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Effects of Phosphorous Application on Growth Performance, Yield and Nutritional Value of Cockscomb *(Celosia argentea* L)

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ABSTRACT: Effects of phosphorous (P) level on performance, yield and nutritional value of *Celosia argentea* L. were evaluated with the aim of determining the P level that supports the best growth, yield and nutritional qualities of the crop. The levels of P were: normal (1.348 $mg \cdot kg^{-1}$ of P/pot, NP), medium (6.743 $mg \cdot kg^{-1}$ of P/pot, MP), high (13.48 $mg \cdot kg^{-1}$ of P/pot, HP) and no P application (control, CP). The crop growth rate (CGR) increased with increase in phosphorus gradients (NP = 0.05 $g/m^2 \cdot d^{-1}$, MP = 0.09 $g/m^2 \cdot d^{-1}$ and HP = 0.12 $g/m^2 \cdot d^{-1}$). High and medium P rates increased the relative growth rate (RGR), HP had the highest RGR (0.05 $g \cdot g^{-1}$/day) followed by MP (0.04 $g \cdot g^{-1}$/day). Addition of P increased leaf area (LA) of *C. argentea.* Crude protein of the control was higher (5.56%) compared to the other P treatments (NP = 5.14, MP = 5.11 and HP = 5.03%). Phosphorus applications were beneficial for growth and enhancement of nutritional quality of *C. argentea*. NP and MP are recommended for growing this vegetable crop.

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Leafy vegetables are cheap sources of important nutrition in most countries of tropical Africa (Ayeni, 2016). In Nigeria, a rapid increase in population and urbanization which had led to the use of arable lands for other purposes apart from agriculture had led to a decline in the production of vegetables. Intensive farming activities with little or no fertilization are a key factor contributing to the reduction in productivity of plants (Senjobi *et al*., 2010). Other factors such as soil type, soil nutrient status and fertilizer management are equally significant determinants of the growth, yield and nutritional quality of plant species (Masanobu *et al*., 2016). Many vital processes in plants are affected by phosphorous (P) levels in the soil. Some of these processes include nucleic acids syntheses, photosynthesis, respiration, nitrogen fixation and enzyme regulation (Wahid *et al*., 2015). Application of phosphorus to the soil improves soil P availability, enhances the absorption of some other nutrients, and improves plant tolerance to stress (Cortina *et al*., 2013). However, energy metabolisms as well as biochemical synthesis-related functions are inhibited by a shortage of P in the soil (Burman *et al*., 2009). Growth and yield of plants are reduced by abnormality in root structure caused by phosphorous deficiency (Suriyagoda *et al*., 2014).

Increases in shoot-derived carbohydrates have been observed in many plant species in response to low P availability (Lundmark *et al*., 2010). Despite several reported studies on effects of P on growth, yield and metabolism of plants, little attention has been paid to the growth, yield formation and nutritional value of cockscomb (*Celosia argentea* L.). *C. argentea* is reported to be of great medicinal value (Zheng *et al.*, 2009). The leaves were reported to be rich in folic acid, β-carotene, medium levels of vitamin E, ascorbic acid, calcium, iron and contain 4.7% protein (Oroka, 2015). The plant provides an affordable source of important nutrition at little cost when it accompanies starchy staple foods that are commonplace in Nigerian diets. However, there are few published studies on the biology of *C. argentea*. It is therefore essential to evaluate effects of level of P on performance of *C. argentea* to ascertain its level that may be either detrimental or beneficial, for adequate developments of the plant. For good seed production in *Celosia* and indeed most crops, at least the knowledge of the right

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amount of nutrients required by the crop for optimum growth and seed reproduction is essential. Therefore, the research was undertaken to investigate the effects of phosphorous application on the growth performance, yield and nutritional value of Cockscomb *(Celosia argentea* L).

MATERIALS AND METHODS

Preparation of Soil: Soil that was used in raising plant seedlings was collected from the botanical garden of the Obafemi Awolowo University Ile-Ife, Nigeria. The soil was air-dried and sieved to remove particles other than soil. It was later washed with 1N HCl to remove contaminants.

Determination of Soil Physico-chemical Properties of the Soil: The following physico-chemical properties of the soil were determined from the soil sample: particle size distribution (PSD: sand, silt and clay) and textural class, pH, organic carbon, organic matter, total nitrogen, available phosphorus, exchangeable cations (calcium, magnesium, potassium, sodium), exchangeable acidity and effective cation exchange capacity (ECEC).

Experimental Design: A factorial experiment laid out in completely randomized design (CRD) consisting of 3 levels of P and a no P control was established in a screen house at Obafemi Awolowo University Ile-Ife, Osun State, Nigeria. To produce seedlings, a big plastic pot was filled with loamy soil, and seeds of *C. argentea* were sown and maintained for 30 days. The big plastic pot was supplied with 500 mL of water in the morning and evening throughout the 30 days. The experiment was carried out under screen house conditions to minimize extraneous factors from interfering with the plants. The mean daily temperature under the screen house was measured using a thermometer and the intensity of light was determined with the aid of a digital Lux meter.

Soil samples for raising test plants were stabilized for soil nutrient using a modified method of the long Ashton formula (Hewitt, 1952) and carefully homogenized. Homogenized soil samples (3.5 kg/pot) were transferred into 40 plastic pots measuring 10.0 cm by 15.0 cm. Levels of P added to pots were: normal (1.348 $mg \cdot kg^{-1}$ of P, NP), medium (6.743 $mg \cdot kg^{-1}$ of P, MP), high (13.48 $mg \cdot kg^{-1}$ of P, HP) and no P application (control, CP). Phosphorus was administered as $NaH_2PO_4 \cdot 2H_2O$, after mixing with 100 mL of water. Each treatment was replicated 10 times.

Evaluation of plant Yield: Leaf area measurement (calculated using the formula of Osei-Yeboah *et al*., 1983) and shoot heights were carried out weekly starting from 30 days after planting. The yield of *C. argentea* determined from the biomass of the plant components at the end of each week. Plants were harvested 30 days after planting and at the end of the experimental period. They were then separated into leaves, stems, and roots. These samples were oven-dried at 80°C and used for quantification of net assimilation rate (NAR), relative growth rate (RGR), crop growth rate (CGR) and leaf area ratio (LAR). Photosynthetic pigments were extracted in the dark from leaves of each plant in each treatment. Eight grams of frozen fresh leaves from each treatment was extracted for chlorophyll and carotenoid contents using 0.1 g of sodium bicarbonate and 16 mL of 80% acetone. The absorbance of each extract was determined using digital spectrophotometer at wavelengths of 470 nm, 646 nm, and 663 nm.

Soluble sugar content was determined at the beginning and the end of the experiment to ascertain the level at P fertilization that may produce stress for *C. argentea.* A 0.1 g of dry leaf samples were homogenized with deionized water, filtered and the extract treated with 2% (w/v) phenol and 98% sulphuric acid (Dubois *et al*., 1956). This mixture was incubated for 1 hr at room temperature and the absorbance at 490 nm read using a spectrophotometer.

Proximate content Analysis: The percent moisture, crude fat, and ash content were determined using the AOAC (1975) method. Crude fiber was determined using a Fibretec 2021/2023 system (Foss Tecator, 2002). The dry, defatted sample (0.875 g) was placed in a Kjeldahl digestion flask and analyzed (AOAC, 1980). Standard solutions using nitrate salts of the metals were prepared (AOAC, 1980). The digest was analyzed with a flame photometer for determining K and Na. UV-Visible spectrophotometer was used for determining P at 660 nm wavelength. Atomic absorption spectrophotometer (AAS) was used to determine other metals (Donald & Clyde, 1979). The metal concentration in the sample was determined from a standard curve by extrapolation. The defatted sample (0.292 g) was hydrolyzed in 6 N HCl at 105°C for 22 hr in nitrogen. The hydrolysate was analyzed for amino acids using the sequential multi-sample amino acid analyzer as described by Sparkman *et al*., (1958). The chromatogram of the sample was compared using norleucine as a standard.

Data analysis: The data obtained from the study were subjected to analysis of variance (ANOVA) using SPSS (version 18.0, SPSS Inc., Chicago, IL). One-way ANOVA was used to test the effect of different levels of phosphorus application on the growth indices, photosynthetic pigment accumulation and proximate contents of the plant.

RESULTS AND DISCUSSION

Crop growth rate (CGR) was affected by P level (Table 1), with CGR increasing as P level increased. High and medium P level increased RGR, with HP having the highest RGR followed by MP. The NAR was not different among treatments except for MP which had the highest value. The NAR of *C. argentea* was in an increasing order: MP > HP > NP > CP (Table 1). Compared with the control, P, at all levels, decreased LAR in *C. argentea*. The increment in CGR is directly proportional to that of phosphorus. The effects of High and medium P level on the plant indicated that P application improves soil fertility and possibly lowers the incidence of biotic stress (Ayeni, 2016). With increase in P fertilization, accumulation of dry matter by *C. argentea* might increase. The RGR signifies the rate of dry matter production and CGR corresponds to accumulation of dry matter (Adebo & Olaoye, 2010). There were gradual and steady increases in shoot height and leaf area of plants in the treatments from the beginning to the end of the experimental period. Leaf area and shoot height of HP plants were higher than the other treatments towards the end of the experiment. Root and shoot biomasses of plants could be described to have erratic pattern throughout the experiment (Fig. 1). Phosphorus is an important nutrient element and its role in plant growth, development and productivity cannot be overemphasized. It is a component of many cell constituents and plays a major role in several key processes, including photosynthesis, respiration, energy storage and transfer, cell division, and cell enlargement. Adequate phosphorus is vital to early root formation, growth, improvement in crop quality and is necessary for seed formation.

Table 1: Effect of phosphorus level on growth indices of *C. argentea*.

Parameters/ Treatments	LAR (cm^2/g)	NAR ($g/m^2 \cdot d^{-1}$)	CGR ($g/m^2 \cdot d^{-1}$)	RGR ($g \cdot g^{-1}/day$)
CP	12.62^{ab}	0.07^{b}	0.02^{d} ±0.01	0.03^{b}
NP	9.69^{b}	0.10^{ab}	0.05^{c}	0.03^{b}
MP	7.89^{b}	0.13^{a}	0.09^{b}	0.04^{a}
HP	8.06^{b}	0.12^{ab}	0.12^{a}	0.05^{a}

NP = Normal P level, MP = medium P, HP = high P, CP= no P; Values within the same columns with the same alphabets are not significantly different, at p<0.05

Table 2: Effect of the different gradient of phosphorus application on photosynthetic pigments accumulation of *C. argentea*.

Treatment	Chlorophyll a ($mg \cdot g^{-1}$)	Chlorophyll b ($mg \cdot g^{-1}$)	Carotenoid ($mg \cdot g^{-1}$)	Soluble sugar ($mg \cdot g^{-1}$)
CP	1.72^{a}	0.74^{a}	5.64^{b}	3.97^{b}
NP	1.70^{a}	0.83^{a}	5.82^{b}	3.97^{b}
MP	1.71^{a}	0.78^{a}	5.48^{b}	3.98^{b}
HP	1.76^{a}	0.76^{a}	6.06^{a}	4.00^{a}

NP = Normal P application, MP = medium P application, HP = high P application, CP = no P application; Values within the same columns with the same alphabets are not significantly different, at p<0.05

Table 3: Effects of phosphorus application of proximate content of *C. argentea*.

Treatment	Crude fiber (%)	Crude fat (%)	Crude Protein (%)	PFE	Ash (%)
CP	3.19^{b}	1.17^{a}	5.56^{a}	58.03^{a}	22.46^{a}
NP	3.12^{b}	1.15^{a}	5.14^{b}	58.28^{a}	21.76^{a}
MP	3.09^{b}	1.15^{a}	5.11^{b}	58.30^{a}	21.62^{a}
HP	3.67^{a}	1.12^{a}	5.03^{b}	58.31^{a}	22.15^{a}

NP = Normal P application, MP = medium P application, HP = high P application, CP = no P application, PFE = phosphorus free extract; Values within the same columns with the same alphabets are not significantly different, at p<0.05.

There was no significant difference in chlorophyll a, chlorophyll b, carotenoid and soluble sugar contents except in the high P treatment (Table 2). The chlorophyll a content in the high P treatment at week 1 was higher than at week 8. The carotenoid and soluble sugar contents at week 1 were lower than week 8. Chlorophyll is a major component of chloroplasts and has a positive relationship with photosynthetic rate. Chlorophyll and carotenoids play roles in the maintenance of plant quality. Reduction in chlorophyll content is a typical symptom of oxidative stress and a consequence of pigment photo-oxidation and chlorophyll degradation (Demmig-Adams and Adams, 1996).

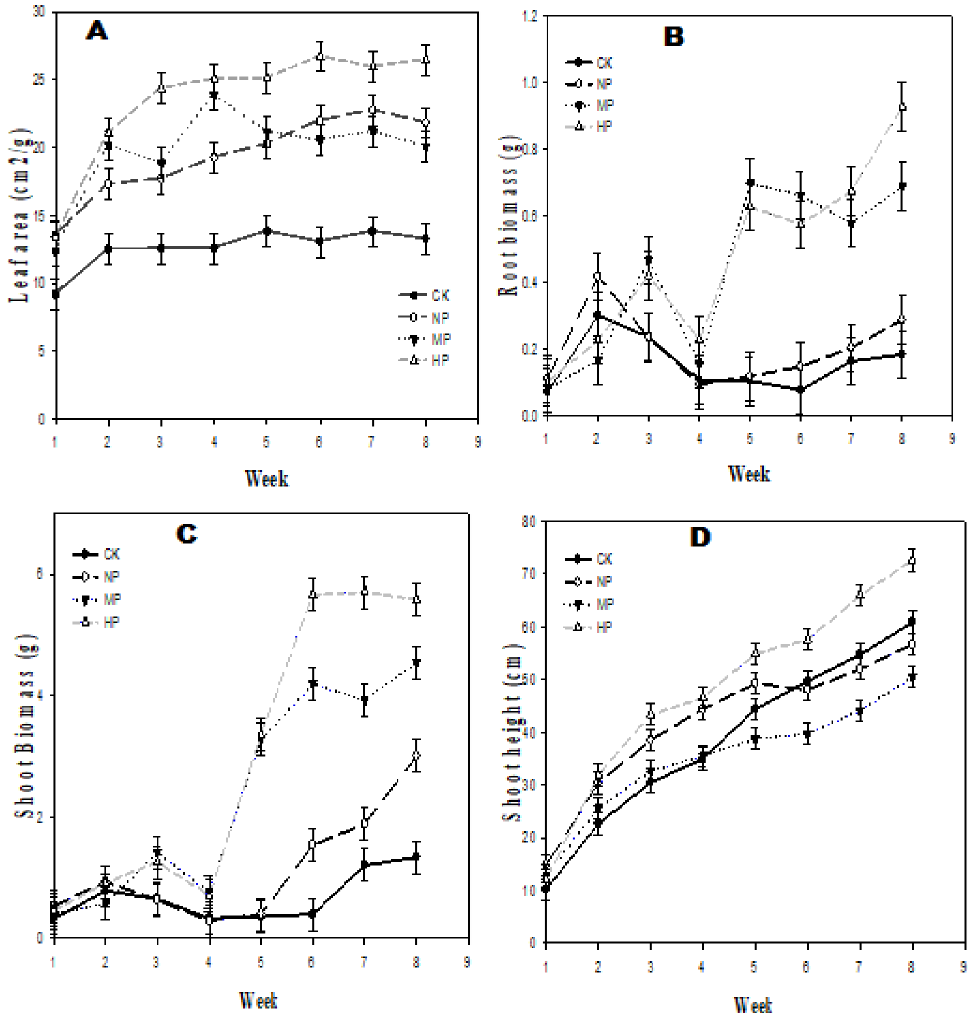

Fig 1: Effect of phosphorus rate on (A) leaf area, (B) root biomass, (C) shoot biomass, and (D) shoot height across weeks. P= phosphorus level, W= weeks of planting, NP = normal P, MP = medium P, HP = high P, and CK = no P application. Error bars are SD.

The chlorophyll a content, affected by the high P treatment, was higher at initial than later stages of plant development. Carotenoid and soluble sugar contents were lower as plants advanced in age. Soluble sugar is essential in plant metabolism, mainly as substrates in biosynthesis processes, energy production and hydrolytic processes. The increase in soluble sugar content with high P in the later growth stage of *C. argentea* could indicate inhibition of their utilization and translocation.

There were no significant differences in ash content and crude fat of C. *argentea* due to P level and the control (Table 3). The crude protein of the control plants was higher when compared to those for P treatments. High P increased crude fiber content of *C. argentea.* Our results indicated that using the high rate of P at 13.48 mg/kg produces the highest ash and crude fiber contents.

Conclusion: Phosphorus applications were found to be beneficial for growth and improvement of nutritional quality of *C. argentea*. However, its application might not be beneficial for crude protein and fat synthesis. None of the P levels used were detrimental for adequate yield and development of this plant.

REFERENCES

Adebo, FA; Olaoye, G (2010). Growth indices and grain yield attributes in six maize cultivars representing two eras of Maize breeding in Nigeria. *J. Agric. Sci.* 2(3): 218-228.

AOAC (1975). Official Methods of Analysis (Horwitz, W., Ed.) 12th edition. Association of Official Analytical Chemists, Washington.

AOAC (1980). Official Methods of Analysis of the Association of Official Analytical Chemists, 13th

edition. Association of Official Analytical Chemists (Washington DC: AOAC International).

Ayeni, MJ (2016). The effects of organic and inorganic fertilizers on the growth performance of *Celosia argentea* L. N Y *Sci J.* 9(2): 98-103.

Ayub, M; Nadeem, MA; Naeem, M; Tashir M; Tariq, M; Ahmad, W (2012). Effect of different levels of P and K on growth, forage yield and quality of cluster bean (*Cyamospsis tetragonobus* L.). *J. Appl. Pharm. Sci.* 22(2): 479-483.

Burman, U; Garg, BK; Kathju, S (2009). Effect of phosphorus application on clusterbean under different intensities of water stress. *J.Plant Nutr.* 32: 668-680.

Cortina, JA; Vilagrosa, A; Trubat, R (2013). The role of nutrients for improving seedling qualityin drylands. *New Forests* 44: 719-732.

Demmig-Adams, B; Adams, WW *(*1996*)*. The role of xanthophyll cycle carotenoids in the protection of photosynthesis*. Trends in Plant Sci.* 1: 21-26.

Donald, JP; Clyde, WF (1979): Analytical Chemistry, 2nd Edition, Academic Press, pp. 658, New York.

DuBois, M; Gilles, KA; Hamilton, JK; Rebers, PA; Smith, F *(*1956). Colorimetric Method for Determination of Sugars and Related Substances. *Anal. Chem*. 28(3): 350 – 356.

Foss, T (2002). Application subnote on fibre determination using the Fibertec 2021/2023 Fibrecap System. SE-26321 Hoganas, Sweeden.

Hewitt, EG (1952). Sand and water culture methods used in the study of plant nutrient. Commonwealth Bureau Horticultural Plantation Crop Technical Communication, pp. 22.

Lundmark, MT; Nilsson, L; Kørner, CJ; Nielsen, TH (2011). Overexpression of the MYB-related transcription factor GCC7 in *Arabidopsis thaliana* leads to increased levels of P_i and changed P-dependent gene regulation. *Funct Plant Biol*. 38: 151–162.

Masanobu, O; Amzad, HM; Nakamura, I; Akamine, H; Tamaki, M; Bhowmik, PC; Nose, A (2016). Effects of soil types and fertilizers on growth, yield, and quality of edible *Amaranthus tricolor* lines in Okinawa, Japan*. J. Plant Prod. Sci.* 19(1): 61-72.

Oroka, F (2015). Comparative effects of municipal solid waste compost and NPK fertilizer on the growth and marketable yield of *Celosia argentea*. *N Y Sci J*. 5(10): 34-38.

Osei-Yeboah, S; Lindsay, JI; Gumb, SFA. (1983). Estimating leaf area of cowpea (*Vigna unguiculata* (L.) Walp) from linear measurement of terminal leaflets. *Trop. Agric*. 60(2): 149-150.

Senjobi, BA; Ande, OT; Senjobi, CT; Odusanya, OA; Ajilore, OD (2010). Effects Organic Amendments on the Growth and Performance of *Celosia argentea* on an OxicPaleusalf in South Western Nigeria. *J. Agric.* Biotech*. Sustain. Dev.* 2(8):142-150.

Sparkman, DH; Stein, EH; Moore, S (1958). Automatic recording apparatus for use in Chromatography of amino acids. *Anal. Chem*. 30: 1190-1206.

Suriyagoda, L; De Costa, WA; Lambers, H (2014). Growth and phosphorus nutrition of rice when inorganic fertiliser application is partly replaced by straw under varying moisture availability in sandy and clay soils. *Plant soil*. 384: 53-68.

Wahid, F; Shanif, M; Khan, MA; Ali, A; Khattak, AM; Saljoqi, AR. (2015). Addition of RoCPPhosphate to different organic fertilizers influences phosphorous uptake and wheat yield. *Ciência e Técnica Vitivinícola,* 30: 91-100.

Zheng, XL; Xing, FN (2009). Ethnobotanical study of medicinal plants around Mountain Yinggeling, Hainan Island, China*. J. Ethnopharmacol*. 124: 97-210.