International Scholars Journals

Advances in Agricultural Biotechnology ISSN 7301-6381 Vol. 2 (6), pp. 110-118, June, 2018. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Effects of organic amendments on the growth and performance of *Celosia argentea* on an oxic Paleustalf in South western Nigeria

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Accepted 20 January, 2018

The problems associated with availability of space for cultivation due to high demands on land for other uses has made virtually all farmers to embark on continuous cropping at the expense of soil fertility management. This study was therefore conducted to assess the effect of organic amendments on the yield and yield components of *Celosia argentea*. A field experiment was carried out to examine the effects of four different levels 0, 100, 150, and 200 g of different organic amendments (maize stovers, legume and cassava) on growth and yield of *C. argentea* and soil fertility. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data collected were analyzed and significant means was compared using analysis of variance (ANOVA) and Duncan multiple range test (DMRT) at 5%. Application of organic amendments had significant effect ($p < 0.05$) on growth and short yield of *Celosia*. The leguminous residues gave the highest plant growth and cumulative yield while the least was obtained with control. Cassava residues particularly, gave its best yield (133.36 g/ha) mainly at the second rate (150 g) of treatment while legumes gave the highest yield at the highest level of treatment (345.6 g/ha). There is no significant increase between the second (150 g/ha) and third (200 g/ha) rates of maize stovers treatment although, the third rate still gave the highest, that is, yield the same as legume. It was concluded that organic amendments significantly increased the soil fertility and yield of *Celosia* planted on the soil.

Key words: Organic amendments, yield and yield components, soil fertility, *Celosia* spp.

INTRODUCTION

Soil nutrients depletion is one of the most serious problems currently affecting agricultural productivity in developing countries of the tropics, including Nigeria. The intensification of cultivation with little or no fertility management has been one of the critical factors contributing to this decline in natural ecological conservatory balances in the landscape. This in turn poses great difficultly for productivity increase to meet the food and fibre needs of a rapidly growing population, thus, endangering food security (Senjobi, 2007). As population increases geometrically and more intensive demand are made on the earth's natural resources, including land, available land for cultivation will reduce. The problems of urbanization, incessant demand for food crops, land tenure system, indifferent or outdated government policies and industrialization make farmlands scarce and inaccessible to farmers. Consequently, continuous cultivation is prevalent. This in turn reduces fallow period and other cultural practices that can help to replenish the soil nutrients (Akinsehinwa, 2007; Adedipe, 1991). The depletion of soil nutrients due to continuous cropping reduces the soil organic matter, cause significant acidification and yield reduction (Batiano and Makwunye, 1991; Anonymous, 1995; Ajilore, 2008). There is therefore need for adequate fertilization or manuring in order to sustain soil productivity for optimum growth and yield of planted crops to ensure food security for the ever increasing growing population. The impor-tance of mineral and organic fertilizers in improving soil productivity has been documented (Cooke, 1982; Setia

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and Sharma, 2004; Odu and Mba, 1991; Ketiku et al., 1985; Palada et al., 1992; Adenawoola et al., 2005).

Although, there is a wealth of information on the dietary importance of *Celosia argentea*, a leafy vegetable which is extensively grown in West Africa (Tindall, 1983; Akanbi, 2000a), little is known about its nutritional requirements generally. This is because in West Africa's farming system, leafy vegetables are regarded as back-yard crops. However, this idea is changing, with the development of private and government vegetable gardens on a large scale. This, coupled with the scarcity and high cost of obtaining mineral fertilizer, calls for search for alternatives (Akanbi et al., 2006), and thus necessitate this research. Specifically, this work focuses on the assessment of effect of organic amendment on the growth and performance of *C. argentea* and soil properties.

MATERIALS AND METHODS

Description of the study area

The study was carried out at the Teaching and Research Farm of Olabisi Onabanjo University, College of Agricultural Sciences, Ayetoro, Ogun State. The site is located on latitude 7˚12'N and longitude 3˚0'E. The site is situated in a derived guinea savannah part of South Western Nigeria. The geology of these is mainly lateritic with low activity clay mineral soils that are more of an Alfisol. The land is mainly used for farming, especially for the cultivation of cassava, maize and vegetables.

Field work

The experimental site was manually cleared, ploughed and harrowed before cultivation. Organic amendments: legumes, maize stovers, and cassava were incorporated into the soils two weeks before planting to allow decomposition and mineralization to take place effectively. The soil samples were then taken and analyzed for physico-chemical constituents. Soil pH was determined in both water and 0.01 M potassium chloride solution (1:1) using glass electrode pH meter (Mclean, 1965). Total nitrogen was determined by the macro-kjeldahl digestion method of Jackson (1962) available P was extracted using Bray- 1 extract followed by molybdenum blue colorimetry. Exchangeable cations were extracted with 1M NH4OAC (pH 7.0), potassium, calcium and sodium were determined using flame photometer and exchangeable Mg by atomic absorption spectrophotometer (Sparks, 1996). Exchange-able acidity was determined by the KCl extraction method (Mclean, 1965), organic carbon was determined using dichromate wet oxidation (Walkley and Black, 1934). Organic matter was got by multiplying the percent organic carbon by 1.72. Cation exchange capacity (CEC) was calculated from the sum of all exchangeable cations. Available micronutrients were determined by atomic absorption spectrophotometer (AAS) method after leaching on NH4Cl (Senjobi, 2007). Particle size analysis was by the Bouyoucos (1951) hydrometer method using calgon as dispersing agent.

Seeds of TLV8 variety of *Celosia* spp were used as test crop. The experimental design was a randomized complete block design (RCBD) with three replicates. Agronomic attributes such as plant height, leaf area etc. were measured. The data collected were subjected to analysis of variance (ANOVA) and means were separated using the Duncan multiple range test as at 5%.

RESULTS AND DISCUSSION

The pH of the soil is slightly acidic ranging from 6.1 - 6.9 for cassava and legume treated soils. The pH increases slightly with increase in concentration or level of materials applied. Maize treated soils have a relatively constant pH value except in the second level of treatment that is, 150 g (Table 1). Legume treated soil gave the highest total nitrogen value. This may probably be due to its nitrogen fixing capacity. This was followed by cassava, with the least value in maize. Organic carbon level in the soil also follows the same trend, with the leguminous treatment having the highest value and maize treatment soil had the least. However, this is lower than the value obtained in the control soil. There was an appreciable increase in the level of available phosphorus over control in all the treatments. Available P in cassava treated soils increases with the concentration of amendment. The highest values were obtained at the third rate in maize. Other nutrients e.g. Ca, Mg, Fe, K etc. followed the same trend either with N or available P (Table 1).

Enhancement of various attributes with significant increase in growth (at $p < 0.05$) varying proportionally with increase in the level of organic amendment applied. Virtually all the measurable parameters such as root weight, whole shoot for market, leaf stalk, leaf girth etc. increase significantly compared to control (Tables 2 - 20). They all increase at an increasing rate, except in cassava and maize treatments where the whole leaf stalk weight gave appreciable lower value at first level. In case of legume, the second level gave a value relatively lower than that of the control (Table 2).

The results showed that the third level of legume treatment (PL C3) and the second level of cassava (Pc C3) gave higher values of root weights that are significantly different at $p < 0.05$ than other treatments (Table 5) . However, the PL C3 and Pc C3, respectively, gave the values that are significantly different ($p < 0.05$) from other treatments with respect to which shoot and plant heights (Tables 6 and 7). All the treatments are not significantly different from one another ($p < 0.05$) with respect to root biomass of the planted crops except the PL C3 which gave appreciably significant value (Table 8). The similar trend occurred in number of leaves and whole leaf stalk weights where PC C2 gave a significant higher value (Tables 9 and 11). The following trend was observed in leaf girth PL C1 < PL C3 < Po Co < Pc C2 with organic amendments (Table 10).

The use of organic amendments produced significant effect on the performance of *Celosia* when compared with the control plants. All the growth parameters taken were positively improved by the organic amendments Adequate nutrients availability had been indicated to improve crop growth and yield parameters. For instance, it has been reported that when N supply is not limiting, dry matter production, partitioning and assimilation as well as production of certain organic compounds (e.g. Proteins) would not be hampered. But a shortage in any

Table 1. Physico-chemical properties of the soil used.

Type of plant residue: P_o - Control (No plant residue); P_m - Maize residue; P_c - Cassava residue; P_L - Legume (Mucuna) residue. Concentration of plant residue: C_o - Control (No inclusion); C_1 - 100 g inclusion level; C_2 - 150 g inclusion level; C_3 - 200 g inclusion level.

Table 2. Mean weight (g) of yield/agronomic parameters.

No	Morphological properties	Control	Legume			Maize			Cassava		
			C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
1	Root WT (g)	6.80	12.60	8.20	8.20	10.50	11.00	17.00	6.10	47.90	15.70
2	WSM (g)	39.80	90.20	58.30	58.30	85.70	62.20	86.40	56.10	62.80	133.60
3	WLS (g)	38.30	41.80	30.80	30.80	29.90	30.20	51.20	23.50	82.40	47.70
4	DRYRT	6.10	3.90	2.80	2.80	6.70	6.60	6.80	2.40	17.10	8.60
5	BMASS (g)	8.30	8.70	5.40	5.40	6.10	10.40	13.20	6.90	14.30	13.20
6	NL	24.80	22.30	24.80	24.80	13.40	15.20	32.20	18.70	17.80	17.80
7	PH (cm)	20.20	18.30	19.40	19.40	13.30	15.50	19.40	16.70	18.50	17.60
8	G (cm)	2.70	2.80	2.50	2.50	1.90	2.00	2.50	2.00	2.90	2.40
9	NB	8.00	5.00	5.50	5.50	6.00	7.00	5.90	5.20	5.30	4.60
10	LA (mm)	14.80	28.70	19.60	19.60	22.70	12.90	20.40	11.30	33.30	20.20

RTWT - Root weight; WSM - Whole shoot for market; WLS - Whole leaf stalk weight; NL - Number of leaves; DRYTRT - Dry root weight; BMASS - Root biomass; G - Leaf girth; NB - Number of branching; LA - Leaf area (cm); PH - Plant height.

of the required nutrients may have pronounced effect on some or all these physiological processes (Akanbi et al., 2000 cited from Ajilore, 2008). This explains the better performance and attributes of the crops treated with leguminous residues (mucuna), especially the third level of application, which have high nitrogen content and is able to fix nitrogen into the soil through the help of micro-organisms in their root nodules, over other crops treated with non-leguminous treatments and the control.

Also, phosphorus, when optimally available, helps in cellular processes, being a component of RNA and DNA (Ajilore, 2008). It aids cell division and fast growth and can be found mainly in large quantities in young plants (Schlegel, 1986 cited from Ajilore, 2008) . This explains the higher values of some morphological properties e.g. leaf girth, leaf area etc. of crops treated with cassava residues which have a higher level of available P compared to the control and other treatments. The

Table 3. Mean weight (g) of morphological properties.

Obs	TRT	_Type	_Freq	NL	PH	G	NB	LA
1	P_o C_o	0	3	26.4	20.2	2.7	8.6	30.0
2	P_c C_2	0	3	17.8	18.5	3.0	5.3	33.3
3	P_c C_3	0	3	17.8	17.6	2.4	5.7	18.4
4	P_L C_o	0	3	22.0	22.4	2.5	6.2	21.6
5	P_L C_1	0	3	22.3	18.3	2.8	5.0	28.7
6	P_L C_2	0	3	24.8	19.4	2.5	5.5	19.6
7	P_L C_3	0	3	33.2	23.1	2.8	6.7	26.6
8	P_m C_1	0	3	13.4	13.3	1.9	6.0	22.7
9	P_m C_2	0	3	15.2	15.5	2.0	7.0	12.9
10	P_m C_3	0	3	32.2	19.4	2.5	7.5	20.4

Type of plant residue: P_o - Control (no plant residue); P_m - Maize residue; P_c - Cassava residue; P_L - Legume (mucuna) residue. Concentration of plant residue: C_o - Control (No inclusion); C_1 - 100 g inclusion level; C_2 - 150 g inclusion level; C_3 - 200 g inclusion level. NL - Number of leaves; G - Leaf girth; NB - Number of branching; LA - Leaf area (cm); PH - Plant height (cm).

Table 4. Weight (g) of morphological properties with standard deviation and co-efficient of variation.

Obs	TRT	RTWT	WSM	WLS	DRYRT	BMASS	NL	PH	G	NB	LA
1	P_o C_o	6.80	39.80	38.30	6.10	8.30	24.80	20.20	2.70	8.00	14.80
2	P_c C_2	6.10	56.10	23.50	2.40	6.90	18.70	16.70	2.00	5.20	11.30
3	P_c C_3	47.90	362.80	182.40	17.10	14.30	17.80	18.50	2.90	5.30	33.30
4	P_L C_o	15.70	133.80	47.70	8.60	13.20	17.80	17.60	2.40	4.60	20.20
5	P_L C_1	12.60	90.20	41.80	3.60	8.70	22.30	18.30	2.80	5.00	28.70
6	P_L C_2	8.20	58.30	30.80	2.80	5.40	24.80	19.40	2.50	5.50	19.70
7	P_L C_3	49.30	345.60	128.50	16.20	33.10	33.20	23.10	2.80	5.70	26.60
8	P_m C_1	10.50	85.70	29.90	6.70	6.10	13.40	13.30	1.90	6.00	22.70
9	P_m C_2	11.00	62.20	30.20	6.60	10.40	15.50	15.50	2.00	7.00	12.90
10	P_m C_3	17.00	86.40	151.20	6.80	13.20	19.40	19.40	2.50	5.90	20.40
	MEAN	18.50	132.10	70.40	7.70	11.90	22.00	18.20	2.50	5.80	21.00
	STDEV	16.00	119.90	59.50	5.10	8.10	6.80	2.70	0.40	1.00	7.00
	SE	3.40	24.80	12.50	1.10	1.80	1.50	0.70	0.10	0.50	1.60
	CV	82.90	86.00	83.80	62.90	66.50	27.40	14.60	13.90	33.50	30.60

TRT – Treatment; RTWT - Root weight; WSM - Whole shoot for market; WLS - Whole leaf stalk weight; DRYTRT - Dry root weight; BMASS – Root biomass; NL - Number of Leaves; G - Leaf girth; NB - Number of branching; LA - Leaf area (cm); PH - Plant height.

Table 5. ANOVA test of significant difference in root weight.

Source	Df	Sum of square	Mean square	F-Value	Pr > F
Treatment	17	8737.87526	513.99266	2.34	0.0205
Residual	30	6600.45094	220.01503		
Total	47	15338.32620			

Table 6. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
49.33_a	P_L C_3
47.97_a	P_c C_2
17.00_b	P_m C_3
15.73_b	P_c C_3
12.57_b	P_L C_1
11.03_b	P_m C_2
10.47_b	P_m C_1
8.17_b	P_L C_2
6.75_b	P_o C_0
6.07_b	P_c C_1

Means with same letter in same column are not significantly different at 5%.

Table 7. ANOVA test of significant difference in whole shoot for market.

Source	Df	Sum of square	Mean square	F-value	Pr > F
Treatment	17	448687.4298	26393.3782	1.63	0.1173
Residual	30	485143.5150	16171.4505		
Total	47	933830.9448			

Table 8. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
362.8_a	Pc C_2
345.6_a	P_L C_3
133.6_{ab}	P_c C_3
90.2_b	P_L C_1
86.4_b	P_m C_3
85.7_b	P_m C_1
62.2_b	P_m C_2
58.3_b	P_L C_2
56.1_b	P_c C_1
39.8_b	P_o C_0

Means with same letter in same column are not significantly different at 5%.

Table 9. ANOVA test of significant difference in plant height.

Source	Df	Sum of square	Mean square	F-value	Pr > F
Treatment	17	1888.711696	111.100688	15.60	<.0001
Residual	30	213.597296	7.119910		
Total	47	2102.308992			

significant increase in the % clay and of all the treatments compared to the control indicates that, apart from supplying nutrients to the soil and plant, the organic amendments applied also improve the soil texture and

Table 10. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
33.223_a	P_L C_3
32.223_{ab}	P_m C_3
24.777_{abc}	P_o C_0
24.777_{abc}	P_L C_2
22.330_{abc}	P_L C_1
18.670_{bc}	P_c C_1
17.780_c	P_c C_2
17.777_c	P_c C_3
15.223_c	P_m C_2
13.443_c	P_m C_1

Means with same letter in same column are not significantly different at 5%.

Table 11. ANOVA test of significant difference in root biomass.

Source	Df	Sum of square	Mean square	F-value	Pr > F
Treatment	17	2580.012783	151.765458	2.38	0.0186
Residual	30	1916.334517	63.877817		
Total	47	4496.347300			

Table 12. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
33.090_a	P_L C_3
14.337_b	P_c C_2
13.213_b	P_m C_3
13.173_b	P_c C_3
10.413_b	P_m C_2
8.717_b	P_L C_1
8.260_b	P_o C_0
6.930_b	P_c C_1
6.117_b	P_m C_1
5.357_b	P_L C_2

Means with same letter in same column are not significantly different at 5%.

Table 13. ANOVA test of significant difference in number of leaves.

Source	Df	Sum of square	Mean square	F-value	Pr > F
Treatment	17	10202.30954	600.13586	12.11	< 0.0001
Residual	30	1487.15720	49.57191		
Total	47	11689.46673			

stability (Lee, 1988; Anonymous, 1995; Akanbi 2006). Finally, the similarity in the growth and yield parameters and soil physico- chemical properties, of crops treated with 150 and 200 g of organic amendments might be an

Table 14. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
33.223_{a}	$P_L C_3$
32.223_{ab}	$P_m C_3$
24.777_{abc}	$P_o C_0$
24.777_{abc}	$P_L C_2$
22.330_{abc}	$P_L C_1$
18.670_{bc}	$P_c C_1$
17.780_{c}	$P_c C_2$
17.777_{c}	$P_c C_3$
15.223_{c}	$P_m C_2$
13.443_{c}	$P_m C_1$

Means with same letter in same column are not significantly different at 5%.

Table 15. ANOVA test of significant difference in leaf girth.

Source	Df	Sum of square	Mean square	F-value	Pr > F
Treatment	17	11.59551875	0.68208934	5.95	< 0.0001
Residual	30	3.44011250	0.11467042		
Total	47	15.03563125			

Table 16. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
2.9533_{a}	$P_c C_2$
2.8333_{ab}	$P_L C_3$
2.7567_{ab}	$P_L C_1$
2.7333_{ab}	$P_o C_0$
2.5367_{abcd}	$P_m C_3$
2.4667_{abcd}	$P_L C_2$
2.3767_{abcd}	$P_c C_3$
2.0233_{abcd}	$P_m C_2$
2.0000_{abcd}	$P_c C_1$
1.9333_{abcd}	$P_m C_1$

Means with same letter in same column are not significantly different at 5%.

Table 17. ANOVA test of significant difference in whole leaf stalk weight.

Source	Df	Sum of square	Mean square	F-Value	Pr > F
Treatment	17	125110.0217	7359.4130	1.33	0.2382
Residual	30	165470.7820	5515.6927		
Total	47	290580.8037			

Table 18. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
182.37_a	$P_c C_2$
151.17_{ab}	$P_m C_3$
128.53_{ab}	$P_L C_3$
47.73_{ab}	$P_c C_3$
41.83_{ab}	$P_L C_1$
38.25_b	$P_o C_0$
30.77_b	$P_L C_2$
30.17_b	$P_m C_2$
29.97_b	$P_m C_1$
23.50_b	$P_c C_1$

Means with same letter in same column are not significantly different at 5%.

Table 19. ANOVA test of significant difference in dry root weight.

Source	Df	Sum of square	Mean square	F-value	Pr > F
Treatment	17	836.963450	49.233144	1.84	0.0700
Residual	30	802.292617	26.743087		
Total	47	1639.256067			

Table 20. Result after ANOVA (Post hoc) test conducted using Duncan multiple range test procedure.

Mean	TRT
17.067_a	$P_c C_2$
16.240_{ab}	$P_l C_3$
8.560_{abc}	Pc C_3
6.823_{bc}	$P_m C_3$
6.683_{bc}	$P_m C_1$
6.597_{bc}	$P_m C_2$
6.090_c	$P_o C_0$
3.850_c	$P_L C_1$
2.810_c	$P_L C_2$
2.437_c	$P_c C_1$

Means with same letter in same column are not significantly different at 5%.

indication that the optimum requirement is in between the two levels of treatment (Akanbi 2006; Adenawoola, 2005).

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