Evaluation of poultry manure application rate and plant population on growth, dry matter partitioning and nutrient uptake of Cock's comb (*Celosia argentea. L*)

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ABSTRACT

Cock's comb (*Celosia argentea* L.) is an important leaf vegetable in the tropics grown for its succulent leaves that are rich sources of protein, vitamins and minerals essential for combating malnutrition, especially in the rural communities. Two field experiments were conducted to evaluate the growth, dry matter partitioning and nutrient uptake of Cock's comb in response to different application rates of poultry manure (PM) and plant population between August 2013 and July 2014. The experiment was a split plot arrangement fitted into a randomized complete block design, with four replicates. PM was applied at 0, 5 and 10 t/ha while Cock's comb was established at plant populations of 200,000 and 400,000 plants/ha in the late season of 2013 and early season of 2014 concurrently. Data were taken on plant growth, dry matter partioning, yield and nutrient contents. Application of 5 t/ha PM significantly ($P \leq 0.05$) increased plant height, number of leaves, leaf area, total fresh yield of stem and leaves, leaf dry weight, stem dry weight, root dry weight and total dry weight relative to plants in control plots in the early and late seasons. Plant population had no significant effect on growth and dry matter partitioning of Cock's comb. Interaction of PM and plant population on nitrogen uptake was significantly high when 10 t/ha PM was applied at 400,000 plants/ha. Phosphorus and Potassium uptake increased in plots fertilized with 5 t/ha PM at at 400,000 plants/ha. For optimum growth, dry matter yield and nutrient uptake, Cock's comb could be planted at a population up to 400,000 plants/ha with 5 t/ha PM.

Keywords: Cock's comb, *Celosia argentea*, performance, plant nutrients, manure.

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INTRODUCTION

Cock's comb, *Celosia argentea* (L) is a popular leaf vegetable in the tropics. The leaves are very succulent and serve as an excellent source of protein, calcium, iron, vitamins A and C. It is majorly cultivated on small and scattered plots in home gardens, farmland and urban and peri-urban areas, making it difficult to estimate the cultivated area, but it amounts to thousands of hectares (Denton, 2004). In the tropics, Cock's comb is produced by small holder farmers, solely or intercropped with arable starchy staples to produce enough food to satisfy their dietary and cash requirements (Gbadamosi and Adeoluwa, 2014). The leaves and succulent stem are consumed as vegetable because they constitute a cheap and rich nutrient sources for the low income earners, and the seeds could also be processed into food items, supplement and additives (Schippers, 2000). It is also used for medicinal purposes and the treatment of ailments such as abscesses, cough, diabetes, diarrhoea, dysentery, eczema, eye problems, gonorrhea, infected sores, liver ailments, menstruation problems, muscle troubles, skin eruptions, snakebites and wounds (Schippers, 2000). Cock's comb thus has high potentials for reducing malnutrition which is rampant in the tropics (Adeyeye *et al.*, 2013)

Cock's comb grows rapidly from seed and it is easy to plant in most climates and thrives in well-drained soils with pH 6.0 - 6.4 (Grubben, 2004). It could either be cultivated during the wet or dry season but irrigation is usually required for the dry season cultivation (Schippers 2000). However, there has been 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 (Babajide and Olla, 2014) Achieving food security in its totality has therefore been a major challenge. Farmers are often faced with the challenge of producing Cock's comb on poor soil conditions resulting from continuous cultivation.

Cock's comb could however, be cultivated using either organic or inorganic fertilizers but the use of synthetic, inorganic fertilizers has been on a decline, resulting from high cost and scarcity in Nigeria. Comparing the growth, dry matter accumulation and shoot yield of Cock's comb with poultry manure and urea inorganic fertilizer, Adeyeye *et al.* (2013) has recommended either 140 kg N/ha Urea or 6 t/ha poultry manure. However, an optimal rate for fresh shoot weight of 90 kg/ha NPK 15-15-15 was recommended by Ojo (1998). According to Adedokun and Aiyelaagbe (2008), synthetic, inorganic fertilizers provide readily- available nutrients for plants; and their uses in Nigerian agriculture is hampered by problems of high cost, scarcity and lack of established soil testing programmes. Some of the chemical fertilizers, like Urea and Sulphate of ammonia aggravate soil acidity, as a result of H^+ released into the soil. Also, Nigerian farmers have limited access to synthetic fertilizers because of its low production, availability, procurement and poor distribution (NISER, 2003). The undesirable pollution of the soil and water by inorganic fertilizers is also responsible for increasing rate of the use of organic manures that are cheaper, readily available, and less harmful (Eghareva and Ogbe, 2002). Organic manures however, increase soil nutrient status and enhance the soil biological, chemical and physical properies (FAO 2005; Ibeawuchi *et al.*, 2006; Odeyemi *et al.,* 2015) and support crop performance and yield (Adebayo and Akoun, 2002). Poultry manure is an organic waste material consisting of faeces and urine from poultry. It is an excellent fertilizer material because of its high nutrient content, especially nitrogen, phosphorus and potassium (Hochmuth *et al.,* 2009). It decomposes in the soil and releases nutrients for crop uptake. It also serves as a soil amendment to increase the organic matter content of the soil which increases the soil moisture holding capacity; improves overall soil structure; lowers soil bulk density and thus increasing the efficiency of the crop production and irrigation. Poultry manure application has been reported to increase N, P, K uptake in fluted pumpkin leaves (Awodun, 2007).

Plant population affects competition for growth resources. Plant spacing, planting density and spatial arrangement make up the population. Same population can be achieved with different spacings at different spatial arrangements. Using the same spacing with varying planting densities results in varying populations. Increased plant population decreases plant yield and yield components. Decreased plant growth and yield due to competition may result from high plant populations. The increased population may however compensate for decreases in growth and yield. High planting density can be sustained with adequate nutrient supplies. Optimum population of Cock's comb needs to be investigated with nutrient supplies. This study was conducted to determine the poultry manure application rate and plant population that supports optimum growth, nutrient uptake and dry matter yield of Cock's comb, *Celosia argentea*.

MATERIALS AND METHODS

Location of the Experiment

Two field trials were conducted at the Federal University of Agriculture, Abeokuta, Nigeria (7°, 15' N, 3° 20' E; 100 m above sea level) between August and October, 2013 and between May and July, 2014. The area lies within the forest savanna transition zone (Aiboni, 2001). The wet season usually extends from March to October while the dry season starts in November and ends in February. Total rainfall recorded was 266.6 mm during the 2013 planting period but was 321.0 mm during the 2014 planting period. Monthly maximum temperature range was between 28.6°C and 31.7°C in 2013 but was between 29.9°C and 32.1°C in 2014. The monthly minimum temperature range was between 21.1°C and 23.1°C in 2013 but was between 23.3°C and 23.4°C in 2014. Relative humidity was between 67.2 and 71.4 % in 2013 but was between 64.4 and 68.8 % in 2014 (Table 1).

Cropping History

A pre-cropping visual estimation of the vegetation of the site indicated that broad leaf weeds were more common than grasses. Prominent weeds were: *Aspilia africana* (Pers) C. and *Eleusine indica* Gartn. Other weeds present were: *Alternanthera pungens* H.B.K.; *Mariscus flabelliformis* Kunth and *Aneilema beninense* L. The site had been cropped with cereals and fruit vegetables for two years, using crop residues to re-cycle nutrients and left un-cropped for two years prior the establishment of this trial.

Pre Cropping Soil and Poultry Manure Analysis

The soil of the experimental plot was a sandy - loam with a pH of 6.9. Nitrogen was very low at 0.08 %, available P and the exchangeable K were also marginal (Table 2). The poultry manure (PM) contained 2.5, 3.9 and 2.2 % N, P and K, respectively with an organic matter of 25.5 % (Table 2). The 5 t/ha PM was applied to supply 127, 196 and 110 kg/ha of N, P and K, respectively while the 10 t/ha PM was applied to supply 225, 392 and 221 kg/ha of N, P and K, respectively.

Experimental design and treatments

The experiment was a split plot arrangement fitted into a randomized complete block design, replicated four times. Poultry manure was applied at 0, 5 or 10 t/ha at 2 weeks before sowing on sub-plots of 3 m by 1.5 m with border spacing of 1m with intra row spacings of 10 or 5 cm to give the populations of 200,000 and 400,000 plants/ha, respectively.

Crop Husbandry

Seeds of Cock's comb (var. TLV 8) were planted in August, 2013 for the late season and in May, 2014 for the early season. Weeding was carried out at 3 weeks after sowing (WAS), manually with a hoe. Harvesting was at 4 and 6 WAS by total plant removal method. The experiment was repeated between May and July, 2014 with the same procedures as with earlier cultivation but without a re-application of poultry manure. The plots were maintained as in the previous year, with new crops established.

Soil and Plant analysis
Prior to planting, the initial nutrient content of the soil was determined by taking ten core samples from the top 20 cm of the soil. At the end of both late and early planting seasons, three core samples were taken per plot, bulked to have one composite sample per plot that was analysed. Leaves from five tagged sample plants from the inner rows were detached at 4 weeks after sowing in both seasons to determine the foliar nutrient content. The leaf samples were placed in paper bags and air dried at room temperature (28ºC) for 48 hours.

Data collection
Data collected include: plant shoot height, number of leaves/plant, average leaf area (cm^2), fresh plant weight (g), dry plant weight (g/plant). Leaf area was estimated from its relationship with the midrib length. One hundred leaves of varying sizes from the upper, middle and lower portions of plants from the border rows were detached at 4 weeks after sowing. The mid rib lengths and width of each leaf was measured. The area of each leaf was determined by graph paper tracing. The measurements of the lengths and the widths were each regressed with the graph paper tracing values to generate a regression relationship.
The resulting regression relationship for the leaf mid rib length was:

$$Y = 7.49X - 35.66 \quad (R^2 = 0.93)$$

For the leaf breadth, the resulting regression relationship was:

$$Y = 8.51X - 11.67 \quad (R^2 = 0.83)$$

The relationship with the midrib length was adopted, as a result of the better relationship.
Mid rib lengths of five leaves/plant from the upper, middle and lower portions of the foliage of ten plants per plot sampled from the inner rows were measured at 4 weeks after sowing. The average per plot was used to estimate the leaf area, using the generated regression equation:

$$Y = 7.49X - 35.66 \quad (R^2 = 0.93)$$

Where: Y = Estimated Leaf Area
X = Average mid rib length of leaves from 10 plants/plot.
The sampled plants were separated into leaves, stem and root to determine the dry matter contents. Plant dry weight was from the fresh samples dried in the oven at 105ºC for 48 hours.
Plant nutrient uptake (kg/ha) was calculated as the product of plant sample concentration and the biomass generated per treatment (Drakopoulos *et al.,* 2015)
Nutrient Uptake = Nutrient Concentration x Plant Biomass/treatment.
Apparent Nitrogen recovery (ANR) was calculated as:

$$ANR = \frac{(Ntrt - Nctl)}{Napp} \times 100$$

Where: Ntrt = Nitrogen Uptake in treated plant, averaged over the replicates.
Nctl = Nitrogen Uptake in untreated plant
Napp = Nitrogen applied
Same procedure for Apparent Nitrogen Recovery (ANR) was applied for Apparent Phosphorous Recovery (APR).

Data Analysis
Data obtained were subjected to analysis of variance (ANOVA) using procedures of GenStat statistical software package (2011). Treatment means were separated using Least Significant Difference (LSD) $p \le 0.05$.

RESULTS

***Plant height, number of leaves/plant and leaf area of Cock's comb as affected by poultry manure rate and plant population*:** Application of poultry manure significantly increased plant height, number of leaves/plant and the leaf area of *Celosia argentea* both at the late and early seasons (Table 3). At 4 and 6 WAS in both late and early seasons, plants from plots fertilized with 5 t/ha grew taller than plants on 0 t/ha plots that were not fertilized but were comparable with plots fertilized with 10 t/ha. The number of leaves/plant recorded a similar trend as the plant height, with 5 t/ha application resulting in comparable number of leaves/plant as 10 t/ha but were significantly ($P<0.05$) higher than from the untreated control plots. In the late season, the unfertilized plots could not develop fully-expanded leaves, even with 6 weeks of growth. Plant leaf area with 5 t/ha application were comparable with 10 t/ha application but were higher than from the untreated control plots (Table 3). Plant population had no significant effect on plant height, number of leaves/plant and leaf area in both seasons (Table 3).

***Yield of Celosia argentea as affected by poultry manure rate and plant population*:** In both seasons, application of 5 t/ha of PM significantly influenced the fresh leaf, stem and root weights of *Celosia argentea* (Table 4). The fresh leaf weight was higher in both seasons at either 4 or 6 WAS, relative to the control plants. In the late season, 5 t/ha had higher root weights than 10 t/ha at 4 WAS but were similar at 6 WAS. The unfertilized plots had lower root weights at either 4 or 6 WAS. In the early season, application of 10 t/ha PM resulted in comparable leaf weights, except at 6 WAS. The fresh stem weight recorded a similar trend as the fresh leaf weight. Application of 10 t/ha also resulted in comparable stem weights except at 4 WAS in the early season. By 6 WAS, fresh root weight with the unfertilized plots were similar with root weights from both manure levels. (Table 4). Plant population did not significantly affect Celosia plant fresh leaf weight, fresh stem weight, fresh root weight and total fresh weight (Table 4).

***Biomass accumulation of Celosia argentea as affected by poultry manure rate and plant population*:** Total plant fresh weight was higher with 5 t/ha than with 10 t/ha PM at both 4 and 6 WAS in the two seasons. The unfertilized plots accumulated a lower fresh weight than the two manure levels in the both seasons (Table 5). At 6 WAS, with 5 t/ha, total plants fresh weight was reduced from 1206 to 371 kg/ha in the late season while at 10 t/ha, it was reduced from 807 to 244 kg/ha. Total plants dry weights were generally about 8% of the fresh weight at 4 WAS in the early season and were all similar. At 6 WAS, dry plant weight from 5 t/ha PM was about 8.8 % of the fresh weight and was higher than the 8.0 % dry plant weight of plants fertilized with 10 t/ha. The unfertilized plots had lower dry plant weights of about 8.2 % of their fresh weight. In the late season at 4 WAS, application of 5 t/ha PM had a plant dry weight that was 6.9 % of the fresh weight while 10 t/ha had a weight which was 7.5 % of the fresh weight. By 6 WAS, total plant weight from 5 and 10 t/ha PM were both 12.6 % of their fresh weights (Table 5). Plant population had a similar range of dry weight proportions over the seasons. There was no interaction effect of the poultry manure and plant population on plant biomass accumulation (Table 5).

Biomass partitioning of Celosia argentea as affected by poultry manure rate and plant population: Leaf dry weight of celosia was not influenced by the rate of poultry manure applied in the early seson at 4 WAS. However, at 6 WAS, plots fertilized with 5 t/ha produced higher leaf dry weight, compared with 0 and 10 t/ha that had lower but similar dry leaf weights (Table 6). The trend was similar in the late season, with 5 t/ha having higher leaf weight at 4 WAS. At 6 WAS, 10 t/ha had comparable leaf weight. The unfertilized plots had lower leaf dry weights. Both the dry stem weight and the dry root weights had a similar trend as the dry leaf weight. They were similar at 4 WAS in the early season but 5 t/ha had higher weight at 6 WAS in the early season and throughout the late season. They were however, comparable with weights from 10 t/ha. The unfertilized plots generally had lower weights than from 5 t/ha PM. The leaf, stem and root dry weights were generally higher at 6 WAS, relative to 4 WAS in both seasons but were all comparable with both populations at each period. About 80 % of the plant parts were generally consumable, with plant roots less than 20 % (Fig.1). The interaction of poultry manure and plant population on biomass partitioning was not significant (Table 6).

Table 1: Meterological data during the experiment in 2013 and 2014 at Abeokuta

	Rainfall (mm)	Relative Humidity (%)	Temperature (ºC)	
2013			Maximum	Minimum
August	35.2	71.7	28.6	21.1
September	136.0	69.7	28.9	22.4
October	94.4	67.2	31.7	23.1
Total	265.6			
2014				
May	113.8	67.7	32.1	23.4
June	116.5	64.4	31.5	23.4
July	90.7	68.8	29.9	23.3
Total	321.0			

Source: Department of Agrometerology and Water Resources Management, University of Agriculture, Abeokuta, Nigeria (2013-2014)

Table 2: Initial soil chemical and physical properties and poultry manure analysis.

Parameter	Soil	Poultry Manure
pH (H_2O)	6.9	7.48
Organic matter	1.15 %	25.5 %
Organic Carbon	0.67 %	14.83 %
Total N	0.08 %	2.55 %
Available P	5.88 mg kg^{-1}	3.92 %
Exchangeable K	0.28 cmol kg^{-1}	2.21 %
Exchangeable Ca	8.68 cmol kg^{-1}	8.45 %
Exchangeable Mg	2.01 cmol kg^{-1}	0.36 %
Exchangeable Na	0.77 cmol kg^{-1}	1.23 %
ECEC	11.53	-[a]
Base Saturation	996.00 $g.kg^{-1}$	-[a]
Sand	932.00 $g.kg^{-1}$	-[a]
Silt	60.00 $g.kg^{-1}$	-[a]
Clay	8.00 $g.kg^{-1}$	-[a]
Textural class	Sandy loam	-[a]

-[a] = not determined.

Table 3: Plant height, number of leaves/plant and leaf area of *Celosia argentea* with poultry manure rate and plant population

	Plant height (cm) *				Number of leaves/plant*				Leaf area (cm^2) *			
	Late season		Early season		Late season		Early season		Late season		Early season	
Treatment	4*	6	4	6	4	6	4	6	4	6	4	6
Poultry manure (PM)												
0 t/ha	0.0	0.0	10.3	31.0	0.0	0.0	9.1	18.9	0.0	0.0	25.7	102.0
5 t/ha	11.6	19.5	17.0	56.7	12.9	16.8	14.1	34.1	15.2	14.0	50.4	196.0
10 t/ha	11.5	18.5	13.5	48.6	12.3	17.4	13.1	36.3	12.5	13.4	37.4	166.0
LSD (5%)	2.4	3.6	6.1	14.5	1.0	1.2	4.1	10.0	3.1	2.5	22.3	53.6
Plant Population (PP)												
200,000 plants/ha	7.7	12.8	12.3	39.8	8.5	11.8	11.1	28.6	9.7	9.6	33.0	133.0
400,000 plants/ha	7.7	12.5	14.9	51.2	8.3	11.1	13.0	30.9	8.8	8.7	42.7	175.0
LSD (5%)	ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns
PM x PP	ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns

*WAS: Weeks after sowing

Table 4: Fresh weight of *Celosia argentea* as influenced by poultry manure rates and plant population

Treatment	Fresh leaf weight (g/plant)				Fresh stem weight (g/plant)				Fresh root weight (g/plant)			
	Late season		Early season		Late season		Early season		Late season		Early season	
	4*	6	4	6	4	6	4	6	4	6	4	6
Poultry manure (PM)												
0 t/ha	0.0	0.0	34.0	87.0	0.0	0.0	21.0	68.0	0.0	0.0	7.9	30.0
5 t/ha	44.6	58.6	112.0	209.0	28.2	79.6	86.0	219.0	3.5	29.1	29.4	114.0
10 t/ha	32.2	43.1	66.0	137.0	16.0	47.2	56.0	168.0	2.0	19.2	23.8	58.0
LSD 5%	17.6	24.4	56.3	56.9	18.4	46.5	58.5	107.6	0.8	15.5	20.4	58.8
Plant Population (PP)												
200,000 plants/ha	24.2	40.7	65.0	160.0	13.8	54.9	47.0	166.0	102.7	259.9	18.8	86.0
400,000 plants/ha	27.0	27.2	76.0	128.0	15.7	29.7	61.0	138.0	115.6	151.1	21.9	48.0
LSD 5%	ns	ns	Ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns
PM x PP	ns	ns	Ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns

*WAS Week after sowing

Table 5: Biomass accumulation of *Celosia argentea* with poultry manure rate and plant population

	Plant fresh weight (kg/ha)				Plant dry weight (kg/ha)			
	Late season		Early season		Late season		Early season	
Treatment	4*	6	4	6	4	6	4	6
Poultry manure (PM)								
0 t/ha	0.0	0.0	62.9	185.0	0.0	0.0	5.2	15.1
5 t/ha	76.3	167.3	227.4	542.0	6.2	21.0	18.4	47.8
10 t/ha	50.2	198.5	145.8	363.0	4.4	14.0	11.7	29.0
LSD (5%)	15.7	28.7	55.4	36.3	0.3	4.8	9.6	4.7
Plant Population (PP)								
200,000 plants/ha	140.7	355.5	130.8	312.0	4.0	8.4	10.6	33.3
400,000 plants/ha	158.3	208.0	158.9	314.0	3.1	8.4	12.9	28.0
LSD (5%)	Ns	Ns	ns	Ns	ns	ns	ns	Ns
PM x PP	Ns	Ns	ns	Ns	ns	ns	ns	Ns

* WAS: Weeks after sowing

Table 6: Biomass partitioning of *Celosia argentea* with poultry manure rate and plant population

	Dry Leaf Weight (g/plant)				Dry Stem Weight (g/plant)				Dry Root Weight (g/plant)			
	Late season		Early season		Late season		Early season		Late season		Early season	
Treatment	4*	6	4	6	4	6	4	6	4	6	4	6
Poultry manure (PM)												
0 t/ha	0.0	0.0	3.1	7.9	0.0	0.0	1.3	4.2	0.0	0.0	0.8	3.0
5 t/ha	3.5	9.9	10.8	20.5	1.3	5.6	5.0	16.5	1.4	5.5	2.6	10.8
10 t/ha	2.0	7.8	7.8	12.9	1.4	3.3	2.8	9.6	1.0	2.9	1.1	6.5
LSD (5%)	0.8	4.4	Ns	6.4	0.7	3.4	3.8	7.2	0.4	3.5	ns	4.8
Plant Population (PP)												
200,000 plants/ha	2.1	7.3	5.8	14.7	1.0	3.6	3.0	10.7	0.9	3.8	1.8	7.9
400,000 plants/ha	1.6	4.4	8.6	12.8	0.8	2.2	3.0	9.6	0.7	1.8	1.3	5.6
LSD (5%)	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
PM x PP	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

* WAS: Weeks after sowing

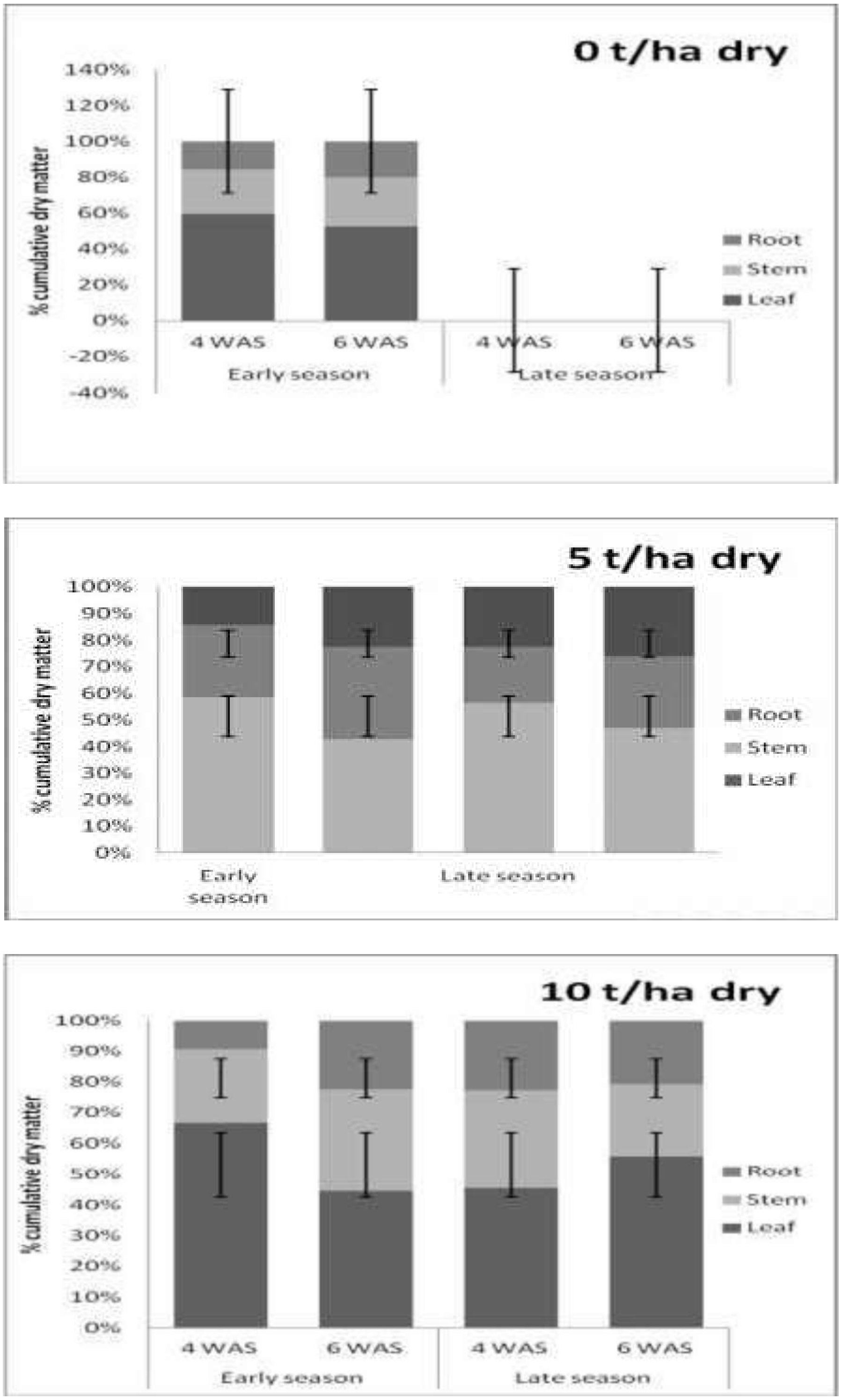


Fig. 1 Cumulative dry matter proportions of *Celosia argentea* with poultry manure rate

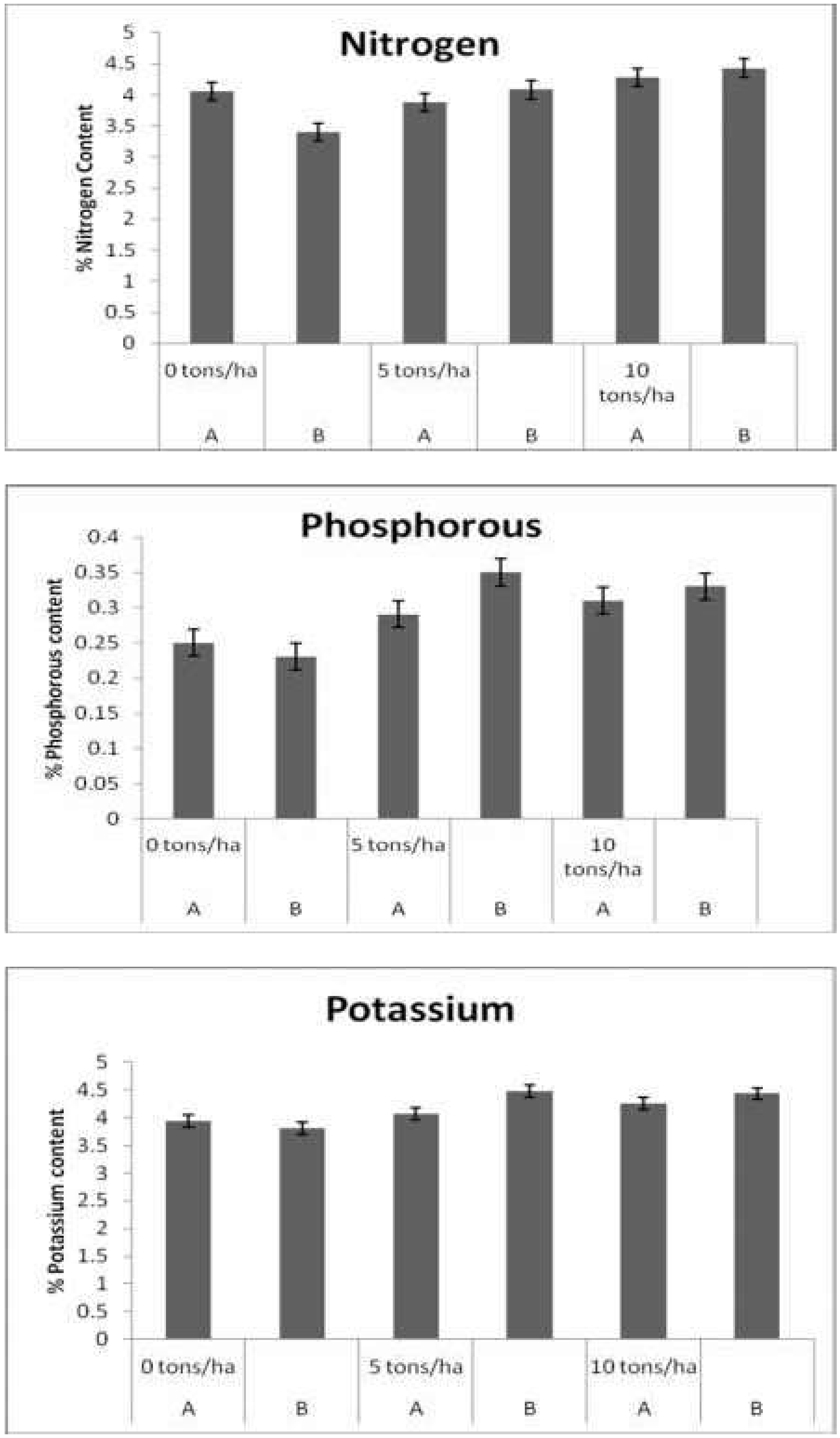
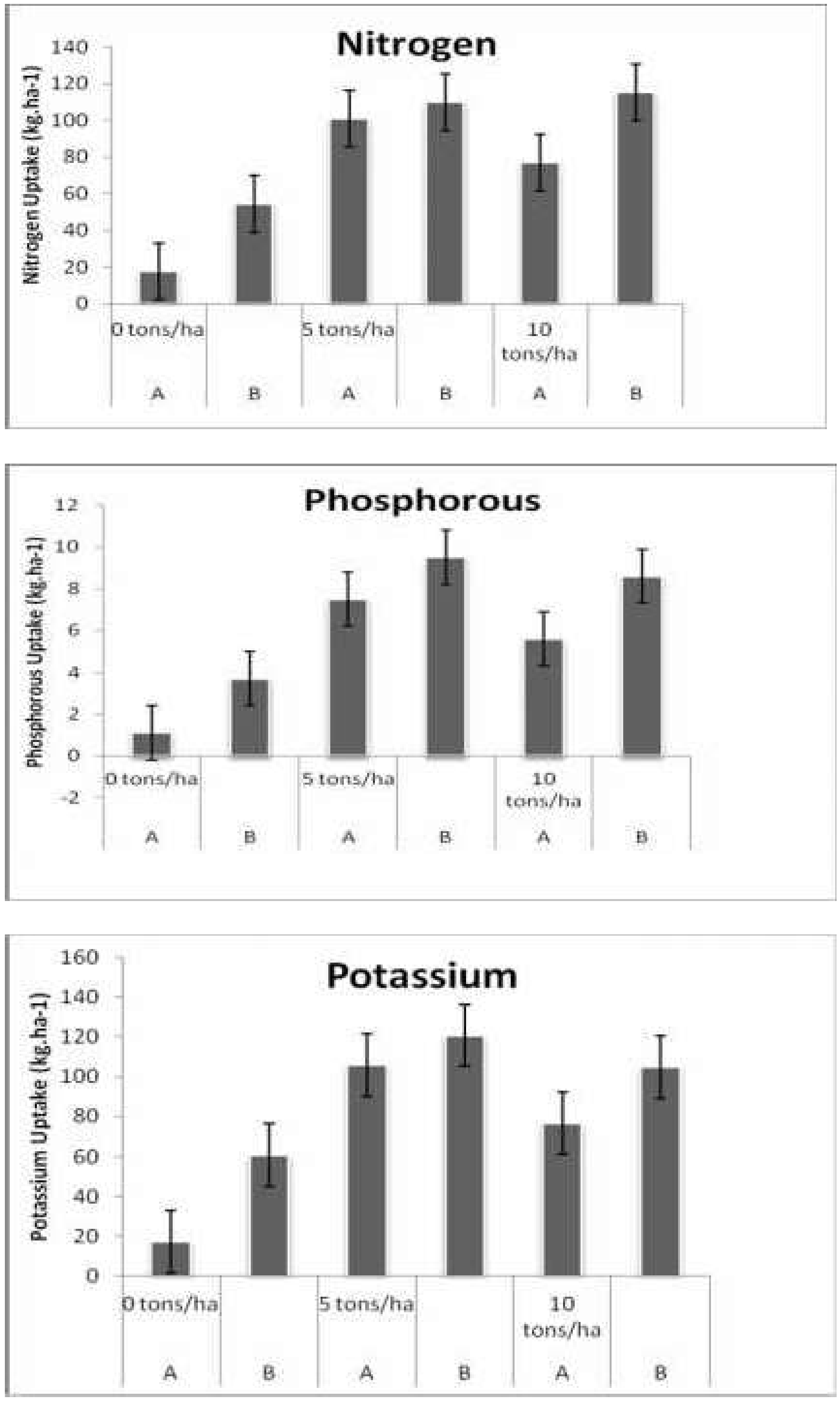
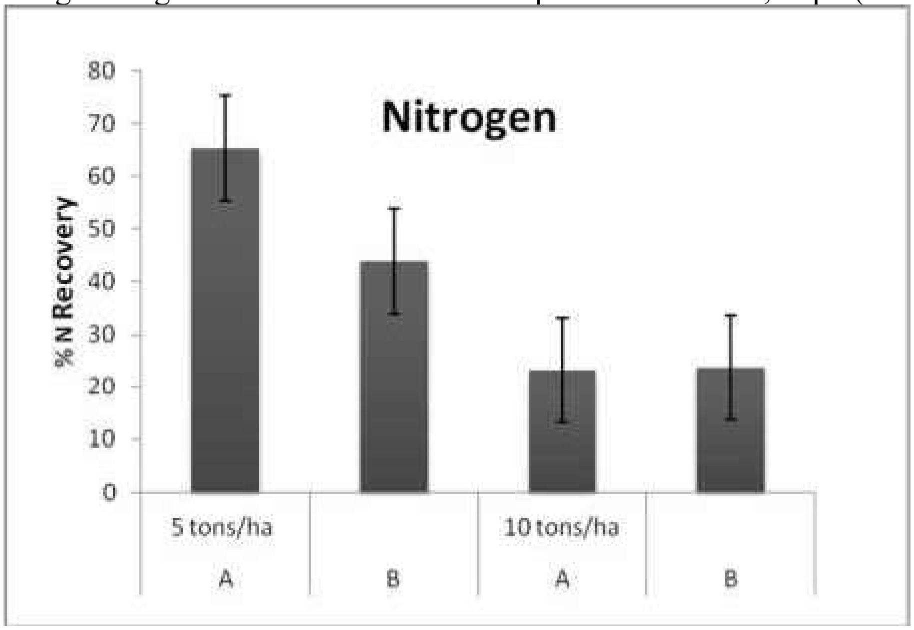


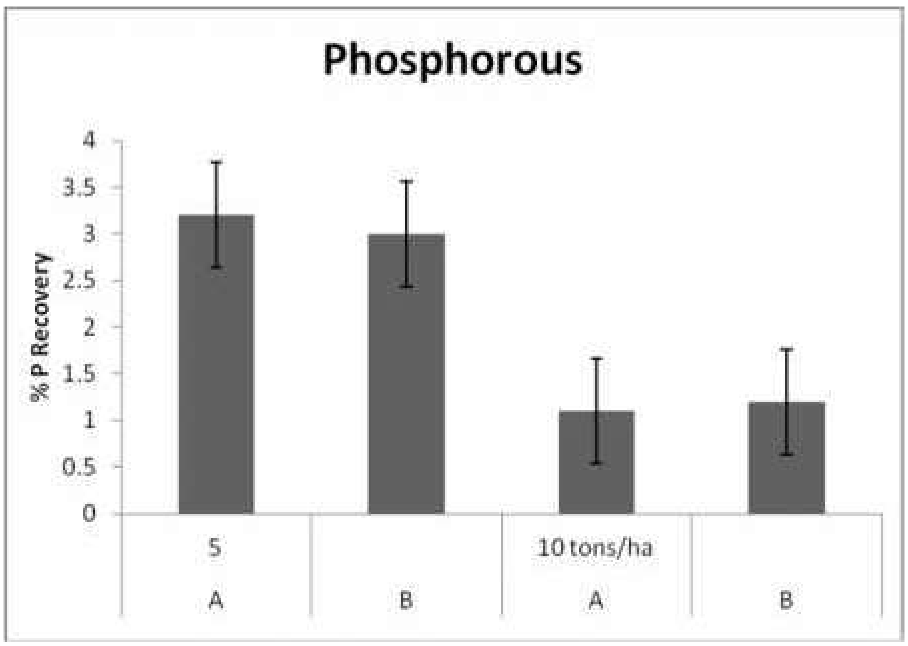
Fig. 2: Nitrogen, Phosphorous and Potassium contents (%) of *Celosia argentea* with interaction of poultry manure rate and plant population.
A – 200,000 plants/ha; B – 400,000 plants/ha



A – 200,000 plants/ha; B – 400,000 plants/ha

Fig. 3: Nitrogen, Phosphorous and Potassium uptake (Kg/ha) of *Celosia argentea* with interaction of poultry manure rate and plant population.
A – 200,000 plants/ha; B – 400,000 plants/ha





A – 200,000 plants/ha; B – 400,000 plants/ha

Fig.4: Average Nutrient recovery (%) of *Celosia argentea* with interaction of poultry manure rate and plant population

***Nutrient concentration of Celosia argentea as affected by poultry manure rate and plant population*:** The nitrogen, phosphorous and the potassium contents of the Celosia plants were affected by the interaction of poultry manure and plant population (Fig.2). The lower population of 200,000 plants/ha contained a higher nitrogen concentration of 4.05 % when 400,000 plants/ha population had 3.4 %. With 5 t/ha PM application, plant nitrogen concentration was higher with 400,000 plants/ha, when they were similar with 10 t/ha application. A similar trend as nitrogen was observed for P and K concentrations. The lower population of 200,000 plants/ha had higher P and K concentration. With 5 and 10 t/ha PM, the population of 400,000 plants/ha had higher values than 200,000 plants/ha (Fig.2).

Nutrient uptake of Celosia argentea as affected by poultry manure rate and plant population: Nutrient uptake by *Celosia argentea* was significantly influenced by combined application of poultry manure and plant population (Fig.3). Planting at 200,000 plants/ha had a lower uptake relative to uptake with 400,000 plants/ha. With 200,000 plants/ha, plant nitrogen uptake was lower with 0 t/ha than with 5 t/ha. With 400,000 plants/ha, nitrogen uptake increased with increase in poultry manure application. The P and K uptake showed a similar trend as N uptake (Fig.3). The highest P and K uptake from application of 10 t/ha PM with 400,000 plants/ha was followed by application from 10 t/ha with 200,000 plants/ha population. The lowest uptake was from the unfertilized plants at 200,000 plants/ha (Fig.3).

Apparent Nutrient Recovery: Apparent Nitrogen Recovery (ANR) was generally higher with 5 t/ha than with 10 t/ha. The highest was from 5 t/ha with 200,000 plants/ha. It was reduced with increased population to 400,000 plants/ha (Fig 4). The ANR was 24 % at 10 t/ha with 400,000 plants/ha but was 23 % with a population of 200,000 plants/ha. The Apparent Phosphorous Recovery (APR) was highest at 5 t/ha with 200,000 plants/ha followed by 400,000 plants/ha of 5 t/ha. The 10 t/ha application had an APR of 1.10 and 1.20 %, at 200,000 and 400,000 plants/ha, respectively (Fig 4).

DISCUSSION

Cock's comb, *Celosia argentea* is a crop of the warm, moist environment and was supported by the rainfall, the temperature and the relative humidity of the study area over the two years. The pre cropping nutrient status of the experimental site was a reflection of previous cropping of the land, with no records of optimum fertilizer application other than crop residues that were recycled. This accounts for the soil's low contents of organic carbon, total N, available P and exchangeable K. The total N content was below the critical level of 1.5 g/kg (Aduayi et al. 2002). Available phosphorus (Bray 1) was very low based on the 8-12 mg/kg critical level reported by Udo *et al.* (2009) or the 10 – 16 mg/kg critical level reported by Adeoye and Agboola (1985). The exchangeable K content was also lower than the critical 0.6-0.8 cmol/kg content recommended in the region by Adeoye and Agboola (1985).

Cock's comb growth and biomass accumulation was generally more favoured in the early season due to the higher total rainfall, relative to the late season. The weather data showed that rainfall was low in the first 4 weeks of growth in the late season and was inadequate to establish the crops, unlike in the early season, when the rainfall was much higher and plant establishment was achieved early. Manure application resulted in a better growth due to the supply of nutrients required for optimum Cock's comb growth as earlier reported (Senjobi *et al.*, 2010). Application of 5 t/ha poultry manure, to supply 127 kg N/ha, on a tropical soil, with a native content of 0.08 % was optimum for cultivation of celosia. Higher rate of application has shown a reduced performance, with plant height, number of leaves per plant and leaf area, indicating an antagonistic effect of the high rates of nutrients supplied. The leaf production of *Amaranthus* has been reported enhanced by manure application (Adewole and Dedeke, 2012; Seeiso and Materechera, 2014). On a tropical soil, with a native content of 0.08 % N, establishing Cock's comb up to a population of 400,000 plants/ha is still supported. The season of cultivation, as well as the plant age at harvest affected the growth and biomass accumulation of *Celosia argentea*. The better growth of the early season generally translated to higher biomass yields. Plants generally had about 8% dry matter in the early season, indicating the need for a high fresh intake to meet a nutritional target. A reduced fresh weight intake to meet a nutritional target can only be met by producing Cock's comb in the late season and harvesting late when the fresh weight is lower and the plant dry weight is higher. With delayed harvesting till 6 weeks after sowing, plant biomass was increased. A higher biomass yields of Cock's comb with more frequent cuttings have been reported (Seeiso and Materechera, 2014) and also with age of transplants in *Solanum melongena* (Lawal *et al.*, 2015).

Fertilizer application increased the plant N, P and K contents due to supply of nutrients for plant uptake with the applied fertilizers. The rate of application however, did not affect the plant N, P and K contents but rather plant population, indicating the contribution of the plant population, as a result of the increased number of plants considered to determine the uptake. Individual plants had higher concentrations of N, P and K with the lower population of 200,000 plants/ha due to the lower total nutrient demand. The concentrations were lower with 400,000 plants/ha due to limitation in available nutrients but the high population amounted to a higher total nutrient uptake. Increased uptake of N, P and K with increased fertilizer rate was an indication of release of more nutrients with higher rates of fertilizer. The 5 t/ha poultry manure however, supplied enough nutrients for optimal N, P and K uptake and nutrient recovery. This agrees with an earlier observation with poultry manure, compared with Cowdung application (Makinde and Ayoola, 2012).

CONCLUSION

Application of 5 t/ha of poultry manure to *Celosis argentea* resulted in optimum growth and nutrient uptake in both early and late seasons. A population of 400,000 plants/ha can be adopted for cultivating Cock's comb, *Celosia argentea* on a tropical soil with a native 0.08 % Nitrogen content.

REFERENCES

Adebayo, O and Akoun, J. (2002). Effect of organic manure and spacing on the yield and yield components of Amaranthus cruentus. In: Proceedings of the 20th Annual Conference of the Horticultural Society of Nigeria held at National Horticultural Research Institute, Ibadan. Umeh, V.C and J. A. Fagbayide (Eds) 14 – 17 May, 2002. pp. 63 – 67.

Adedokun, S.A. and Aiyelaagbe, I.O.O. (2008). Growth and reproductive development of field grown cucumber to compost. Proceeding of the 1st West African Submit asnd 4th National Conference on Organic Agriculture. 17-21 November, 2008. University of Agriculture, Abeokuta. pp 184-187.

Adeoye G. O. and Agboola A. A. (1985). Critical levels for soil pH, available P, K, Zn and Mn and maize ear-leaf content of P, Cu and Mn in sedimentary soils of South-Western Nigeria. *Fert Res*. 6: 65-71

Adewole, M. B and Dedeke, O. A. (2012). Growth performance, yield and nutritional quality of *Amaranthus cruentus* L. under repeated applications of poultry manures. *Ife Journal of Science*. 14(2): 345 – 355.

Adeyeye, A.S., Ogunwale, O.A. and Mofikoya, F.A. (2013) Growth, dry matter accumulation and shoot yield of *Celosia argentea* as affected by poultry manure and urea application. *International Journal of Agricultural Policy and Research*.1 (8): 210-215.

Aduayi, E.A., Chude, V.O., Adebusuyi B.A. and Olayiwola S.O. (2002). Fertilizer use and management practices for crops in Nigeria. Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja Nigeria. pp16.

Aiboni, V.U. (2001). Characteristics and classification of soils of a representative topographic locationin the University of Agriculture, Abeokuta. Nigeria. *ASSET Journal* series. 1:35-50.

Awodun, M. A. (2007) Effect of poultry manure on the growth, yield and nutrient content of Fluted Pumpkin. *Asian Journal of Agricultural Research* 1 (2): 67 – 73.

Babajide, P.A. and Olla, N.O. (2014). 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. *Journal of Biology, Agriculture and Healthcare*. 4(19):69-74

Denton, O.A. (2004). Celosia argentea. Record from PROTA4U. Grubben, G.J.H. and Denton, O.A. (eds). PROTA (Plant Resources of Tropical Africa/ Tressources vegetales de l"Afrique tropicale), Wageningen, Netherlands. www.prota4u.org. Accessed 28 March, 2016.

Drakopoulos. D, Scholberg, J. M. S, Lantinga, E, A and Tittonell, P. A. (2015) Influence of reduced tillage and fertilization regime on crop performance and nitrogen utilization of organic potato. *Organic Agriculture*, 2015: 1 -13.

Eghareva, R.K.A and Ogbe, F.M. (2002). The effects of different levels of organic and mineral fertilizers on the yield performance of two amaranthus cultivars. *The Plant Scientists*. 3:62-72.

FAO (2005). The importance of soil organic matter. Key to drought resistant soil and sustained food production. FAO Soil Bulletin 80. Food and Agricultural Organization of the United Nations. Rome, Italy.pp 79.

Gbadamosi, R.O. and AdeOluwa, O.O. (2014). Improving the yield of Celosia argentea in organic farming system with sytstem of crop intensification. Proceedings of the 4th ISOFAR Scientific Conference Building Organic Bridges at the World Congress 2014. 13-15 October, Istanbul, Turkey. Rahmann, G. and Aksoy, U(eds). pp 859-861.

GenStat (2011). Procedure library release, ed. 4. VSN International Limited, Rothamsted Experiment Station, Hempstead, UK.

Grubben, G.J.H. (2004). Vegetables. Plant Resources of Tropical Africa (Programs). Backhuys.

Hochmuth, G.J, Hochmuth, R.C. and Mylavarapu, R. (2009). Using Composted Poultry Manure (Litter) in Mulched Vegetable Production. University of Florida, IFAS Extention, SL 293. http://edis.ifas.ufl.edu

Ibeawuchi, I..I., Onwerenmadu, E.U. and Oti, N.N. (2006). Effect of poultry manure on green (Amaranthus cruentus) and water leaf (*Talinum triangulare*) on degraded utisol of Owerri, South Eastern Nigeria. *Journal Anim. Vet. Adv*., 5(1): 53-56.

Lawal, B. A, Ilupeju, E. A. O., Ojo, A. M., Jolaoso, M. A. and Akanbi, W.B. (2015) Effect of NPK fertilizer and transplant age on growth, fruit yield and nutritional content of *Solanum melongena* South western Nigeria. *Journal of Biology, Agriculture and Healthcare* 5(12):81 – 91.

Makinde, E.A. and Ayoola, O. T (2012). Comparative Growth and Yield of Okra with Cowdung and Poultry Manure. *American – Eurasian Journal of Sustainable Agriculture.* 6: 18-23.

Nigerian Institute of Social and Economic Research (2003). Understanding poverty in Nigeria. NISER. College Press and Publishers Limited. Ibadan. Nigeria. pp 441

Odeyemi, O.M., Olubode, O.O. and Makinde, E.A. (2015). Nutrient uptake and residual soil nutrient status of pawpaw (Carica papaya) orchard in response to organic and conventional production systerms. *Journal of Organic Agriculture and Environment.* 3:46-55

Ojo, O.D. (1998) Growth and yield of *Celosia argentea* in response to a balanced NPK fertilizer. *Journal of Vegetable Crop Production*. 4 (1):77-83.

Schippers, R.R. (2000). African indigenous vegetables. An overview of the cultivated species. Chatham, U.K. National Resources Institute /ACP-EU. Technical Centre for Agricultural and Rural Cooperation. Pp 214.

Seeiso, M. T. and Materechera, S.A. (2014) Biomass yields and crude protein content of two African indigenous leafy vegetables in response to kraal manure application and leaf cutting management. *African Journal of Agricultural Research*. 9(3):397-406,

Senjobi, B. A., Ande, O. T., Senjobi, C. T., Odusanya, O. A. and Ajilore, O.D (2010). Effects of organic amendments on the growth and performance of *Celosia argentea* on an oxic Paleustalf in South western Nigeria. *Journal of Agricultural Biotechnology and Sustainable Development* 2(8):142-150,

Udo, E.J. Ibia, T.O., Ogunwale, J.A., Ano, A.O. and Esu, I.E. (2009). Manual of soil, plant and water analysis. Sibon Books Ltd. Lagos. Nigeria.