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RESPONSE OF PLUMED COCKSCOMB (*Celosia argentea* (L.) TO NITROGEN AND PHOSPHORUS FERTILIZER APPLICATION ON GROWTH AND SEED YIELD IN SOUTHERN GUINEA SAVANNA OF NIGERIA

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Abstract

Response of plumed cockscomb *Celosia argentea* (L) to nitrogen and phosphorus on growth and seed yield was investigated at the Garden of Kwara state College of Education, Ilorin, in 2010 and 2011. The experiment was laid out in a randomized complete block design replicated four times. The trial consisted of factorial combination of five levels of Nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and four rate of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}). It was observed that nitrogen at 90 kg ha^{-1}significantly influenced growth parameters and seed yield whereas phosphorus application 60 kg ha^{-1}significantly increased growth and seed yield. The results revealed that nitrogen at 60 kg ha^{-1} and phosphorus at 40 kg ha^{-1} could be used in combination to produce seed yield of celosia in southern guinea savanna of Nigeria.

Key words: Nitrogen, Phosphorus, Seed Yield, Plumed cockscomb, *Celosia argentea*

INTRODUCTION

Plumed cockscomb (*Celosia argentea*) is considered as a very important leafy vegetable, especially among the subsistence farmers who grow it around the home gardens in the tropics. It is an erect plant and which grows up to a height between 1.0 to 2.6 m under favorable conditions. It has numerous lateral roots below the soil surface. It is one of the leading leafy vegetables in Nigeria for its high nutritional value. *Celosia* seeds could be processed into food items, supplements and additives (Okusanya 1980, Armitage, 1986). It is a good source of vitamins such as vitamin A, C, riboflavin, niacin and folic acid.

Fertilization practices undoubtedly increase growth and yields of crops.The growing plant requires nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium(Ca), sodium (Na) and sulphur (S). These nutrients have specialized functions and should be supplied to plant at the right time and in right quantity. Studies have shown that most vegetables respond well to nitrogen and phosphorus application including leaf vegetables where organic matter is limited (Morris, 1994). Phosphorus is the second important plant nutrient after nitrogen. The study of Ojo and Olufolaji (1997) showed that a lack of phosphorus in leaf vegetables is probably as important as a lack of nitrogen in limiting crop performance in the tropics. Phosphorus is concerned with storage and energy transfer in the plant system as well as formation of nucleic acids, phospholipids and coenzymes. An adequate supply of phosphorus early in plant life is important for good development of root system, vegetative growth and reproductive organs (Olaitan and Lombin, 1983). The deficiency of phosphorus (P) is evident in poor or slow growth, slender stalk, delayed maturity, poor seed formation and low seed yield. Ustimenko (1983) reported that plant growth from seed lacking phosphorus is usually weak and gives low yield.It produces 2000 to 3000 seeds plant^{-1} when adequate cultural practices were observed. There are few published studies on the biology of C. *argentea* (Gogga *et al*., 2008). For good seed production in Celosia and indeed most crops, at least the knowledge of the right amount of nutrients required by the crop for optimum growth and seed reproduction is important. Seeds stand to be an important resource for successful crop production. There is paucity of information on nitrogen and phosphorus requirement of C. *argentea* on growth and seed yield. In view of the above, it is necessary to assess the optimum nitrogen and phosphorus levels required by *Celosia argentea* (L) for optimum seed yield.

MATERIALS AND METHODS

The experiment was conducted between August-November, 2010and 2011around the nursery of the Agronomy Department, University of Ilorin, Ilorin at 8^0 29’ 4.32’ E 489 m above the sea level. The soil was properly tilled after clearing and was divided into plots measuring 0.9 m x 1.2 m (1.08m^2) with 1m and 0.5m alleys between blocks and plots respectively. *C. argentea* variety TLV 8 obtained from National Horticultural Research Institute (NIHORT) Ibadan was used for the experiment. The seedlings were transplanted to the field two weeks after planting.

The experiment was a Randomized Complete Block Design (RCBD) with four replications. The treatments consisted of five levels of Nitrogen (0, 30, 60, 90 and 120kg ha^{-1}) and phosphorus levels (0, 20, 40 and 60 kg ha^{-1}) with a spacing of 30 cm x 30 cm. Twenty plants were transplanted per plot and a population of about 111,000 plantsha^{-1} was established. Missing plants were replaced immediately.Fertilizer treatment was applied 3 weeks after transplanting in a single dosage. Nitrogen was applied by the use of Urea 46% N a week after transplanting and phosphorus (SSP 18%) was applied at transplanting according to treatments.

Weeding was done manually at 3 and 6 week after transplanting during the period of the experiment. At 8 weeks after transplanting the growth attributes were evaluated which include leaf number plant^{-1}, plant height; leaf area index (Calculated from leaf area using core borer method) at harvest, fresh shoot and dry matter yield was determined. Seeds harvested from the net plot before converting to seed yield (kg ha^{-1}).

Also harvest index = $\frac{\text{Seed yield}}{\text{Biological yield}} \times 100$

Data analysis

Data generated were subjected to Analysis of Variance (Gomez & Gomez, 1984) using SAS version 9.1 (SAS, 2003). Multiple comparisons of treatments were done and separated by Duncan’s Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Soil analysis and Weather

Prior to the experiment, soil test was carried out to determine the amount of nitrogen, phosphorus and potassium of the soil and the result showed that nitrogen, phosphorus and potassium were 0.08%, 0.041% and 0.29 cmol /kg soil respectively. The amount of nitrogen and phosphorus in the experimental site was very low and the soil texture class was sandy loam. Total annual rainfall was 1,260 mm in 2010 and 1,407 mm in 2011.

Number of Leaves

Effect of nitrogen and phosphorus application on number of leaves per plant is presented in (Table 2). Application of nitrogen significantly increased leaf number in both years and combined mean. In 2010 the application of 90 kg ha^{-1} significantly produced more number of leaves per plant but further increase to 120 kg ha^{-1} was similar to 90 kg N ha^{-1}. However in 2011, applying nitrogen rate from 0 to 90 kg N ha^{-1} did not differ significantly but 120 kg N ha^{-1} produced more leaves than the lower rate applied. The leaf number increased with increases in nitrogen application, this might be attributed to the role of N in vegetative growth of the crop. This finding corroborated with the previous report of Ayodele (2003), Isah *et al*. (2012) who reported that the leaf yield of celosia was increased by N application.

Leaf number was affected by application of phosphorus in all the years and the mean (Table 2). In 2010, application of 60 kg P_20_5 ha^{-1} significantly produced more leaves of celosia than the control, however, statistically similar to application of 20 and 40 kg P_20_5 ha^{-1}. In 2011, applying phosphorus from 0 to 40 kg ha^{-1} did not influence leaf number but beyond 40 to 60 kg P_20_5 ha^{-1} gave significantly more number of leaves. Similarly result was also obtained in the combined year's means. No interaction was observed throughout the years of the experiment. This indicated that this crop feeds very strongly on phosphorus and can be utilized for growth. Sarker *et al*. (2014) reported that P influenced the growth performance of Indian brassica.

Plant height

Celosia plant height is presented in Table 2. The application of N at 90 and 120 kg ha^{-1} produced significantly similar plant height of Celosia which was taller than the lower rates and the control in 2010. In 2011 and across the years, the higher rate of 120 kg N ha^{-1} significantly produced taller plants while the shorter plants were recorded in the control treatment (Table 2). The tallest plants were obtained from the application of 60 kg P_20_5 ha^{-1} which was comparable to application of 40 kg P_20_5 ha^{-1}. Similar result was obtained from the findings of Sarker *et al*. (2014) who indicated that application of 150 kg P increased the growth parameters progressively giving the maximum and the lowest values obtained from 0 kg P (Control) to the highest rate of P. There was no interaction between N x P throughout the period of study.

Leafarea index

The effect of nitrogen and phosphorus fertilizer on leaf index of celosia was significant in only 2010 and the combined years (Table 2). Leaf area index increased as the N fertilizer rate increases. The highest leaf area index was recorded at application of 120 kg N ha^{-1} while the lowest was at 0 kg N ha^{-1}.

Phosphorus application at 60 kg P_20_5 ha^{-1} produced the highest LAI which was statistically similar to 20 and 40 kg P_20_5 ha^{-1}in 2011 and in the combined. There was significant interaction between nitrogen and phosphorus application on leaf area index in 2010 (Table 4). Interaction on leaf area index was significantly influenced by nitrogen and phosphorus application, as the control treatment gave lower leaf area index, while the highest leaf area index was obtained from the application of 60 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} though statistically similar when N was increased to 90 kg ha^{-1} while retaining phosphorus at 40 kg ha^{-1}.

Shoot dry matter

Shoot dry matter was affected by N application (Table 3) in all the years and combined means. The highest dry matter was obtained from the application of 120 kg ha^{-1} of N except in 2010 where applied 90 kg was similar to 120 kg N ha^{-1}. The plant height, number of leaves, fresh and dry shoot yields were significantly affected by the application of N fertilizer with the optimum values obtained at 45 kg N ha^{-1} for all the tested varieties, except ornamental variety which had most leaves at 60 kg N ha^{-1}(Olaniyi and Ojetayo, 2012).

There were significant differences among the phosphorus rates applied on short dry matter in all years of study and mean of the years (Table 3). The shoot dry matter increased significantly at 60 kg ha^{-1} than the lower rates that was statistically similar with the control treatment in 2010. While in 2011 and mean of the years application of 40 kg N ha^{-1} significantly produced higher shoot dry matter, further increase to 60 kg ha^{-1} had no significant increase in shoot dry matter production. Mandal and Khan (1972) observed that more than 80 percent of applied phosphate was converted into unavailable forms in acid soils within very short periods.

There was significant interaction between nitrogen and phosphorus (Table 4). At the control treatment of phosphorus application, increasing N from 0 to 90 kg ha^{-1}did not significantly increased shoot dry matter, further addition of N to 120 kg ha^{-1} significantly increased dry matter production. In all cases of phosphorus application, applied N at 90 kg ha^{-1} significantly produced higher dry matter of celosia while application of 120 kg N ha^{-1} and beyond did not increase dry matter.

Harvest index

The harvest index increased due to nitrogen application from 0 to 120 kg ha^{-1}which was at par with application of N at 90 kg ha^{-1} in all the years of study and the combined means. However the lowest harvest index was obtained in the control treatment. According to Olaniyi *et al*. (2008) vegetable croppingsystem requires a greater degree of m anagement and utilizes a large N input than m ost agronomic cropping systems,

which suggests that increase in N rate increas es cell size and cell number as a result of cell division and expansion leading to increased stem growth, number of leaves and other vegetative parts of the plant.

Phosphorus application influence harvest index in only 2010 and means (Table 3). In all cases the control (0 kg P_20_5**)** produced highest harvest index and declined with increased phosphorus application to 20 kg ha^{-1}. However 40 and 60 kg P_20_5 ha^{-1} had similar harvest index with the control treatment.

Seed Yield

Nitrogen significantly increased in seed yield only in the mean data (Table 3). Applying N from 0 to 60 kg ha^{-1} did not influence seed yield of celosia but further increase to 90 kg ha^{-1} significantly increased seed yield which was also similar to 120 kg N ha^{-1}. This indicated that when N is applied during vegetative phase, increases in growth is recorded but if applied after flowering the N is mainly directed towards seed formation and the synthesis of grain protein (Lambert, 1993).

Seed yield of celosia was significantly affected by phosphorus application (Table 3). In 2010 and combined, application of 20 kg P_20_5 ha^{-1} significantly increased seed yield beyond which there was no significant increase in seed yield. In 2011, the control treatment and application of 20 kg are similar but significantly lower than 40 and 60 kg P_20_5 that produced higher seed yield. Influence of P application to seed weight in this study was minimal, although Hooda *et al.* (1980) observed marked increase in okra seed due to phosphorus application.

There was significant interaction between N and P on seed yield in 2010 is presented in (Table 4). Combined application of 60 kg N and 40 kg P_20_5 ha^{-1}produced the highest seed yield and the control treatments gave the lowest seed yield of celosia. Application of 120 kg N ha^{-1} produced similar seed yield to any rate of phosphorus. This might be attributed to higher level of P application which might have had a synergistic effect on nitrogen uptake by celosia, thereby effectively increasing the final seed yield of Celosia.

CONCLUSION

The results conclude that application of nitrogen and phosphorus offers a large scope for better performance of Celosia. Application of nitrogen along with Phosphatic fertilizer at 90 kg $ha^{-1}$and 60 kg ha^{-1} favoured the growth while nitrogen fertilization at the rate of 60 kg N $ha^{-1}$and 40 kg P_20_5 ha^{-1}appeared to give optimum for seed yield *C. argentea.*

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Table 1: Soil physical and chemical properties at the experimental site

Soil properties	2010	2011
Physical properties		
Sand (g kg^{-1})	758.8	709.1
Silt (g kg^{-1})	164.3	202.0
Clay (g kg^{-1})	76.9	88.9
Textural class	Sandy loam	Sandy loam
Chemical properties		
pH (H_20)	6.50	6.46
Organic carbon (%)	0.78	0.70
Total nitrogen (%)	0.08	0.09
Available phosphorus (mg kg^{-1})	1.62	2.00
Potassium	0.64	0.84
Exchangeable bases		
Calcium	0.89	0.90
Magnesium	1.66	2.00
Sodium	0.60	0.70
Exchangeable acidity	3.09	3.50

Table 2: Effect of nitrogen and phosphorus fertilizer on leaf number, plant height and leaf area index at 4WAS of *Celosia argentea* in 2010 and 2011 wet seasons

	Leaf number plant^{-1}			Plant height (cm)			Leaf area index		
Treatment	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Nitrogen (kg N ha^{-1})									
0	16.2b	17.8b	16.9b	23.0c	25.2d	24.1d	1.18b	1.61	1.39c
30	19.9b	18.7b	19.3b	34.7b	29.9cd	32.3c	1.66ab	1.73	1.69abc
60	21.1b	20.7b	20.9b	35.5b	37.3bc	36.6c	1.82a	1.89	1.85ab
90	30.3a	20.5b	25.7a	57.2a	40.7b	48.9b	1.57ab	1.49	1.53bc
120	31.7a	27.2a	29.4a	65.1	59.1a	62.1a	2.02a	1.94	1.98a
SE±	2.20	1.51	1.41	3.20	2.78	2.45	0.180	0.159	0.136
Phosphorus(kg P_2O_5 ha^{-1})									
0	19.5b	18.4b	19.5c	38.2b	29.4b	35.8b	1.51	1.45b	1.48b
20	23.1ab	18.4b	20.7bc	41.3b	33.4b	35.3b	1.53	1.74ab	1.64ab
40	25.0ab	20.3b	24.2ab	41.4b	44.9a	43.9a	1.65	1.82ab	1.73ab
60	28.2a	25.5a	25.3a	51.3a	46.4a	48.1a	1.90	1.92a	1.91a
SE±	1.96	1.34	1.26	2.87	2.49	2.20	0.161	0.143	0.122
Interaction									
N x P	NS	NS	NS	NS	NS	NS	*	NS	NS

Means followed by the same letters within a column are not significant at $P \leq 0.05$ NS = Not significant * = significant at 5% level of probability

Table 3: Effect of nitrogen and phosphorus fertilizer on shoot dry matter, harvest index and seed yield of *Celosia argentea* in 2010 and 2011 wet seasons

	Shoot dry matter (g)			Harvest index (%)			Seed yield(kg ha^{-1})		
Treatment	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Nitrogen (kg N ha^{-1})									
0	40.3c	44.1d	42.2d	3.72c	4.71c	4.21c	1093.5	947.2	1020.3b
30	60.7b	52.4cd	56.5c	5.17b	5.44bc	5.31bc	1122.2	973.4	1047.8b
60	62.2b	66.2bc	64.2c	5.28b	6.68b	5.98b	1137.3	969.2	1053.3b
90	100.0a	71.3b	85.7b	8.32a	6.80ab	7.56a	1255.9	1125.7	1190.8a
120	113.9a	103.4a	108.6a	8.48a	8.54a	8.51a	1278.0	1181.3	1229.6a
SE±	5.62	4.87	4.30	0.539	0.612	0.465	86.82	79.74	62.15
Phosphorus(kg P_20_5 ha^{-1})									
0	66.8b	58.5b	62.7b	6.48a	7.12	6.80a	974.8b	774.8b	874.8c
20	72.3b	51.4b	61.9b	5.03b	6.13	5.58b	1308.9a	852.0b	1080.4b
40	72.5b	78.6a	76.9a	6.53a	6.53	6.53ab	1177.6ab	1271.3a	1224.4ab
60	89.8a	81.2a	84.2a	6.73a	5.94	6.33ab	1248.2a	1259.4a	1253.8a
SE±	5.02	4.36	3.85	0.482	0.547	0.416	77.65	71.15	55.58
Interaction									
N x P	NS	*	NS	NS	NS	NS	*	NS	NS

Means followed by the same letters within a column are not significant at $P \leq 0.05$ NS = Not significant * = significant at 5% level of probability

Table 4: Interaction between nitrogen and phosphorus on leaf area index in 2010, shoot dry matter (g plant^{-1}) in 2011 and seed yield (kg ha^{-1}) in 2010 wet seasons

	Nitrogen (kg N ha^{-1})				
	0	30	60	90	120
Phosphorus (kg P_2O_5 ha^{-1})	**Leaf area index 2010**				
0	0.85d	0.98d	1.27cd	2.00abc	1.68bcd
20	0.86d	1.13cd	1.49cd	1.54bcd	1.59bcd
40	1.32cd	2.44ab	2.72a	2.72a	1.78abcd
60	0.92d	1.81abcd	2.47a	1.59bcd	1.81abcd
SE±	0.361				
	Shoot dry matter (g plant^{-1}) 2011				
0	48.5d	48.6d	63.8bcd	59.8cd	103.4a
20	32.6d	40.6d	59.8cd	93.2ab	115.3a
40	39.4d	40.6d	56.0d	115.4a	116.4a
60	40.6d	93.8ab	88.2abc	113.4a	113.4a
SE±	11.23				
	Seed yield (kg ha^{-1}) 2010				
0	812.5d	850.5cd	885.8cd	1231.8abcd	1123.2abcd
20	1032.8bcd	1162.9abcd	1203.2abcd	1273.1abcd	1325.8abc
40	1179.8abcd	1272.2abcd	1579.1a	1462.9ab	1199.9abcd
60	1108.3abcd	1203.2abcd	1286.9abcd	1179.9abcd	1203.2abcd
SE±	173.65				

Means followed by the same letter(s) are not significant at $P \leq 0.05$ level of probability according DMRT