Comparative Effects of Municipal Solid Waste Compost and NPK Fertilizer on the Growth and Marketable Yield of *Celosia argentea* L.

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Abstract: Field experiments were conducted during the January to March early dry seasons of 2010 and 2011 in Southern Nigeria. Municipal solid wastes were collected from urban food market bins and composts (municipal sold waste compost. MSWC) were made using the windrow method. The composting process was over a 60 day period. The treatments consisted of six nutrient levels, namely: 0, 100% NPK, 100% MSWC, 50% MSWC + 50% NPK, 75% MSWC + 25% NPK, and 25% MSWC + 75% NPK. The six treatments were arranged in a randomized block design with three replicates. Data on vegetative growth, dry matter and marketable yield were obtained. 100% municipal solid waste compost and organo-mineral fertilizers significantly ($p<0.05$) increased plant height, leaf number, leaf area, number of offshoots over zero application and %100 NPK.Shoot dry matter and harvest index also increased significantly with organic and organomineral applications. Results showed higher growth and yield parameters from 75% MSWC + 25% NPK with dry matter and marketable yield of 1.31 and 8.58kg $^{-1}$ respectively. A mixture ratio of 75% MSWC: 25% NPK is recommended for organomineral soil amendment from municipal solid waste compost in other to obtain optimum marketable yield from *Celosia argentea*.

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1. Introduction

Celosia argentea (L.) or Cock's comb is a popular nutritious leafy vegetable cultivated in Nigeria and other West African countries. It belongs to the family Amaranthaceae and is a native plant in subtropical and temperate zones of Africa, South America and South East Asia. The leaves and young shoots are rich in protein, calcium, phosphorus and iron and used for soup and stews. The demand for this crop as vegetable has increased, especially in the urban centers where people are not involved in primary production. This has made the vegetable to become an important commodity in the market and production an important economic activity for the rural women.

Continuous cropping of soils with leafy vegetables is usually associated with loss of organic matter, since almost all parts of the crop are harvested and crop residues are removed from the field or burned. The practical way to improve the quality of soils with low organic matter is through addition of organic materials to the soil either fresh, composted or farm yard manures. Organic matter possesses many desirable properties such as high water holding capabilities, cation exchange capacity, sequester contaminants (both organic and inorganic), enhanced nutrient uptake, and beneficial effects on the physical, chemical and biological characteristics of soil (Weber *et al*., 2007; Asgharipour, 2012)

The most abundant organic material, locally available in Nigerian urban and peri-urban areas is municipal solid organic waste, which could easily be used as sources of organic material and nutrients. Organic waste composting has been proposed as a technique to generate valuable product rich in plant nutrients (Fernandez-Luqueo *et al.*, 2010). Besides been economical, composting is also a sustainable option for on-site organic waste management as it is easy to operate and can also be conducted in contained space by small holder farmers. The combination of organic matter and mineral fertilizers (organo-mineral fertilizers) provides the ideal environmental conditions for the vegetable, since alone or either of them may not be sufficient (and often not available in large quantities) for the level of vegetable production the farmer is aiming at.

Municipal solid waste compost (MSWC) as an organic soil additive when applied in fields can be used in agricultural production, improving soil physicochemical properties, increasing water retention as well as supply with considerable amount of essential nutrients (Raviv, 1998). Improved growth attribute and yields of *Celosia argentea* due to organic materials and organo-minerals as soil amendments have been documented by other researchers (Akanbi *et al.*, 2000,. Makinde *et al.*, 2010). Law-Ogbomo and Ajayi (2009) observed increased vegetative development and herbage yield of *Amaranthus cruentus* with application of organic manures. Chu and Wong (1987) investigated the yield response of carrot, tomato and Chinese cabbage to compost applications and application of mineral fertilizer. They observed optimum carrot yields compost applications, while the highest tomato and Chinese cabbage yields were observed in the synthetic fertilizer treatment. In this experiment, cabbage leaf yield was not increased with compost applications, while tomato plant biomass increased at a much higher rate than did fruit yield in the compost treatments Roe *et al.* (1997) studied green peppers and cucumbers in a sandy soil fertilized with compost or mineral fertilizers. They found that, yields were usually higher when compost was combined with mineral fertilizers. In a related study, Mahmoud *et al.* (2009) demonstrated that the average cumulative cucumber yield was higher with 75% mineral N + 25% organic N treatments compared to other treatments throughout the experiment, especially in the plots treated with plant compost during two successive cropping seasons.

Researches involving the use of composted municipal solid waste on vegetables have not been extensively studied in Nigeria. Hence this research was aimed at comparing the effectiveness of mineral fertilizer, organic fertilizer or the mixtures of both on the growth and marketable yield of *Celosia argentea*.

2. Materials and methods

Experimental site: Field experiments were conducted in the Teaching and Research Farm of Delta State University, Abraka (latitude 5^0 46' and longitude 6^0 5'), Nigeria during the January to March early dry seasons of 2010 and 2011. Soil properties of experimental site include: particle size analysis (Bouycous method) 750 g kg^{-1} sand, 120 g kg^{-1} silt, 130 g kg^{-1} clay; pH in water = 5.3; 0.65 g kg^{-1} total N (Kjedahl method), and 46.5 g kg^{-1} organic matter (wet dichromate oxidation method).

Composting: Three piles were prepared and arranged into windrows using municipal solid waste collected from urban food market bins. Each pile was approximately 10m long, 1.5m wide and 1.0m high. Materials which constitute the compost piles include cooked and raw food wastes, vegetable residues, fruit wastes, animal wastes (sheep, cattle, and goat manure solid and liquid wastes). Materials were chopped into small pieces and thoroughly mixed. The compost was watered, and each pile was totally covered with black plastic sheet for insulation. The compost was watered and turned once a week for the first four weeks and fortnightly for the next five weeks. The moisture content was maintained at 60%. At the maturation or completion of the composting process (60 days), samples from the three piles were bulked and taken for analysis (Table 1) and mature municipal solid waste compost used for the *Celosia argentea* experiment.

Table 1. Chemical properties of municipal solid waste compost used for the experiment

pH	C	Total N	P	K	Ca	Mg
	%	%	%	%	%	%
7.80	42.3	1.35	1.41	0.38	0.45	0.18
Na	C:/N	Zn	Pb	Fe	Cu	
%		ppm	ppm	ppm	ppm	
0.08	31.3	39.6	3.08	20.6	12.5	

Treatments and Experimental Design: The treatments consisted of six nutrient levels, namely: 0, 100% NPK, 100% MSWC, 50% MSWC + 50% NPK, 75% MSWC + 25% NPK, and 25% MSWC + 75% NPK. The six treatments were arranged in a randomized block design with three replicates. The zero plots (0 t ha^{-1}) where no nutrient was applied were set up as a control treatment. The recommended rates of 4 t ha^{-1} and 400 kg ha^{-1} were applied for 100% MSWC and 100% NPK respectively, while the other treatments varied with the corresponding percentages. Nutrients were applied in two equal splits. The municipal solid waste compost was broadcasted and worked into the soil by light hoeing a week before transplanting of *Celosia argentea* (variety TLV 8) seedlings. Plant spacing was 20 x 20cm to achieve a plant population of 250,000 plants ha^{-1}. The experiment was repeated once during each cropping season.

Harvesting started from four weeks after transplantation (4 WAT), by cutting the plants 10cm above the soil surface. Subsequent cutting of branches (offshoots) was done at three weeks interval. A total of three cuttings were done before regeneration was negligible. Cumulative fresh shoot marketable yield was determined at the end of the last harvest.

Before the start of the first harvest, five plants per plot were randomly selected and the following vegetative parameters were determined: plant height, leaf number, leaf area, stem girth and number of offshoots. Dry matter yield was determined through oven drying of another set of plant samples per plot at 65^0C for 48hours. The harvest index (HI) was determined from the ratio of the economic yield (cumulative fresh marketable yield) to the biological yield (cumulative dry matter yield).

All data were analyzed as average of two years using analysis of variance (ANOVA) as described by Gomez and Gomez (1984). Means were separated by the least significant difference (LSD) at 5% level of probability.

3. Results

Vegetative and growth parameters

The simple effects of different rates of municipal solid waste compost (MSWC) and NPK, alone and in mixtures on the vegetative growth parameters of *Celosia argentea* are shown in Tables 2 and 3. Application of MSWC significantly influenced growth parameters considered in this study. Considering the different MSWC added to the soil, crops planted in NPK mixtures with applied MSWC 50% and above indicated taller plants, higher number of leaves and leaf area. Specifically, plants treated with 75% MSWC + 25% NPK showed the most luxuriant growth with taller plants (75.65cm), more leaf number (66.67) and leaf area (7615.22cm^2). The crops also showed thicker (stem diameter) main stems. Relative to the control, stem diameter was increased by about 115% (50% MSWC) and 124.2% (75% MSWC). In addition, the number of offshoots per plant increased with increasing levels of applied MSWC in mixtures with NPK relative to single application of NPK or MSWC. With exception of plant height and leaf number, no significant difference was observed between leaf area, stem girth, number of offshoots between 100%MSWC and 50%MSWC + 50%NPK.

Table 2. Plant height, number of leaves and leaf area of *Celosia argentea* as influenced by varying nutrient sources

Nutrient source	Plant height (cm)	No. of leaves (plant^{-1})	Leaf area (cm^2)
0	39.61f	32.67d	2000.26e
NPK (100%)	49.33e	46.67c	3806.57d
MSW (100%)	65.22e	56.33b	6536.24b
50% MSW + 50% NPK	70.30b	63.33a	6801.63b
75%MSW + 25%NPK	75.65a	66.67a	7615.22a
25% MSW + 75% NPK	60.36d	60.67b	5930.11c
LSD (5%)	2.74	4.63	269.99

Table 3. Stem girth and number of offshoots of *Celosia argentea* as influenced by varying nutrient sources

Nutrient source	Stem girth (plant^{-1})	No. of offshoots (plant^{-1})
0	1.40c	9.33e
NPK (100%)	1.96bc	12.67d
MSW (100%)	2.82a	19.00b
50% MSW + 50% NPK	3.01a	20.67b
75%MSW + 25%NPK	3.14a	23.33a
25% MSW + 75% NPK	2.52ab	15.67c
LSD (5%)	0.72	2.41

Marketable yield

The response of the cumulative fresh (shoot) marketable yield and dry matter yield to nutrient sources is as shown in Table 4, 5 and 6. Cumulative marketable yield, dry matter yield and harvest index of *Celosia* were significantly affected by varying applied nutrient sources. Cumulative fresh shoot yield increased with increasing quantity of MSWC in mixture with NPK. The highest cumulative fresh marketable yield of 8.58kg plant^{-1} was recorded in plants amended with 75% MSWC in mixture with NPK. This was further translated into higher dry matter and harvest index of 1.31kg plant^{-1} and 6.55 respectively. The order of performance in cumulative fresh shoot marketable yield by the varying nutrient sources is 75% MSWC + 25% NPK > 50% MSWC + 50% NPK > 100% MSWC > 25% MSWC +75% NPK.> 100% NPK > control.

Table 4. Cumulative fresh marketable yield of *Celosia argentea* as influenced by varying nutrient sources

	No. of harvests			
Nutrient source	1	2	3	Cumulative fresh marketable yield (kg)
0	1.10	0.79	0.31	2.20c
NPK (100%)	1.85	1.21	0.75	3.81b
MSW (100%)	3.08	2.75	1.20	7.03ab
50% MSW + 50% NPK	3.42	2.67	1.23	7.32a
75%MSW + 25%NPK	3.89	2.57	2.12	8.58a
25%MSW + 75% NPK	2.77	2.21	1.83	6.81ab
LSD (5%)				3.30

Table 5. Cumulative dry matter yield of *Celosia argentea* as influenced by varying nutrient sources

	No. of harvests			
Nutrient source	1	2	3	Cumulative dry matter yield (kg)
0	0.32	0.24	0.09	0.65b
NPK (100%)	0.42	0.37	0.12	0.91ab
MSW (100%)	0.58	0.33	0.28	1.19a
50% MSW + 50% NPK	0.60	0.38	0.19	1.17a
75%MSW + 25%NPK	0.65	0.39	0.27	1.31a
25%MSW + 75% NPK	0.61	0.42	0.18	1.21a
LSD (5%)				0.43

Table 6.Harvest index of *Celosia argentea* as influenced by varying nutrient sources

Nutrient source	Harvest index
0	3.88c
NPK (100%)	4.19bc
MSW (100%)	5.91abc
50% MSW + 50% NPK	6.20ab
75%MSW + 25%NPK	6.55a
25% MSW + 75% NPK	5.63abc
LSD (5%)	2.21

4. Discussion

The considerable nutrient potential of the municipal solid waste compost was evident from the amount of N. P and K obtained from the routine chemical analysis (Table 1). Increase in plant growth as a result of application of municipal solid waste compost (MSWC) is expected in that the compost contained and released considerable amount of N and Mg for plant use. These are essential for formation of chlorophyll for photosynthesis in plants. These results are consistent with the results of Akinfasoye *et al.* (2008). The carbon: nitrogen ratio of 31.3 was within the range considered suitable for use as soil conditioner for vegetable farming.

The low dry matter at low MSW compost rate may be due to reduced soil quality with these amendments resulting in low available nutrients for plant photosynthetic activity subsequently resulting in reduction in stored plant biomass. The higher dry matter in 100 percent municipal solid waste compost and organ minerals with above 50% MSWC may be attributed increased foliage and leaf area resulting in better plant development.

The significantly lower values obtained for all vegetative growth attributes between 0 kg (control) and the organic and organo-mineral sources indicates that at severe nutrient stress these parameters will be reduced. The higher vegetative growth, dry matter yield and marketable yield of the organo-mineral fertilizer with highest organic manure component show that increased MSW compost application in mixture with mineral fertilizer enables the plants to produce these parameters at their potential capacity. These may be attributed to increased soil nutrients and microbial biomass associated with use of organic manure and chemical fertilization. Related studies by other researchers (Roe *et al*., 1997; Akanbi *et al.,* 2000; Mahmoud *et al*., 2009) confirm the significant contributions of organic and organo-mineral fertilizers in improving vegetative growth and marketable yield of vegetables.

5. Conclusion

The application of municipal solid waste compost (MSWC) whole or in mixture with NPK fertilizer significantly resulted in better performance of vegetative growth parameters such as plant height, girth, number of leaves and leaf area of *Celosia argentea*. Biomass yield and marketable yield (fresh shoot yield) were also increased by the compost. A mixture ratio of 75% MSWC: 25% NPK is threfore recommended for organomineral soil amendment from municipal solid waste compost in other to obtain optimum marketable yield from *Celosia argentea*. The production of MSWC therefore is an important recycling opportunity for many of the communities.

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