amongst the numerous indigenous wild plant species which could be easily exploited as suitable potential fertilizer materials. The plant is well known to be found growing on or near small holder farms. It is believed to be originated from Mexico and now widely distributed all over the humid and sub-humid tropics of the Central and South America, Asia and Africa (Nziguheba *et al.,* 2002; Consolacion *et al.*, 2006). It was probably introduced into Africa as an ornamental plant. It had been observed to be widely spread in Nigeria on abandoned waste-lands, beside highways, waterways and cultivated farmlands (Chukwuka and Omotayo*,* 2009). Although the plant is relatively high in nutrient concentrations, little is known about its potentials as a dependable nutrient source for improved soil fertility and crop yields (Jama *et al.,* 2000).

Rapid decline in tropical soil fertility and crop productivity has become a major concern, and indeed a great hindrance to achieving food sufficiency in the tropics. However, continuous and intensive use of highly priced synthetic fertilizer materials, for boosting crop productivity in the past decades had been obviously linked to this problem as earlier reported to influence nutrient imbalances, nitrate pollution, microbial activities, soil acidity and fatal threats to man (Sobulo, 2000; Akanbi, 2002; Babajide *et al.,* 2008). Hence, it is important to provide alternative sources of nutrients for effective and efficient crop production. Much research had been done to assess the suitability of organic materials (such as crop residues and animal manures) as potential sources of nutrients to replace inorganic fertilizers (Akanbi *et al.,* 2007; Chukwuka and Omotayo, 2009) but, the proposed organic alternatives to inorganic fertilizers were identified as potential fertilizer materials with relatively low nutrient concentrations per given volume. This implies that the organic materials cannot be sufficiently available to reverse soil fertility conditions particularly on large scale farms, apart from the competitive versatility of the same organic materials (for livestock fodder, mulching, fencing, ornamental, medicine etc.), as well as the drudgery involved in preparation and application of the organic materials (Olabode *et al.,* 2007; Palm *et al.,* 2001). Therefore, since both nutrient sources have their attributed advantages and disadvantages, adoption of an organo-mineral nutrient management approach which combines the two major nutrient sources at certain proportions that will reliably elicit crop production efficiency with little or no damage to the soil physico-chemical properties, is a worthwhile technology (Palm *et al*., 1997). This research was then carried out to assess the effects of combining composted Tithonia biomass and synthetic fertilizer at different application rates on growth, yield and nutrient uptake of *Celosia argentea* and post-cropping soil quality.

2.0 Materials and Methods

Field studies were carried out in the year 2008, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso (latitude 8^0 10' N and longitude 4^0 10' E), Nigeria, to evaluate the response of *Celosia argentea* to combined application of four rates (0.0, 1.5, 3.0 and 6.0 t ha^{-1}) of composted *Tithonia diversifolia* biomass and three rates (0.0, 20.0, 40.0 kg N ha^{-1}) of N-mineral (urea) fertilizer and the effects of these treatment combinations on post-cropping soil conditions. Ogbomoso falls under southern guinea savanna of the south-west Nigeria, and characterized by bimodal rainfall distribution with two peaks (between 1150 mm and 1250 mm) in late July / early August and October / November.

2.1 Land Clearing and Preparation

Land clearing and preparation were carried out manually, following farmers' conventional practice, using hoe, cutlass, mattock, rake etc. Plots of 2.0 by 2.0 m^2 size were then made.

2.2 Preparation of Compost

The compost used was prepared mainly from Tithonia biomass and cured poultry manure. Fresh Tithonia plants available at the fallowing experimental plot were cut at eight weeks after emergence and shredded (into smaller fragments of less than 5 cm in length with stem girths ranging from 2.8 cm to 4.2 cm). These materials were air-dried for 14 days to reduce the moisture content to about 6 %.The poultry manure was obtained from the poultry section of the livestock production unit at the Teaching and Research Farms, LAUTECH, Ogbomoso. Stone, metals and other foreign / non-biodegradable materials were carefully removed from the manure before air drying for ten days. Samples were randomly collected from both the Tithonia plant materials and cured manure for laboratory chemical analyses using standard methods (IITA, 1982). Under the shade of *Gmelina arborea-Tectona grandis* plantation located at the opposite side of the Faculty of Agricultural Sciences, LAUTECH, Ogbomoso, a wooden frame of compost bin with a base of 3m (length) by 2m (breadth) and 5m height was erected. Wooden planks of about 10cm wide were nailed at interval of 30cm round the frame. It was a roofless structure with a door-like opening which allows entrance into the structure. The walls and the floor were not cemented to ensure proper ventilation into the structure and water drainage out of the structure as required. When the materials to be composted were ready, the floor and the walls were carefully lined with a big jointed fertilizer sack on which ten (10) layers of Tithonia biomass and cured poultry manure were laid in ratio 3:1 respectively (Abad *et al.,* 1997; Akanbi, 2002). Each layer consists of 30kg Tithonia biomass and 10kg poultry manure. At the completion of the layering, vertical insertion (through the core of the manure) of three plastic pipes of 2.5m long and 10 cm in diameter were carried out. This reduces excessive heating up of the manure. The layers were finally covered with a thin layer of good topsoil, to enhance microbial population of the compost. Adequate watering which allows even saturation of the manure layers with water was done immediately. The layers were then sealed-up with a big black polythene sheet and the terminal edges of the underlined jointed fertilizer sack overlapped that of big black polythene sheet and finally weighed down by heavy objects such as stone, logs of wood etc. Watering and turning of the decomposing manure were carefully done fortnightly. Matured and odourless composted materials were evacuated from the erected structure at the eight week. The compost was then spread thinly on a cemented floor for air-drying for ten days. The materials were then sieved (using 0.8 x 0.8 cm^2 sieve) and spread for further air-drying, before bagging in jute sacks for storage in a cool dry store until when needed. Samples were collected for chemical analyses, using standard methods according to IITA (1982).

2.3 Sowing, Fertilizer Application and Maintenance of *Celosia argentea*

Celosia argentea seeds of variety Ogbomoso-Local were surface sterilized by using 95% ethanol for 10 seconds and later rinsed six times with sterile water after shaking for three to five minutes in 3% hydrogen peroxide (H_2O_2). Seeds were sown at a spacing of 50 cm by 20 cm per plot size of 2.0 by 2.0 m^2 on July 1st 2008. Emerged seedlings were later thinned to one per hole or stand, at one week after sowing (WAS). Plant residues found on the farm site were applied as basal manure application. Urea fertilizer (46% N), was used as the only inorganic nitrogen (N) source. Application of compost was done by incorporating the materials into the soils two weeks before sowing. Regular watering was maintained as at when due. Plots were manually weeded by hoeing, fortnightly.

2.4 Experimental Design

There were twelve treatment combinations introduced as derived from combination of four rates (0.0, 1.5, 3.0 and 6.0 t ha^{-1}) of composted *Tithonia diversifolia* biomass and three rates (0.0, 20.0, 40.0 kg N ha^{-1}) of inorganic nitrogen (urea). The trial was laid out in a randomized complete block design (RCBD) with four replications.

2.5 Soil and Plant Samplings and Analyses

During land preparation, soil samples were collected for pre-cropping physico-chemical analyses, according to IITA 1982. The soil was an Alfisol belonging to Egbeda (Smyth and Montgomery, 1962; Bridges, 1997). After harvesting at six weeks after sowing, plant samples were oven dried at 80^oC for 48 hours and analysed following the procedures of AOA C (1980) and Heanes, (1984). The nutrients accumulated in plant parts were calculated as; Nutrient uptake = % Nutrient content x sample dry weight according to Ombo (1994) and Gungunla (1999).

2.6 Data Collection and Statistical Analysis

Data on growth and yield parameters were collected and analysed using ANOVA at $p<0.05$. Significant means were separated using Duncan Multiple Range Test (DMRT), according to SAS (2009).

3.0 Results and Discussion

The results from the pre-cropping physical and chemical soil analyses revealed that the soil used for this experiment was mildly-acidic (Table 1) and texturally sandy-loam (sand, 85.4%, silt, 11.4% and clay, 3.2%). Also, the soil was grossly low in essential nutrients (total N, 0.04%, available P, 4.78 mg kg^{-1} and exchangeable bases (C mol kg^{-1}), K, 0.62, Ca, 1.31 and Mg, 0.38) and organic carbon, 1.78%. These results agreed with Olabode *et al.* (2007) and Babajide *et al.* (2008), who reported that the soils at the study area was slightly acidic and also that they were grossly low in nutrient concentrations to support successful completion of the vegetative and reproductive stages of most tropical crops.

The significantly highest values of nutrient uptake for N, P and K were not obtained through combined application of 3.0 t ha^{-1} of compost and 20.0 kg N ha^{-1} but through combined application of 3.0 t ha^{-1} of compost and 40.0 kg N ha^{-1} of urea although, the values of uptake of P and K were statistically similar (Table 1). These results corroborated the findings of Akanbi (2002), Babajide et al., 2008 and Chukwuka and Omotayo (2009) who reported the potential of Tithonia biomass as potential fertilizer which could supply adequate nutrients for improved crop yield and nutrient uptakes of crop plants whenever incorporated into the soil.

The pH value of the matured compost was higher than any of the Tithonia materials and poultry manure used for composting (Table 2). Also, the values of N (%), P (%), and K (%), Ca (g kg^{-1}) and organic C (g kg^{-1}) improved in the matured compost and were better than any of the materials used for composting (Table 2). This is a reflection of significance of composting crop residues which creates a better improvement in the nutritional compositions of the compost over the materials used for compost making. These results supported the findings of Chen *et al.,* 1993; Ghosh *et al.,* 2004; Chukwuka and Omotayo, (2008) and Akanbi, (2002) who reported variation in the percentages of nutrient concentrations of organic manure depending on the sources, handling techniques and management strategies. However, the lower values of Mg, Fe, Zn and Cu observed in the matured compost compared to those of the materials used for compost making could be attributed to one or more of the factors that could induce variation in the percentages of nutrient concentrations of organic manure as mentioned above.

Growth and yield parameters significantly increased with increasing rate of Tithonia and N-mineral fertilizer applications (Table 3). The control had the significantly lowest values for all the parameters measured. Combined application of 3.0 t ha^{-1} of compost and 20.0 kg N ha^{-1} had significantly highest values of all the growth and yield parameters measured (Table 3). Generally, values obtained from plants which received combined application of 6.0 tons ha^{-1} compost and 40.0 kg N ha^{-1} were statistically similar to those obtained from combined application of 3.0 t ha^{-1} of compost and 20.0 kg N ha^{-1} but significantly higher than other treatment combinations (Table 3). These results supported the findings of Palaniappan *et al* (1999); Babalad (1999); Nanjundappa *et al* (2001) and Imayavarambani *et al* (2002) who reported improvement in the general performance of crops which received a combination of different nutrient sources. Also, soil physical and chemical properties significantly improved with increasing application of tithonia-compost. These results agreed with the reports of Nziguheba *et al.,* (2002) and Jama *et al.,* (2000) who reported the potential of Tithonia biomass as a potential fertilizer which improved crop yield and nutrient uptake of crop plants when incorporated into the soil.

Table 1: Effect of Combined Application of Composted Plant Residues and Inorganic Fertilizer on Soil Physical and Chemical Properties and Nutrient Uptakes of Celosia

Treatments	Temperature (°C)	Moisture content (%)	pH Pre-cropping	pH Post-cropping	Nutrient uptakes N (g kg^{-1})	P (gkg^{-1})	K (g kg^{-1})
T0N0	30.4a	19.2c	6.02NS	5.70c	3.80e	1.00f	0.65e
T0N1	30.2a	20.6bc	6.02NS	5.70c	18.90d	3.63ef	10.10d
T0N2	30.2a	21.2b	6.02NS	5.70c	31.50bc	5.23de	15.47bcd
T1N0	28.0a	24.0b	6.02NS	5.90b	31.70bc	7.13abcd	19.60ab
T1N1	28.2a	22.8b	6.02NS	5.90b	33.43bc	8.17abc	20.20ab
T1N2	28.2a	22.0b	6.02NS	5.92b	37.30ab	8.80a	21.67ab
T2N0	24.0b	30.0a	6.02NS	6.19a	26.73bcd	5.67cde	18.20abc
T2N1	22.7c	31.2a	6.02NS	6.16a	30.00bcd	7.23abcd	21.67ab
T2N2	24.8b	31.1a	6.02NS	6.16a	44.37a	8.43ab	23.03a
T3N0	20.8c	32.0a	6.02NS	6.20a	37.50ab	8.33ab	21.70ab
T3N1	21.2c	30.1a	6.02NS	6.21a	27.53bcd	6.90bcd	17.87abc
T3N2	21.0c	29.9a	6.02NS	6.18a	23.33cd	4.40de	12.37cd

NS= Not Significant, T0= zero application of tithonia compost, T1= application of 1.5tons ha^{-1} of tithonia compost, T2= application of 3.0 tons ha^{-1}, T3= application of 6.0 tons ha^{-1} of tithonia compost, N0= zero application of urea, N1= 20.0kg N ha^{-1} application of urea, N2= 40.0 kg N ha^{-1} application of urea

Table 2: Chemical Properties of Composted Materials and Matured Compost Used

Properties	Tb	Pm	Mc
pH ($H_2$0)	5.90	6.00	6.22
N (%)	3.62	3.50	3.90
P (%)	0.91	0.29	0.47
K (%)	2.18	1.20	2.09
Ca (g kg^{-1})	8.70	7.60	9.19
Mg (g kg^{-1})	3.35	4.10	4.56
Fe (mg kg^{-1})	10.80	13.82	12.76
Zn (mg kg^{-1})	118.20	145.10	145.82
Cu (mg kg^{-1})	30.16	29.81	31.20
Organic C (g kg^{-1})	34.60	33.70	37.60

Tb = Tithonia biomass, Pm = poultry manure, Mc = matured compost.

Table 3: Growth and Yield Parameters of *Celosia argentea* as Influenced by Combination of Tithonia Compost and N-Mineral Fertilizer.

Treatments	Plant Height (cm)	Stem Circumference (cm)	Number of Leaves	Number of Branches	Above-ground Dry yield (tons ha^{-1})	Below-ground Dry yield (tons ha^{-1})
T0N0	23.3c	1.6a	24.6d	5.0f	2.3d	0.4e
T0N1	34.0b	2.0b	37.8c	6.2e	3.1c	1.0d
T0N2	39.6b	2.0b	44.2b	7.1d	3.4c	1.7c
T1N0	41.0b	2.3b	45.6b	8.2c	3.6c	1.8c
T1N1	40.3b	2.2b	46.3b	8.3c	4.0c	1.8c
T1N2	42.0b	2.4b	49.8b	9.3c	4.4c	1.9c
T2N0	43.8b	2.4b	51.9b	9.6c	6.6b	2.5b
T2N1	58.3a	3.41a	79.4a	13.6a	11.7a	4.6a
T2N2	62.3a	3.5a	80.6a	14.0a	10.9a	4.6a
T3N0	60.8a	3.5a	81.5a	14.2a	11.0a	4.6a
T3N1	62.7a	3.5a	82.5a	14.0a	10.3a	4.7a
T3N2	60.9a	3.5a	85.6a	13.9a	10.7a	4.5a

T0= zero application of Tithonia compost, T1= application of 1.5tons ha^{-1} of Tithonia compost, T2= application of 3.0 tons ha^{-1}, T3= application of 6.0 tons ha^{-1} of Tithonia compost, N0= zero application of urea, N1= 20.0kg N ha^{-1} application of urea, N2= 40.0 kg N ha^{-1} application of urea.

4.0 Conclusion

This research has established that Tithonia is a potential fertilizer material and suitable soil amendment for the tropics which could be easily exploited for improved crop productivity through positive and effective enhancement of the soil physical, chemical and biological conditions of the tropics where soils are mostly marginal. Thus, to ensure continuous flow of nutrients for optimum growth and yield of Celosia and maintenance of soil physical and chemical properties, combined application of 3.0 t ha^{-1} of Tithonia compost and 20.0 kg N ha^{-1} is therefore recommended in the study area.

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