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Growth and Yield of **Celosia Argentea** (L) as Influenced by Mineral Fertilizer and Composted Organic Residues in Ilorin Southern Guinea Savanna Zone of Nigeria

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Abstract
Crop residue is an organic material abundant in Nigeria, but which is yet to be utilized for soil improvement purposes particularly in raising *Celosia argentea.* Hence, a screen house experiment was conducted in Kwara State University, Malete, Nigeria to assess the direct and residual effect of different composted organic residues on the growth and yield of *Celosia argentea*, seven treatments were used, including the control, NPK 15-15-15 and five differently composted organic residues namely; Poultry manure+Gliricidia+Mucuna husk (PGM), Poultry manure+Gliricidia (PG), Poultry manure+Gliricidia+Rice straw (PGR), Poultry manure + Mucuna husk (PM) and Poultry manure +Vetiver grass (PV). The treatments except control were applied at 45 kgN/ha. The experiment was a Completely Randomized Design with three replicates. Growth and yield parameters were taken and data were analyzed using ANOVA ($p < 0.05$).The results indicated all composted organic residues significantly enhanced the growth and yield of *Celosia.* However, residual effect of *Celosia* fresh shoot yield values obtained from PGM (3.7g) was significantly ($p < 0.05$) higher than that of NPK values (1.2g).Therefore, PGM could be used as alternative to mineral fertilizer in raising *Celosia argentea*, thereby enhancing better waste management.

Keywords: : Celosia argentea, Growth, Mineral fertilizer, Organic residue, Yield.

Croissance et rendement de Celosia Argentea (L) influencés par les engrais minéraux et les résidus organiques compostés dans la zone de savane d'Ilorin au sud de la Guinée au Nigéria

Abstrait
Les résidus de culture sont une matière organique abondante au Nigéria, mais qui n'est pas encore utilisée à des fins d'amélioration des sols, en particulier pour l'élevage de Celosia argentea. Par conséquent, une expérience de criblage a été menée à l'Université d'État de Kwara, Malete, Nigéria pour évaluer l'effet direct et résiduel de différents résidus organiques compostés sur la croissance et le rendement de Celosia argentea, sept traitements ont été utilisés, dont le témoin NPK 15-15 -15 et cinq résidus organiques compostés différemment, à savoir; Fumier de volaille + Gliricidia + enveloppe de Mucuna (PGM), Fumier de volaille + Gliricidia (PG), Fumier de volaille + Gliricidia + Paille de riz (PGR), Fumier de volaille + enveloppe de Mucuna (PM) et Fumier de volaille + Herbe de vétiver (PV). Les traitements sauf le témoin ont été appliqués à 45 kgN / ha. L'expérience était une conception complètement aléatoire avec trois répliques. Les paramètres de croissance et de rendement ont été pris et les données ont été analysées à l'aide de l'ANOVA ($p < 0,05$). Les résultats ont indiqué que tous les résidus organiques compostés ont considérablement amélioré la croissance et le rendement de la célosie. Cependant, l'effet résiduel des valeurs de rendement de pousses fraîches de Celosia obtenues à partir de PGM (3,7 g) était significativement ($p < 0,05$) plus élevé que celui des valeurs de NPK (1,2 g), améliorant ainsi une meilleure gestion des déchets.

Mots clés: Celosia argentea, Croissance, Engrais minéral, Résidu organique, Rendement

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Introduction

Celosia argentea is a traditional leafy vegetable produced in Nigeria and other tropical countries of Africa by small holders' farmers; solely or intercropped with arable starchy staples to produce enough food to satisfy their dietary and cash requirements (Gbadamosi and Adeoluwa, 2014; Ayorinde et al., 2017: Onwordi et al., 2019). Celosia is an important source of protein, minerals and vitamins, especially in areas where animal protein sources are scarce (Olaniyi, and Ojetayo 2012). Continuous cropping of soils with leafy vegetables is usually associated with loss of organic matter. This is because almost all parts of the crop are harvested and crop residues are removed from the field or burned (Oroka, 2012). Inorganic fertilizer is the quickest and easiest way of increasing leafy vegetable yield per unit area (Agu et al., 2015.). It has been reported to enhanced crop growth and nutrient uptake (Sridhar and Adeoye, 2003). However, it does not improve the soil texture and microbial population. The impact of increased use of mineral fertilizers has been high but the resulting soil physical degradation, increased soil acidity level and soil nutrient imbalance have drawn the attention of researchers back to the use of organic materials as suitable soil amendment for increasing crop production (Olowoake and Adeoye, 2012). One of the most promising methods to improve soil fertility in intensified cropping systems is composting of organic residue. The most popular combination of waste for composting is mixing animal waste (cow dung, poultry litter, pig manure, fecal sludge etc.) with agro based wastes (rice straw, sawdust, wheat straw, water hyacinth, food waste etc.) (Neves et al., 2009; Khatun et al., 2020). Applications of composted organic residues have been reported to produce high yield and quality food crops (Babajide and Olayiwola, 2014). Some workers have also reported positive responses in vegetables grown under organic fertilizer management (Koura et al., 2015; Azarmi et al., 2009).

Composting of poultry manure, *Gliricidia* leaves, vetiver grass, rice straw and mucuna husk can as well provide a compostable mixture in different proportions that will reduce dependence on chemical fertilizers, increase the yield of *Celosia argentea*, and improve soil fertility as well as eliminating the problems of high rates of organic fertilizer use. In spite of the numerous benefits of compost in crop growth as evidenced from literature (Akanbi *et al.,* 2007, Olowoake and Ojo 2014), there is little or no information on the optimum composted organic residue required for growing *Celosia argentea* in Ilorin, North-central Nigeria. Therefore, this study determined the direct and residual effect of mineral fertilizer and composted organic residue on the growth and yield of *Celosia argentea*.

Materials and Methods

The study was conducted for a period of fourteen weeks in a screen-house at Kwara State University (Latitude 80 71'N and Longitude 40 44'E), Malete. Ilorin, Nigeria, which lies in the southern guinea savanna belt of Nigeria. The annual rainfall in the area is about 1200mm and temperature varies between 33^{0}C and 34^{0}C during the year, with a distinct dry season from December to March. The experiment was carried out to study the growth and yield of *Celosia argentea* as influenced by mineral fertilizer and composted organic residues in Ilorin Southern Guinea Savanna Zone of Nigeria. Twenty one pots were filled with 5.5kg of soil. The treatments used were five differently composted organic residues namely; Poultry manure+ Gliricidia +Mucuna husk (PGM), Poultry manure+Gliricidia (PG), Poultry manure+ Gliricidia+Rice straw (PGR), Poultry manure + Mucuna husk (PM) and Poultry manure +Vetiver grass (PV); mineral fertilizer (NPK 15-15-15); and control. The Gliricidia leaves, mucuna husk and rice straw were shredded before they were composted. The compost used for this study was prepared by pit method (Olowoake and Adeoye, 2012). The constituents of the composted organic residues are as shown in Table 1. The treatments were arranged in a completely randomized design (CRD) with three replicates. The soils and compost were left to mineralize for two weeks before planting while the mineral fertilizer was applied two weeks after planting. Celosia seeds were broadcasted and thinned to two (2) seedlings. The treatments except control were applied at 45 kgN/ha (Olaniyi and Ojetayo 2012). Pre-cropping chemical analysis of the experimental soil used in the screen-house was carried out before the experiment. Soil samples were randomly collected from within the depth of 0-15cm. The soil samples were bulked together to form a composite sample. This was air-dried and pass through a 2mm sieve and taken to the laboratory for physical and chemical analysis to determine their nutrient level prior to application of compost. Representative samples were analyzed for pH, using 1:2 (soil: water) suspension, particle size (Bouyoucos, 1962), total nitrogen using the micro-kjeldahl method (Bremmner, 1966), and exchangeable cations (K, Ca, Mg and Na) after extraction with 1N NH OAC (pH 7). K in the filtered extract was determined with a flame photometer, whereas Ca, Na, and Mg were determined with an atomic absorption spectrophotometer. Available phosphorus (Bray-1-P) was determined by colorimeter using the method of Bray and Kurtz (1945) and organic carbon by method described by (Juo, 1981). The experiment was repeated without any fertilizer application at the second planting. Growth and yield parameters data collected were as follows: plant height, stem girth, number of leaves and yield components such as fresh and dry shoot weight. The data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Duncan Multiple Range Test (DMRT).

Results

The results of chemical analysis of different matured composts used for the experiment are presented in Table 1. The nutrient concentration of N, P and K increased with inclusion of poultry manure in rice straw, mucuna husk and Gliricidia leaves. Generally, N ranged between 6.8 to 10.5 g kg^{-1} N. P ranged from 4.4 to 13.1 g kg^{-1} P and K ranged from 1.6 to 6.0 g kg^{-1} K. PGR had the highest nutrient concentration in g kg^{-1} N, while PGM had the highest g kg^{-1} P. However, PM had the highest nutrient concentration in g kg^{-1} K.

Table 1:Nutrient content of composts

Nutrient	Compost				
gkg^{-1}	PM	PGR	* PV	PG	PGM
N	8.1	10.5	6.8	10.4	6.9
P	4.4	6.1	5.3	5.6	13.1
K	6.0	5.7	1. 6	5.8	5.0

* Source -Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria

Legend
PGM- Poultry manure+Gliricidia+Mucuna husk, PG- Poultry manure+Gliricidia
PGR- Poultry manure +Gliricidia+Rice straw, PM- Poultry manure + Mucuna husk

PV- Poultry manure +Vetiver grass

The chemical properties of the soil used for the experiment are presented in Table 2. The soil was slightly acidic and low in total N, exchangeable K, Ca and Mg. Available P was fairly good for vegetable crop production (Table 2). The low soil contents for the major nutrients signify the need for improvement for optimal *Celosia argentea* performance.

Parameters	Soil test value
pH	6.9
Org. C (gkg^{-1})	11.8
Total N (gkg^{-1})	2.04
P Mehlich ($mgkg^{-1}$)	10.2
Exchangeable bases (c mol kg^{-1})	
K	0.17
Mg	0.46
Ca	2.35
Na	1.86
Extractable micronutrients (c mol kg^{-1})	
Cu	1.58
Fe	67.8
Zn	3.2
Mechanical composition (c mol kg^{-1})	
Sand	872
Silt	94
Clay	34
Textural class	Loamy sand

Table 3 shows the effect of treatments on plants height, stem girth and number of leaves of Celosia at first and second planting. Pots treated with compost and NPK significantly had higher growth parameter values than the control. At first planting, highest plant heights were recorded with NPK. Celosia plants treated with NPK had mean height of 12.8cm which was significantly higher than all other treatments. However, other compost; PGM, PM and PV performed better than the control, which had the lowest plant height of 7.9cm. Pots treated with NPK fertilizer and organic compost also show significant ($P<0.05$) increase in the number of leaves of *C. argentea* when compared with the control. The highest stem girth (3.7mm) recorded in *Celosia argentea* was from NPK. This was significantly ($p<0.05$) higher than other treatments including the control. Mean stem girth value ranged from 3.7 mm in NPK to 1.4 mm in the control. At second planting, NPK, and compost significantly ($P<0.05$) increased plant height. PGM had significantly ($P< 0.05$) highest plant height compared with the NPK treatment, PV came second and it was significantly better than other compost (PG. PGR and PM respectively). At the end of the second planting, PGM had the highest number of leaves (13.2), while the least was recorded in the control (8.5). Stem girth differed significantly across the treatments at the end of second planting. Stem girth value of Celosia amended with PGM was however higher than values obtained from NPK and other compost. Mean stem girth value ranged from 1.9 mm in PGM to 0.2 mm in the control.

Table 3: Effects of composted organic residue and inorganic fertilizer on the growth parameters of *Celosia argentea* at first and second cropping

Treatment	Plant height (cm)	Number of leaves	Stem girth (mm)
	First Planting		
Control	7.9d	8.5d	1.4d
PGM	10.6b	14.8b	2.9b
PG	9.4c	11.0c	2.4c
PGR	9.3c	11.2c	2.3c
PM	10.2b	11.6c	2.4c
PV	10.9b	11.7c	2.5c
NPK 15-15-15	12.8a	19.7a	3.7a
	Second Planting		
Control	3.2e	4.0e	0.2e
PGM	8.3a	13.2a	1.9a
PG	4.2d	9.0c	0.8c
PGR	4.5d	9.2c	0.9c
PM	5.1c	9.4c	0.9c

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Legen

PGM- Poultry manure+Gliricidia+Mucuna husk, PG Poultry manure+Gliricidia PGR- Poultry manure +Gliricidia+Rice straw, PM-Poultry manure+Mucuna husk PV- Poultry manure +Vetiver grass

Figure 1 shows the effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea* at the end of first planting. The result of the yield parameters revealed better performances of the inorganic fertilizer (NPK) on the plant compared to the composted organic residue. At the end of the first planting, NPK produced the highest fresh shoot weight (11.8 g) and the least fresh shoot weight (4.2 g) was recorded in the control. NPK had the highest dry shoot weight (5.4 g), followed by PGM (4.0 g) while the least was recorded in the control treatment (1.8 g). However, there were no significant ($P<0.05$) differences between the compost treatments; PG PGR and PM from the dry shoot weight recorded.

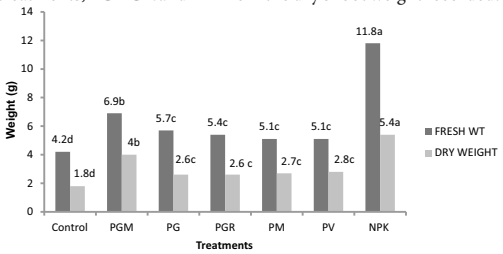


Fig. 1: Effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea* at first planting

Legend

PGM- Poultry manure+Gliricidia+ Mucuna husk, PG- Poultry manure+Gliricidia PGR- Poultry manure +Gliricidia+Rice straw, PM- Poultry manure + Mucuna husk PV- Poultry manure +Vetiver grass

Figure 2 shows the residual effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea*.When compared with the control, NPK fertilizer and composted organic residues significantly increased ($P< 0.05$) the fresh shoot and dry shoot weight of *C. argentea*. Pots applied with compost PGM recorded the highest fresh shoot weight (3.7 g) and dry shoot weights (2.7 g) respectively; it was closely followed by PV.

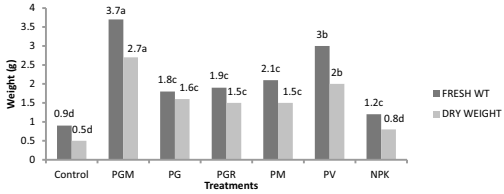


Fig. 2: Residual effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea*

Legend

PGM- Poultry manure+Gliricidia+Mucuna husk, PG- Poultry manure+Gliricidia

PGR- Poultry manure +Gliricidia+Rice straw, PM- Poultry manure + Mucuna husk

PV- Poultry manure +Vetiver grass

Discussion

Based on the established critical level of 4.3 g kg-1 for total N, 10-16mg kg-1 for available P, 0.20 cmol/kg for K, 2.6 cmol/kg for exchangeable Ca recommended by (Adeoye andAgboola, 1985, Adeoye, 1986, Agboola and Corey 1972).The soil at the commencement of the experiment was deficient in N, K, Ca, and adequate in P. The low soil N and K status are expected to benefit from the application of soil amendments. The use of composted organic residues and NPK fertilizer 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 and inorganic amendments. This might be due to the low nutrient status of the soil used. The higher growth and shoot yield of *Celosia argentea* obtained in pot treated with NPK fertilizer over the organic compost in the first planting could be attributed to the immediate availability of nutrients in the chemical fertilizer as previously observed by (Adeoluwa and Adeogun 2010; Bhatt *et al*., 2019). Although the result of the laboratory analysis of Poultry manure+Gliricidia (PG), Poultry manure +Gliricidia+Rice straw (PGR) showed that it has high percentage of N. The low performance of the compost on *Celosia argentea* at the end of first planting could be due to slow rate of decomposition of compost compared with NPK. The crop performance in the second planting is better with treatment that received the compost is an indication of the residual pool of the nutrients. (Eghball *et al*., 2004; Adekayode and Ogunkoya, 2011). The release of nutrients under Poultry manure+Gliricidia+Mucuna husk (PGM) and Poultry manure +Vetiver grass (PV) which enhanced better growth and yield after second planting could be attributed to the higher nitrogen availability and beneficial effects of these materials. This is similar to the results obtained by Gnansounou *et al.* (2017); Are et *al.* (2012) and Olowoake and Adeoye, (2012) and Roongtanakiat, (2000) who obtained better crop yields from PV and PGM. The values of growth and yield of *Celosia argentea* were observed to be low in the pot without any treatment. This might be as a result of low nutrients status of the soil especially N and K. Generally, from the study there was an increase in the performance of the crop on the parameters measured and overall yield. This implies that Celosia responds well to organic fertilizer as the application of Poultry manure+Gliricidia+Mucuna husk (PGM), Poultry manure+Gliricidia (PG), Poultry manure+Gliricidia+Rice straw (PGR), Poultry manure + Mucuna husk (PM) and Poultry manure +Vetiver grass (PV) influences its growth and yield. This implies that the addition of compost in *C. argentea* production is a means of improving the yield in and thus, making its cultivation productive and sustainable.

Conclusion

This study showed that composted organic residues can be used as fertilizer for production of *Celosia argentea*. The result of this experiment revealed that NPK presented good growth and yield after first planting. However, residual effect of compost (Poultry manure + Gliricidia + Mucuna husk and poultry manure +

vetiver grass) presented better yield than NPK. In summary, composted organic residues used for production of *C. argentea* could constitute an alternative to mineral fertilizer. Furthermore, application of compost PGM and PV at the rate of 45 kgN/ha led to higher *Celosia argentea* yield.

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