INFLUENCE OF PHOSPHORUS AND GA_3 ON GROWTH AND FLOWERING OF COCKSCOMB

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CERTIFICATE

This is to certify that the thesis entitled "**INFLUENCE OF PHOSPHORUS AND GA_3 ON GROWTH AND FLOWERING OF COCKSCOMB**" submitted to the Department of Horticulture, Sher-e-Bangla agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by, **MONIRA YEASMIN LIZA,** Registration Number: **12-05015** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

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DEDICATION

LOVINGLY DEDICATED TO MY BELOVED PARENTS AND RESPECTED TEACHERS OF SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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ABSTRACT

The experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2017 to February 2018. The experiment consisted of two factors. Factor A: Three levels of phosphorus i.e. P_0: Control, P_1: 60 and P_2: 110 P_2O_5 ha^{-1}, respectively and Factor B: Four levels of GA_3 i.e. G_0: 0ppm, G_1: 60ppm, G_2: 110 ppm and G_3: 160ppm GA_3, respectively. The experiment was laid out in Randomized Complete Block Design with three replications. In the case of Phosphorus, the highest number of flowers (304,333 ha^{-1}) were recorded from P_2 and the lowest number of flowers (252,833 ha^{-1}) were recorded from P_0. In the case of GA_3, the highest number of flowers (353,111 ha^{-1}) were noted from G_2 and the lowest (256, 222 ha^{-1}) were recorded from G_0. For combined effect the highest number of flowers (406,667 ha^{-1}) were noted from P_1G_2 and the lowest (207,333 ha^{-1}) were recorded from P_0G_0. So, it may be concluded that 60 kg P_2O_5 $ha^{-1}$with 110 ppm GA3 $ha^{-1}$was found suitable for growth and flowering of Cockscomb.

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ABBREVIATIONS AND ACRONYMS

Abbreviation	**Full word**
%	Percent
AEZ	Agro-Ecological Zone
ANOVA	Analysis of Variance
cm	Centimeter
DAP	Days After Planting
DMRT	Duncan’s Multiple Range Test
et. al	All Others
g	Gram
ha	Hectare
LSD	Least Significant Difference
m^2	Square Meter
Max.	Maximum
Min.	Minimum
No.	Number
P	Phosphorus
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources Development Institute
t	Ton
TSP	Triple Super Phosphate
Viz.	Namely

CHAPTER I

INTRODUCTION

Cockscomb (*Celosia cristata*), a member of amaranthaceae family is a beautiful and attractive colored annual herbaceous bedding flower grown usually for landscape purpose. Some of its hybrid cultivars are commercially used as cut flowers as well.*Celosia* is commonly known as "Cockscomb" because of its resemblance to rooster (Cock) head (Wilkinson *et al*., 2006). It has a branching growth habit and produces feathery flower spikes in a pyramidal fashion resembling ostrich plumes, in various colors of silver, yellow, golden-yellow, red orange etc. (Randhawa and Mukhopadhay, 1986). There are three types of cockscomb such as plumes, cones and crests. The inflorescence is terminal with broad, showy fan-shaped heads (Foster and Chongxi, 1992). The plant can be 6.0 cm to 1.5 m in height. It is propagated from seed. The exact geographic origins of Cockscomb are unknown, although speculations include the dry slopes of Africa and India as well as dry stony regions of both North and South America. Its blossom time ranges from mid-summer to mid-fall. *Celosia cristata* prefers fertile, moist soil, but will grow in most soils including acidic, sand, loam and clay. The preferred soil temperature is 16°C (Gilman and Howe, 1999).

In Bangladesh Cockscomb is grown usually for landscape purposes. Cockscomb is considered fairly unknown to consumers in specialty cut flower production and has potential grow (Gilman and Howe, 1999). The flowers are good for cutting and can be dried for table decoration as the dried flowers retain the colors for a long time (Randhawa and Mukhopadhay, 1986). It can be cultivated in waste-lands, beside highways, waterways and cultivated farmlands (Chukwuka and Omotayo, 2009). It can be used to treat uterine bleeding, bloody stool, bleeding hemorrhoids and infections of the urinary tract (Wang *et al*., 2010). Their leaves are often used as vegetables and dressings for boils and sores. However the seeds have been used in the treatments of eye ailments and blood diseases (Foster and Chongxi, 1992).

In addition, Phosphorus is an essential macro nutrient and is a component of the complex nucleic acid structure of plants. It plays an important role in an array of cellular processes, including maintenance of membrane structures, synthesis of biomolecules and formation of high-energy molecules. It also helps in cell division, enzyme activation/inactivation and carbohydrate metabolism (Razaq *et al.,* 2017). At whole plant level, it stimulates seed germination; development of roots, stalk and stem strength; flower and seed formation; crop yield and quality. Phosphorus plays an essential role in improving the reproductive growth of plants, including flower and seed formation. Phosphorus contributes to the production of anthocyanin in flower stalks, which was found to decrease under Phosphorus deficient conditions (Malhotra *et al.,* 2018). Plants need Phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and development of new tissue. It also regulates protein synthesis. Additionally, phosphorus increases stalk strength, root growth, grain, fiber and forage yield. Medium application of Phosphorus improve the growth and flowering of Cockscomb.

On the other hand, Gibberellic Acid (GA_3) is an active form of many types of gibberellins and is extensively used in commercial horticulture. Gibberellins (GAs) are plant growth regulators that regulate various developmental processes, including stem elongation, germination, dormancy, flowering, flower development and leaf and fruit senescence (Hedden and Sponsel, 2015). Gibberellins mainly cause hyper elongation of stems by stimulating cell division, elongation and enhance the flower bud formation (Brian, 2008). It enables greater photosynthesis and plant metabolism as well as increases flower size. Gibberellins initiates early flowering in many ornamental plants and increases the number of flowers (Sajid *et al*., 2016). GA_3 improves the stem length and flower size of flower which are considered as quality factors for better acceptance to the consumers and fetch better price in the flower market. Optimum level of GA_3 improves the flower quality of Cockscomb.

The demand of flower is increasing day by day in Bangladesh. Cockscomb is a new member in floriculture industry of our country. The flower has attractive color and longer shelf life than many other flower. Besides, it can also be used in room decoration. Scientific findings about its cultivation relating to fertilization and hormone application for successful production is scanty in Bangladesh. There is scope for increasing yield of this flower by using suitable Phosphorus fertilizer and GA_3 application with other fertilizers under the agro-ecological condition of Bangladesh.

Considering the above mentioned facts the present study was undertaken and designed with the following objectives.

- To find out the adequate dose of Phosphorus for growth and flowering of Cockscomb.
- To investigate the influence of GA_3 on growth and flowering of Cockscomb.
- To find out the best combination of Phosphorus and GA_3 for growth and flowering of Cockscomb.

CHAPTER II
REVIEW OF LITERATURE

Cockscomb is newly introduced flower in our floral market. Most of the soil and climate of Bangladesh is suitable for Cockscomb production. Fertilizers and plant growth regulators play a vital role in the production system of modern agriculture. Growth and yield performance of Cockscomb at different level of phosphorus and GA_3 have not been studied adequately in Bangladesh. But some researcher works on different aspects of Cockscomb had been conducted in different parts of the world. Available literature related to the present study has reviewed in this chapter under following sections.

2.1 Literature on Phosphorus

Naznin *et al*. (2014) carried out an experiment on Gladiolus at the Horticulture Farm of SAU, Dhaka during October 2010 to May 2011. The experiment consisted with four levels of phosphorus (P_0: control; P_1: 100 kg; P_2: 150 kg and P_3: 200 kg P_2O_5 ha^{-1}). They found significant variation for number of florets per spike of Gladiolus due to the effect of P levels. The maximum number of florets per spike (14.5) was recorded from P_2 (150 kg P_2O_5 ha^{-1}) which was statistically identical (14.4) with P_3 (200 kg P_2O_5 ha^{-1}) and closely followed (13.3) by P_1 (100 kg P_2O_5 ha^{-1}), whereas the minimum number of florets per spike (11.9) was found from P_0. The plant height of gladiolus differed significantly due to the application of different levels of phosphorus where the longest plant (25.3 cm, 35.0 cm, 47.5 cm, 61.7 cm, 74.3 cm and 83.4 cm) was recorded from P_2 while the shortest (18.5 cm, 26.5 cm, 38.4 cm, 50.8 cm, 56.7 cm and 65.3 cm) was found from P_0.

Islam (2013) conducted an experiment on Cockscomb at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from March 2012 to May 2012. The experiment consisted with two factors, such as factor-A: three levels of plant spacing; S_1: 35×20 cm, S_2: 35×25 cm and S_3:

35×30 cm and three levels of Phosphorus; P_0: 0 kg, P_1: 50 kg and P_2: 100 kg $P_2O_5ha^{-1}$ respectively. The experiment had three replications and it was set up in Randomized Complete Block Design. Spacing and phosphorus fertilizer significantly influence on most of the parameters of Cockscomb. In case of Phosphorus, the tallest plant (23.8 cm) and the tallest stem (16.2 cm) was recorded from P_1 treated plant and the smallest plant (19.7 cm) and smallest stem (12.1 cm) was found from P_2 treatment at 40 DAT. The highest diameter of crown of Cockscomb (18.6 cm) was found from P_1 treated plant and the smallest diameter of crown (15.9 cm) was recorded in P_0 treatment at 40 DAT. The tallest spike (16.2 cm) and the highest breadth of spike (4.4 cm) was found from P_1 treated plant and the smallest spike (12.1 cm) and lowest spike tip breadth(2.6 cm)was found in P_2 treatment at 40 DAT. Highest number of spike (101,265 ha^{-1}) was obtained from P_1 and the lowest (20,320/ha) from P_0. For combined effect, highest number of spike (132,531 ha^{-1}) was obtained from S_2P_1 and the lowest (27,260 ha^{-1}) from S_3P_0 treatment.

Shauk at *et al.* (2012) studied the effect of phosphorus on corm and flower productivity of Gladiolus. Result revealed that the P_5 (160 kg P_2O_5 ha^{-1}) produced maximum plant height i.e. (156.0 cm) followed by P_4 (151.8 cm) while minimum plant height was recorded in P_0 (128.4cm). The increase in plant height with increasing level of phosphorus levels was might be due to the fact that phosphorus helps to stimulate root growth and is connected with the early maturity of crops. Minimum numbers (14.59) of flowers $spike^{-1}$were recorded for P_0 (control) while maximum numbers (19.15), (19.03) and (18.48) of flowers $spike^{-1}$ were recorded for P_5: (160 kg P_2O_5 ha^{-1}), P_4: 130 kg P_2O_5 ha^{-1} and P_3: 100 kg P_2O_5 ha^{-1} respectively.

An experiment was conducted on an ornamental flower called *Scaevula aemula* R.Br. (Whirlwind Blue) by Burnett *et al.*(2008) at University of Maine, USA to study the effects of Phosphorus on morphology of it. To quantify the response, flower plants were grown in Hoagland solutions containing 0,20,40,60 or 80 mg per L Phosphorus. Plants fertilized with either the highest (80 mg per L) or lowest (0mg per L) Phosphorus concentration had significantly shorter stem, smaller shoot dry weights and fewer flowering branches. On the other hand plants fertilized with 20 or 40 mg per L Phosphorus gave the best results.

Yadav (2007) conducted an experiment in Bikaner, Rajasthan, India, to study the effect of N (0, 10 and 20 g/m2) and P (0, 6 and 12 g/m2) fertilizers on the growth and flowering of tuberose cv. Stringer. Plant height, number of leaves per plant, number of flowers per spike, length of spike, length of rachis, number of spike per plot and weight of flower per spike was remarkably increased with N and P application, alone and in combination. However, N and P fertilizers did not have any significant effect on the flower length. Plant height (35.50 cm), number of leaves per plant (34.40), number of flowers (37.50) per spike, length of spike (49.40 cm), length of rachis (20.80 cm), number of spike per plot (33.90) and weight of flower (109.50 g) per spike were higher with combination of 20 g N and 12 g P per plot.

Gupta *et al.* (2006) carried out field studies in Uttar Pradesh, India, during the 1998/99 and 1999/2000 cropping seasons, to determine the role of nitrogen (N) at 0, 40 and 80 g/m^2 and phosphorus fertilizers (P) at 0, 150 and 300 g/m^2 in 4 tuberose (*Polianthes tuberosa*) cultivars, i.e. Single, Double, Semi-double and Variegated, for reproductive growth parameters such as growth period of bud, spike emergence, total number of flowers per spike and number of flowers appeared at a time per spike and the report showed that the Variegated cultivar showed positive response with 80 g N/m^2 and 150 and 300 g P/m^2 applications.

Santos *et al.* (2004) conducted a field trail to investigate the influence of P application method on the critical period of amaranth with phosphorus fertilizer at rates of 125 or 250 kg ha^{-1}, respectively. Significant differences in respect of fresh yield, marketable yield and stem diameter were recorded at harvest. Fresh yield was 20% higher in 250 kg ha^{-1} compare with 125 kg ha^{-1} P in the method of broadcasting application.

Rana and Rameshwar (2003) carried out an experiment in Sangla, Kinnaur, Himachal Pradesh, India during the summer seasons of 2000 and 2001 to study the response to phosphorus fertilizer at 20, 40 and 60 P_20_5 kg ha^{-1} rate under irrigated conditions on amaranth. Yield and yield contributing characters increased significantly with the increase in the rate of fertilizer. But maximum net returns and benefit cost ratio were obtained from the phosphorous fertilizer application @ 40 kg P_20_5 per hectare under irrigated conditions.

Dahiya *et al*. (2001) conducted a pot culture experiment with sandy loam soil to evaluate the effect of N (0, 60, 120, 180, and 240 ppm as urea) and P (0, 20, 40, 60, and 80 ppm as KH) on the growth and dry matter yield of tuberose cv. Double. The authors observed that application of N and P greatly improved the growth (plant height and number of leaves) and dry matter yield (dry weight of leaves and spike), and total dry weight (leaves + spike). Growth and dry matter yield increased up to 180 ppm N and 60 ppm P levels. However, further increments in N above 180 ppm and P above 60 ppm adversely affected growth and dry matter yield.

Alsaeedi *et al.* (2000) investigated that plants suffering from P-deficiency showed retarded growth and low shoot/root dry matter ratio. Phosphorus, an important nutrient for propagation, vigor and general health of all plants, is often referred to as the ‘energizer’ because it helps store and transfer energy within plants during photosynthesis process.

Lian *et al.* (1997) carried out a study to analyze fertilizer response and efficiency in vegetable production in Taiwan with three successive crops, mostly edible amaranth (*Amaranthustricolor*). Phosphate fertilizer showed increase of yield with sufficient irrigation.

Bcrnejillo *et al.* (1994) investigated that DAP solution treatment significantly increased total yield per plot (74.96 kg, compared with 58.66 kg in control treatment; equivalent to 49.973 and 39.226 kg/ha, respectively). In second trial they applied 30 or 60 kg/ha as solid DAP or DAP solution and resulted significantly higher early yield increase of liquid treatment than the corresponding solid DAP treatment. In ease of total yield both liquid treatments gave significantly higher result than the both solid treatments (19.03-22.57 vs. 12.05-12.49 kg/ 15 m^2 plot, respectively).

Vijayakumar (1980) carried out a study on the growth and development of nineteen types of amaranth in South India at different fertilizer doses of phosphorus (0, 15, 30, or 60 kg ha^{-1}). The highest plant height was recorded as 122.15 cm and highest plant diameter was 2.38 cm at 60 kg ha^{-1}.

Portal (1992) conducted an experiment with different level of phosphorus on amaranth. Treatments were 20, 40, 60 or 80 kg P per hectare. Different growth parameters were evaluated. Maximum plant height, number of leaves and number of branches were significantly increased with 80kg of phosphorus ha^{-1}.

Mathai (1978) evaluated some *Amaranthus* sp. in India. The cultivar Co.l grown only for green have been reported to yield up to 16 t ha^{-1} and dual purpose types 12 t ha^{-1} greens and 10 t ha^{-1} grains by using 60 kg phosphorus per hectare.

2.2 Literature on GA_3

Afroz (2017) evaluated an experiment on Cockscomb at horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from February 2016 to May 2016.It studied the effect of plant population and foliar application of GA_3 on growth and flowering of cockscomb. The experiment was consisted of two factors: Factor A: three levels of plant population viz. P_1: 160,000 plants ha^{-1}, P_2: 200,000 plants ha^{-1} and P_3: 240,000 plants ha^{-1}. Factor B: four levels of GA_3 viz. G_0: Control (0 ppm GA_3), G_1: 50 ppm GA_3, G_2:100 ppm GA_3 and G_3: 150 ppm GA_3.The experiment was done in a Randomized Complete Block Design (RCBD) with three replications. For the application of different concentration of GA_3 showed a significant effect. The highest plant height (30.18, 51.18 and 66.95 cm at 15, 30 and 45 DAT respectively), leaves number(44.18, 86.39 and 112.40 at 15, 30 and 45 DAT respectively), branch number (2.47, 5.02 and 7.47 at 15, 30 and 45 DAT respectively), stem length (11.54, 18.58 and 33.51 cm at 15, 30 and 45 DAT respectively), spike length (7.66, 12.51 and 22.12 cm at 15, 30 and 45 DAT respectively), spikelet number (1.58, 2.49 and 3.78 at 15, 30 and 45 DAT respectively), spike number per plant (7.47 after harvesting), spike number per plot (109.38 after harvesting), dry weight of plant (191.22 g after harvesting), dry weight of spike (20.78 g after harvesting) was recorded from the medium level of GA_3 (G_2 : 100 ppm GA_3). Again, the minimum plant height (19.61, 41.97 and 60.67 cm at 15, 30 and 45 DAT respectively), number of leaves (36.02, 75.32 and 100.21 at 15, 30 and 45 DAT respectively), branch number (1.60, 2.00 and 2.91 at 15, 30 and 45 DAT respectively), stem length (7.42, 10.34 and 23.65 cm at 15, 30 and 45 DAT respectively), spike length (3.50, 5.31 and 14.32 cm at 15, 30 and 45 DAT respectively), spikelet number (0.89, 1.00 and 1.18 at 15, 30 and 45 DAT respectively), spike number per plant (2.91 after harvesting), spike number per plot (42.31 after harvesting), dry weight of plant (182.50 g after harvesting), dry weight of spike (14.78 g after harvesting) was found from control treatment G_0 (0 ppm GA_3). The highest number of spike ha^{-1} (1445, 333) was also obtained from G_2 (100 ppm GA_3) and the lowest result was performed by control G_0 (0 ppm) treatment.

Sable *et al.* (2015) carried out an experiment to analyze the effect of plant growth regulators on growth and flower quality of gladiolus cv. 'H.B. Pitt'. It was found that the maximum height of the plant (59.43 cm), number of leaves (13.9), leaf area (64.8 cm^2) were recorded by treatment GA_3 200 ppm foliar spray while maximum number of florets $spike^{-1}$ (13.4), floret length (8.4 cm), length of spike (80.28 cm) and length of rachis (41.50 cm) were recorded with foliar spray of GA_3 at the rate of 200 ppm. However, maximum weight of floret (10.1 g), diameter of floret (9.5 cm) and girth of spike (2.60 cm) were produced by CCC 750 ppm foliar spray.

Sajjad *et al.* (2015) carried out an experiment to enhance the sprouting of multiple buds and evaluate its effects on other growth parameters. Result revealed that the Gibberellic acid at 100 ppm concentration increased plant height to 105 cm compared to 97.60 cm in control plants, flowering percentage (84.67%), spike length (40.03 cm) and also boosted the corm weight (68.30 g).

Ghadage *et al*. (2013) conducted an experiment to study the effect of foliar application of different plant growth regulators on growth, yield and quality of gaillardia. A foliar application of 200 ppm GA_3 showed early flowering (67.30 days), diameter of flower (6.68 cm) and length of flower stalk (21.30 cm) in gaillardia. On the other hand application of MH 500 ppm produced maximum number of flowers per hectare (57.62 lakh) and higher yield (114.12 q. per hectare).

Kumar *et al*. (2013) carried out an experiment to study the effect of plant growth regulators on flowering of tulip. The three different growth regulators; gibberellic acid (GA_3) at 100, 200, and 400 ppm, 2-chloroethyl trimethyl ammonium chloride (CCC) and maleic hydrazide (MH) each at 100, 200 and 500 ppm along with control were applied as dip treatment and foliar spray. GA_3 at 400 ppm significantly caused earliest flowering (141.30 days) followed by 200 ppm GA_3 (142.43 days) as compared to the control (148.93 days), while delayed flowering was recorded 500 ppm MH (152.96 days) followed by 200 ppm MH (151.93 days). The longest blooming period was recorded in 200 ppm GA_3 (28.46 days) followed by 400 ppm GA_3 (27.76 days) in comparison to the control (21.59 days), respectively and thereby enhanced propagation coefficient was obtained in 400 ppm GA_3 (258.66%) followed by 500 ppm CCC (237.73%) as against the control (170.00%).

Mori *et al.* (2013) carried out an experiment to show the effects of GA_3 application after flower budding on the flowering and cut flower quality of summer-to-autumn flowering small flowered spray type chrysanthemums harvested in August. GA_3 application after the flower budding stage on the flowering and cut flower quality were investigated. In experiment 1, GA_3 application (50 or 100 ppm, 2 or 3 times) for 'Sansui' was started at the terminal flower budding stage. In almost all GA applications, flowering of the second lateral flower accelerated, and the flower cluster and pedicel lengths increased. In experiment 2, GA_3 application (100 or 200 ppm) for 'Sansui' and 'Kurenai' was started at the flower budding, 10 days after budding, and bud break stages. Flowering accelerated in almost all GA_3 applications. Flower cluster and pedicel lengths increased with GA_3 application at the flower budding and 10 days after budding stages but were not affected at the bud break stage. In experiment 3, GA_3 application (100 or 200 ppm) was started when the terminal flower bud diameter was 3.5 (flower budding), 6, and 8.5 (bud break) mm respectively. Flower cluster and pedicel lengths increased in GA application at 3.5 and 6 mm diameters, but were not affected at 8.5 mm. Therefore, GA_3 application (100-200 ppm, twice) after the bud break stage accelerates flowering without reducing the cut flower quality.

Patel *et al*. (2010) conducted a field experiment at Anand Agricultural University, Anand during Kharif to Rabi season of the year 2007-2008 to study the "Effect of growth regulators on growth, flowering and yield of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. 'IIHR-6' under middle Gujarat conditions".The treatment GA_3 150 ppm gave significantly minimum days required for first flower initiation (108.33 days) and 50% flowering (116.00 days). Significantly maximum flower diameter (8.76 cm), flower weight (5.93 g) and shelf life of flowers (8.00 days) were obtained in the treatment GA_3 150 ppm. Number of flowers per plant (48.30), flower yield per plant (170.77 g) and flower yield per hectare (12.65 t) were found significantly maximum in the same treatment.

Havale *et al*. (2008) carried out an experiment to find out the effects of different doses of gibberellic acid on gladiolus and revealed that corm treatment for gladiolus with GA_3 200 ppm attributed to superior results regarding early emergence of spike, length of rachis, number of florets per spike, number of spikes per plant, weight of spike and vase life over all other treatments

Tyagi *et al.* (2008) investigated the effects of GA_3 [gibberellic acid] at 50, 100, 150 or 200 ppm each on the performance of *Calendula officinalis* (cv. Red Orange) at Uttar Pradesh, India, during the winter of 2006-07. GA_3 significantly enhanced the growth and yield parameters over the control. GA_3 at 200 ppm resulted in the greatest number of flowers per plant (19.60), flower diameter (10.13 cm), fresh weight of flower (8.90 g), flower dry weight (2.78 g) and yield (60.12 quintal/ha), and in the longest vase life (4.92 days).

Moond and Rakesh (2006) studied the effect of GA_3 (50, 100, 150, 200 and 250 ppm), CCC (2000, 4000, 6000, 8000 and 10000 ppm) and MH (250, 500, 750, 1000 and 1250 ppm) on vegetative growth and yield of chrysanthemum. Minimum plant height (104 cm) was recorded with MH at 1250 ppm, while shortest internode (1.64 cm) and maximum number of internodes (52.6) were produced with 10000 ppm CCC. GA_3 at 250 ppm resulted in tallest plants (178 cm) with longest internodes (3.83 cm) and maximum flower yield per plant. MH at 1250 ppm produced maximum number of primary branches (38.8) and leaves per plant (1878), whereas, CCC at 4000 ppm recorded plants with maximum basal diameter of stem (3.15 cm)

Srinivasa (2006) investigated that anthurium plants treated with GA_3 at 300 ppm produced significantly maximum plant height (44.44 cm), leaf length

(21.0 cm), number of lateral shoots (4.56) and induced early flowering (206 days) as compared to other treatments. Maximum leaf width (11.19 cm) and number of leaves (13.33) were produced in plants treated with GA_3 at 225 ppm, while untreated plants had lowest leaf width (5.84 cm) and number of leaves (6.44 cm).

Verma *et al.* (2003) conducted a field experiment during the winter seasons of 1997/98 and 1998/99, in Bichpuri, Agra, Uttar Pradesh, India, to investigate the effects of IAA (0, 1000 and 2000 ppm) and GA_3 (0, 1000 and 2000 ppm) on the growth and flowering of aster. IAA at 2000 ppm produced the best-quality flowers followed by GA_3 at 2000 ppm. Flowering was delayed with each increase in the concentration of IAA, GA_3 and STS, with the maximum delay being recorded with IAA at 2000 ppm.

Manisha *et al.* (2002) conducted an experiment on tuberose (*Polianthes tuberosa*) cv. Single in Varanasi, Uttar Pradesh, India, during 1999-2000. Treatments comprised of a control and foliar sprays of gibberellic acid (GA_3) at 100, 150 and 200 ppm at 40, 60 and 80 days after planting. Treatment with GA_3 at all concentrations promoted the height of the plants and increased the number of leaves per plant, being maximum (55.50 cm and 15.99, respectively) with 150 ppm application. Approximately 5 days early appearance of floral bud (96.82 days) over control (102.00 days) was also observed with this treatment. GA_3 at all concentrations significantly increased the number of spikes per plant, number of flowers per spike and per hectare yield. All these characters were maximum in plants applied with GA_3 at 150 ppm.

Porwal *et al.* (2002) studied on the influence of plant growth regulators on Damask rose, GA_3 at 200 ppm recorded maximum plant height, maximum number of shoots per plant and plant spread.

Sujatha *et al.* (2002) investigated that foliar application of GA_3 100 ppm in gerbera, Cv. Versace was effective in enhancing plant spread, number of leaves per plant and also showed increased leaf area. The number of suckers per plant (3.9) was also found to be highest when treated with 100 ppm GA_3 followed by GA_3 500 ppm.

Tiwari and Singh (2002) carried out an experiment to identify the effects of bulb size, i.e. large (> 1.5 cm diameter), medium (1.0-1.5 cm), and small (< 1.00 cm), and preplanting soaking in gibberellic acid (GA_3) at 50, 100, 150, 200, and 250 ppm on the growth, flowering, and yield of tuberose (*Polianthes tuberosa*) in Kanpur, Uttar Pradesh, India, during 1992-93. Plants raised from large bulbs had the greatest plant height, number of leaves per clump, leaf length, leaf width, foliage weight, clump weight, bulb and bulb let per clump, inflorescence length, spike length, flower length, spike diameter, flowers per spike, and spikes per plant, and showed earliest flowering. Similar results were recorded for plants from bulbs treated with 200 ppm GA_3, except for leaf width which was highest with 150 ppm GA_3. Large bulbs soaked in 200 ppm GA_3 showed significant increase in growth, flowering and bulb production.

Spraying of GA_3 recorded maximum plant height, plant spread and more number of leaves and branches in chrysanthemum and other flowering plants (Lal &Mishra, 1986; Nagarjuna *et al*., 1988; Sujatha *et al*., 2002; Kumar *et al*., 2003; Rana *et al*., 2005).

Sreekala *et al.* (1999) carried out a field experiment and found that GA_3 treatment at 200 ppm showed significance increase in plant height (71.5 cm) and higher plant spread (3852.8 cm^2) in Crossandra.

Deotale *et al.* (1994) studied on the effect of date of planting and foliar spray of GA_3 on flowering and yield of chrysanthemum. Plants were sprayed with different concentrations of GA_3 (0, 50, 100 and 150 ppm) and recorded that time to bud initiation and flower opening, and the difference between the two, were reduced with both later planting dates and increasing GA_3 concentration.

The number of flowers/plant tended to increase with later planting dates and increasing GA_3 concentration up to 100 ppm maximum flowering was obtained from planting on 14 July and spraying with 100 ppm GA_3, which resulted in 256 flowers/plant. Flower yield/plant increased with both later planting dates, up to 24 June, and increasing GA_3 concentration: planting on 24 June and spraying with 150 ppm GA_3 gave the greatest flower yield of 474.0 g/plant.

Dutta *et al.* (1993) investigated the regulation of flowering by growth regulators in chrysanthemum (*Chrysanthemum indicum* Linn.). All the growth regulator treatments significantly increased the duration of flowering, which was longest (212.67 and 219.00 days in the 1989/90 and 1990/91 seasons, respectively, compared with 83.67 and 87.33 days, respectively for controls) in the 50 ppm GA_3 treatment. Flower quality (size and stalk length) and yield were also improved by most treatments. The highest flower yields (0.682 and 0.685 kg/plant in the 1st and 2nd seasons, respectively, compared with 0.253 and 0.263 kg/plant, respectively, in controls) were obtained with GA_3 150 ppm and this treatment also resulted in the longest cut flower shelf lives (20.00 and 19.67 days in the 1st and 2nd seasons, respectively, compared with 8.67 and 8.00 days, respectively, in controls).

Farooqi *et al.* (1993) carried out an experiment and observed that among the different concentration of gibberellic acid sprayed (viz., 100, 150 and 200 ppm) to davana, application of 200 ppm five week after transplanting registered maximum plant height, number of branches and plant spread compared to other concentrations under Bangalore conditions.

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in prosecution of the experiment.

3.1 Experimental Site

The experiment was conducted at experimental plot of Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October 2017 to February 2018.The location of the site was at 23.774^0 N latitude and 90.335^0 E longitude with an elevation of 8.2m from sea level (BBS, 2009). The experimental site was medium high land in Agro-Ecological Zone of Madhupur tract (AEZ No.28).

3.2 Climate

The experimental field was under subtropical climate characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March (SPARSO, 2010). The monthly means of daily maximum, minimum and average temperature, relative humidity, total rainfall and sunshine hours received at the experimental site during the period from October, 2017 to February, 2018 are presented in Appendix I.

3.3 Soil

The soil of the experimental site was grey in color and it belongs to the Madhupur Tract under AEZ 28. The selected plot was medium high land and the pH was 5.6. Soil sample was collected and analyzed in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka. Details of the soil characteristics are added in Appendix II.

3.4 Land Preparation

The land was ploughed with power tiller in the month of November 2017 and then kept open to sun for seven days prior to further ploughing. Then it was prepared by ploughing and cross ploughing followed by laddering. After each laddering, weeds of the land were removed and the clods were broken. In this way the soil was made into good tilt. Then the basal dose of manures and fertilizers were mixed into the soil and final land was prepared.

3.5 Treatments of the Experiment

The experiment was designed to study the influence of phosphorus and foliar application of GA_3 on growth and flowering of cockscomb.

The experiment consisted of two factors, which are as follows:

3.5.1 Factor A: Phosphorous concentration

P_0: Control

P_1: 60 kg $P_2O_5ha^{-1}$

P_2: 110 kg $P_2O_5ha^{-1}$

3.5.2 Factor B: GA_3 concentration

G_0: Control

G_1: 60 ppm GA_3

G_2: 110 ppm GA_3

G_3: 160 ppm GA_3

3.5.3 Interaction effect of plant population and phosphorus

There were altogether 12 treatment combinations such as: P_0G_0, P_0G_1, P_0G_2, P_0G_3, P_1G_0, P_1G_1, P_1G_2, P_1G_3, P_2G_0, P_2G_1, P_2G_2, P_2G_3.

3.6 Design and Layout of the Experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Each block was divided into 12 plots.

Treatments were allotted at random. Thus, there were 36 unit plots altogether in the experiment. The size of each plot was 1 m × 0.8 m. The distance between blocks was 0.5 m. Drains with 0.5 m were made between the plots. Row to row and plant to plant distance in each plot was maintained as per treatment. The detailed lay-out is presented in Figure 1.

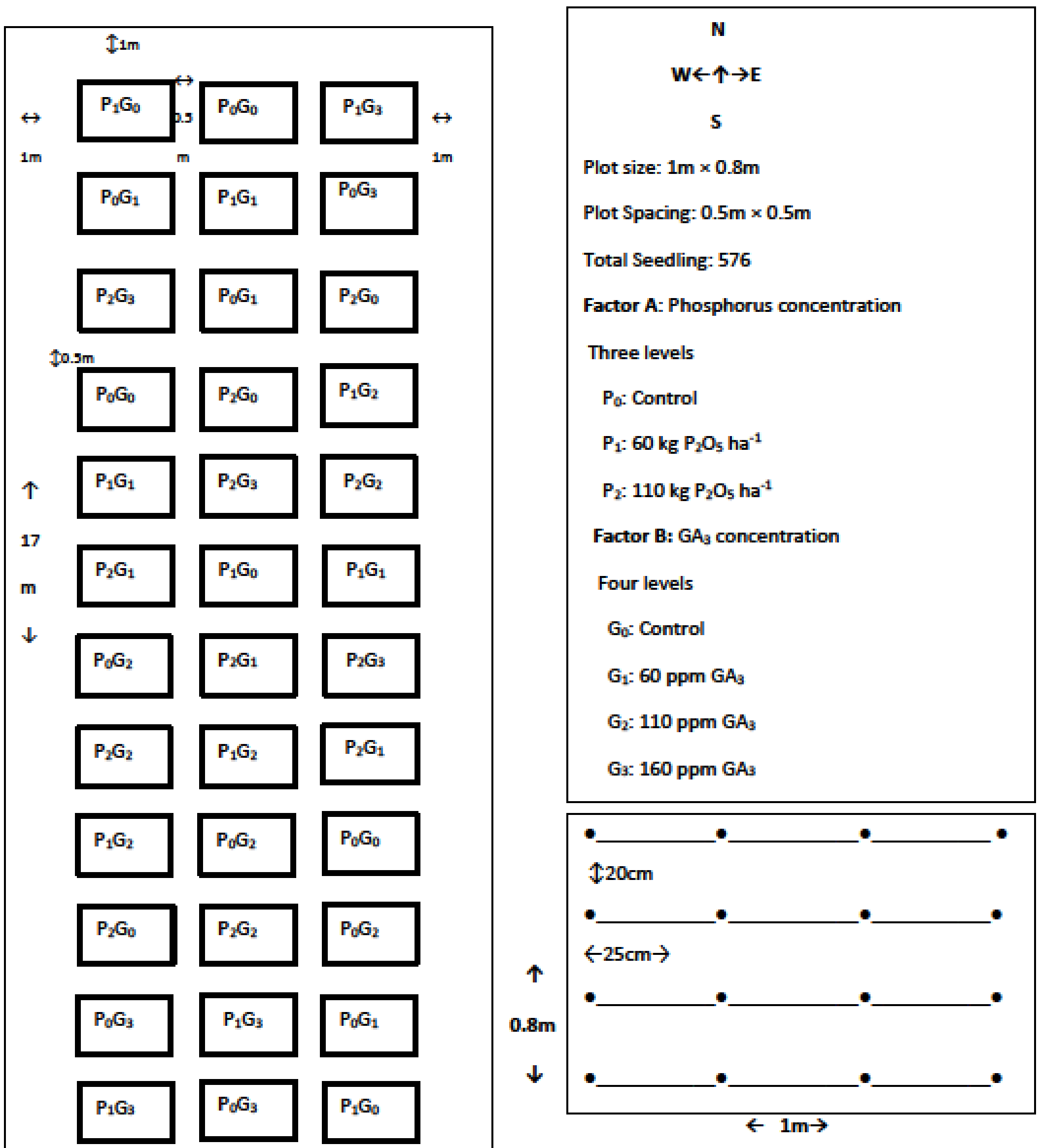


Fig: Layout of one plot

Figure 1. Layout of the experimental site (17m× 6m)

3.7 Production Method

3.7.1. Collection of materials

Seed of Havana-mix Cockscomb (*Celosia cristata*) was collected from Barisal Nursery, Aricha road, Savar, Dhaka on the month of October, 2017. Single packet of cockscomb contained two thousand seeds.

3.7.2 Seedbed Preparation

Standard seed bed was prepared on 20 October, 2017. Cockscomb seed was sown on 26 October, 2017 by broadcasting method. Frequently irrigation was done up to emergence of seedling.

3.7.3 Manures, fertilizers and their application methods

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP) were used as source of nitrogen, phosphorus and potassium respectively. Full dose of cow dung (5t ha^{-1}), Urea, TSP, MOP and Gypsum were incorporated during final land preparation. The following doses of manure and fertilizer were used for cockscomb cultivation shown as tabular form.

Table 1. Dose and method of application of fertilizers in Cockscomb field (Bangladesh Agricultural University, Mymensingh)

Fertilizer	Dose ha^{-1}	Application%
Cow dung	5 ton	100
Nitrogen (as Urea)	68 kg	100
P_2O_5 (as TSP)	23 kg	100
K2O (as MoP)	17 kg	100
Gypsum (as S)	4 kg	100

3.7.4 Collection, preparation and application of growth regulator

Plant growth regulator Gibberellic Acid (GA_3) was collected from Hatkhola Road, Dhaka. A 1000 ppm stock solution of GA_3 was prepared by dissolving 1 g of it in a small quantity of ethanol prior to dilution with distilled water in one liter of volumetric flask. The stock solution was used to prepare the required concentration for different treatment i.e. 60 ml of this stock solution was diluted in 1 liter of distilled water to get 60 ppm GA_3 solution. 110 ppm stock solutions were diluted to 1 liter of distilled water to get 110 ppm solution. In a similar way, 160 ppm stock solutions was diluted to 1 liter of distilled water to get 160 ppm solution. Control solution also prepared only by adding a small quantity of ethanol with distilled water. GA_3 as per treatment were applied three times at 15, 30 and 45 days after transplanting by a mini hand sprayer.

3.7.5 Transplanting of seedlings

Plantlet at the height of 2.5-5.0 cm was transplanted to the main field in the afternoon considering preconized plant population.

3.7.6 Irrigation and drainage

Light over-head irrigation was provided with a watering can to the seedbed. It was also done immediately after transplanting of cockscomb seedlings to main plots.

3.7.7 Weeding

Weeding was done in all the plots as required to keep the plot free from weeds, easy aeration of soil which ultimately ensured better growth and development of plants. Breaking of crust of the soil was done when needed.

3.7.8 Protection

Sevin powder and Bavistin 50 WP was sprayed around the seedbed to protect from black ant, termites and leaf spot disease. Before sowing seed treatment was done by Sevin powder.

3.7.9 Selection and tagging of plants

Ten plants from each of the plots were selected randomly for recording data for different characters.

3.7.10 Pest management

During seedling stage, mole cricket, field cricket and cutworm attacks were a problem for cockscomb cultivation. As a preventive measure against the insect pest, Karate was sprayed at 1 day interval for three times after transplanting.

3.7.11 Disease management

To check the fungal infection Dithane M-45 @ 0.2% was sprayed.

3.8 Data Collection

3.8.1 Plant height (cm)

The plant height was measured from the attachment of the ground level up to the tip of the growing point of plant. Plant height was recorded in centimeter (cm) from ten randomly selected plants at 15, 30 and 45 days after transplanting (DAT) by using scale and mean was calculated.

3.8.2 Stem length (cm)

The stem length was measured from the attachment of the ground level up to lower level of the growing point of plant. Stem length was recorded in centimeter (cm) from ten randomly selected plants at 15, 30 and 45 days after transplanting (DAT) by using scale and mean was calculated.

3.8.3 Number of leaves per plant

Number of leaves per plant was counted and data were recorded from randomly selected ten plants at 15, 30 and 45 days after transplanting (DAT) and mean was calculated.

3.8.4 Diameter of crown

Diameter of crown was recorded in centimeter (cm) and data were recorded from randomly selected ten plants at 15, 30 and 45 days after transplanting (DAT) and mean was calculated.

3.8.5 Length of spike (cm)

Length of the flower stalk was measured from the base to the tip of the spike at 15, 30 and 45 days after transplanting (DAT) and mean was calculated.

3.8.6 Breadth of the tip of spike

The spike tip of the cockscomb is wide, fleshy, crested, colorful and similar to conical shape. Tip breadth was measured from the base of the spike and up to the tip of the spike. Spike length was recorded in centimeter (cm) from ten randomly selected plants at 15, 30 and 45 days after transplanting (DAT) by using scale and mean was calculated.

3.8.7 Number of branches

The branch number was measured and recorded in centimeter (cm) from ten randomly selected plants at 15, 30 and 45 days after transplanting (DAT) by using scale and mean was calculated.

3.8.8 Number of spike per plant

All the spikelet of the spike was counted from 10 randomly selected plants and their mean was calculated at 15, 30 and 45 days after transplanting (DAT).

3.8.9 Number of spike per plot

Total number of spike was calculated from 10 randomly selected plants and it was multiplied with total number of plants in each plot of 0.8 m^2 area.

3.8.10 Number of spike per ha

Total number of spike calculated from eachplot of 0.8 m^2 area was converted to ha.

3.8.11 Dry weight of spike (g)

After electric oven drying of the cockscomb the dry weight of spike was recorded. The separation of spike from the stalk was done by cutting at the basal point of the stalk with the help of knife. Dry weight of spike was recorded in gram (g) from two randomly selected plants after harvesting by using electric balance. Then mean was calculated.

3.8.12 Dry weight of plant (g)

The entire cockscomb plant was dried with the help of electric oven and dry weight of plant was recorded. Dry weight of plant was recorded in gram (g) from two randomly selected plants after harvesting using electric balance and then mean was calculated.

3.9 Statistical Analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different doses of Phosphorus treatment and GA_3 application on growth and flower yield of cockscomb. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the "F" (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan"s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Plate 1. Seed bed for Cockscomb

Plate 2. Seed of Cockscomb

Plate 3. 1st day of emergence

Plate 4. Seedling in seedbed

Plate 6. 1st day of flowering

Plate 5. Transplanting of seedlings in main field

Plate 7. Cockscomb plant at 40 DAT

Plate 8. Field of Cockscomb

CHAPTER IV
RESULTS AND DISCUSSION

The present research was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka to find out the influence of Phosphorus and GA_3 on growth and flowering of Cockscomb. The analysis of variance (ANOVA) of the data on different growth and yield parameters had been shown in Appendices IV-XII. The outcome of the research have been presented and discussed in this chapter with the help of graphs and tables. Possible interpretations given under the following sub-headings:

4.1 Plant Height

Phosphorus plays an important role in manipulating plant growth. Plant height of Cockscomb showed significant differences due to application of phosphorus (Appendix III). Fig.2 represents a gradual increasing trend of plant height with days after transplanting for different doses of phosphorus application. The tallest plant (24.33 cm) was recorded from P_1 (60 Kg P_2O_5 ha^{-1}) treated plant and the smallest plant (20.54 cm) was found in P_0 treatment (0 Kg P_2O_5 ha^{-1}) at 15 DAT. On the other hand the maximum plant height (49.98 cm) was observed in the medium level of Phosphorus (P_1: 60 kg $P_2O_5ha^{-1}$) and the minimum plant height (31.76 cm) was recorded from the P_0 treatment (0kg P_2O_5 ha^{-1}) at 30 DAT. The tallest plant (53.300 cm) was recorded from P_1 (60 Kg $P_2O_5ha^{-1}$) treated plant and the smallest plant (42.45 cm) was found in P_0 treatment (0 Kg P_2O_5 ha^{-1}) at 40 DAT. Plant height was the lowest where there was no phosphorus applied to bed. Plant height 23.66, 44.54 and 51.72 cm were found from P_2 (110kg P_2O_5 ha^{-1}) at 15, 30 and 45 DAT, respectively. It was observed that with the increasing doze of phosphorus, plant height of cockscomb increased but after a certain level it decreased. Because excessive doze of phosphorus may occurred toxic condition and plant growth was hampered.

GA_3 act as growth promoter by promoting cell elongation and cell division. In considering the plant height at 15, 30 and 45 days after transplanting (DAT), the plant height of cockscomb was significantly influenced by foliar application of different concentration of GA_3 (Figure 3 and Appendix III). At 15 DAT, the longest plant height (24.20 cm) was obtained from medium level of GA_3 (G_2: 110 ppm of GA_3) and the shortest plant height (21.35 cm) was found from the control level of GA_3 (G_0: 0 ppm of GA_3). The highest plant height (45.91 cm) was observed from medium level of GA_3 (G_2: 110 ppm of GA_3) and the lowest plant height (38.25 cm) was found from the control level of GA_3 (G_0: 0 ppm of GA_3) at 30 DAT. At 45 DAT, the longest plant height (51.94cm) was obtained from medium level of GA_3 (G_2: 110 ppm of GA_3) and the shortest plant height (45.07cm) was found from the control level of GA_3 (G_0: 0 ppm of GA_3). So, the longest plant height was obtained from medium level of GA_3 (G_2) and the shortest plant height was found from the control level of GA_3. Plant height 23.41, 44.33 and 51.43 cm were found from G_3 treatment (160ppm) at 15, 30 and 45 DAT, respectively. It was found that with increasing dose of GA_3 plant height became start to decrease. So it was observed that high dose of GA_3 was not good for the growth of plant. Similar results were found by Talukdar and Paswan (1994).

Interaction effect between Phosphorus and foliar application of different levels of GA_3 on plant height of cockscomb was found significant at different days after transplanting (DAT) (Table 2 and Appendix III). At 15 DAT, the tallest plant (26.86 cm) was obtained from P_1G_2 (medium level of phosphorus with 110 ppm GA_3) while the shortest plant height (19.40 cm) was found in P_0G_0 (0kg P_2O_5 ha^{-1} with 0 ppm GA_3).The longest plant (53.33 cm) was found from P_1G_2 (60kg P_2O_5 ha^{-1} with 110 ppm GA_3) while the shortest plant height (30.73 cm) was observed in P_0G_0 at 30 DAT. At 45 DAT, the tallest plant (56.50 cm) was obtained from P_1G_2 (medium level of Phosphorus with 110 ppm GA_3) while the shortest plant (37.50 cm) was found in P_0G_0 (0 kg P_2O_5 with 0 ppm GA_3). Results explained that the growth was significantly differed due to different level of Phosphorus and GA_3 application. Maximum plant height was found in the medium level of P_2O_5 along with medium level of GA_3.

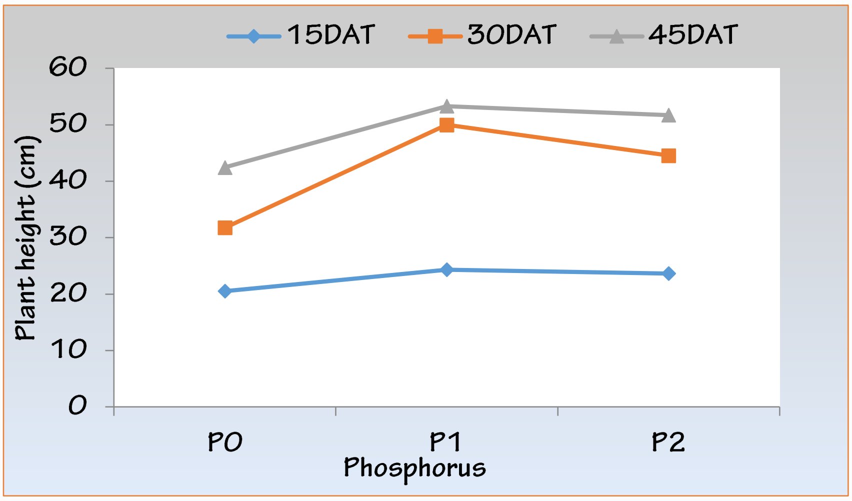


Figure2. Effect of Phosphorus on plant height (cm) of cockscomb at different days after transplanting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

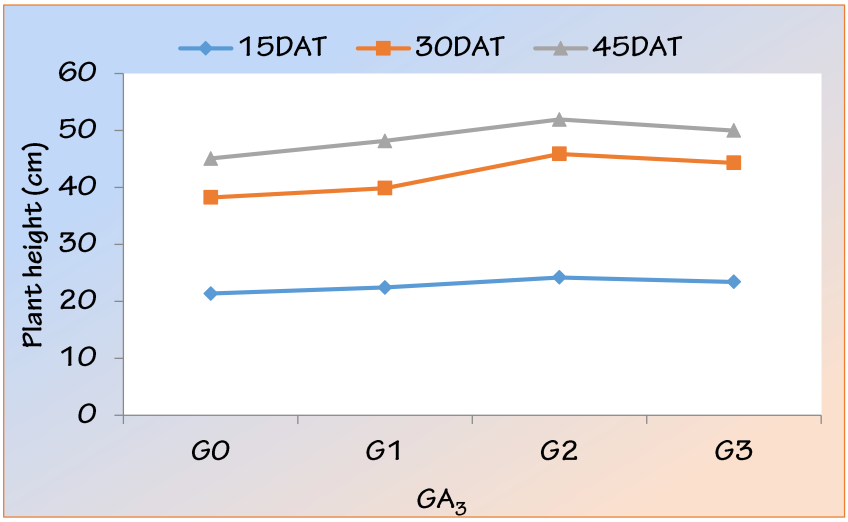


Figure 3. Effect of GA_3 on plant height (cm) of cockscomb at different days after transplanting. G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G3 -160 ppm GA_3.

Table 2. Effect of Phosphorus and GA_3 on plant height (cm) of cockscomb at different days after transplanting

TREATMENT	15 DAT	30 DAT	45 DAT
P_0G_0	19.40 f	30.73 c	37.50 g
P_0G_1	20.33 ef	32.00 bc	41.73 f
P_0G_2	21.66 cde	32.66 bc	44.66 e
P_0G_3	20.76 def	31.66 c	45.93 e
P_1G_0	22.86 bcd	35.50 bc	46.06 e
P_1G_1	23.20 bc	39.00 b	50.33 d
P_1G_2	26.86 a	53.33 a	56.50 a
P_1G_3	24.40 b	50.33 ab	54.00 abc
P_2G_0	21.80 cde	48.53 b	51.66 cb
P_2G_1	23.73 bc	48.66 b	52.50 bcd
P_2G_2	24.06 b	51.73 ab	54.66 ab
P_2G_3	25.06 ab	51.00 ab	54.36 abc
$LSD_{(0.05)}$	1.070	3.29	1.35
CV%	5.74	9.59	3.38

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}

G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

4.2 Stem Length

Stem length of cockscomb showed statistically significant differences on different application of Phosphorus at 15, 30 and 45 DAT (Figure 4 and Appendix IV). The highest stem length (18.46 cm) was obtained from the medium level of Phosphorus (P_1:60kg P_2O_5 ha^{-1}) and lowest stem length (15.01 cm) was obtained from P_0 treatment (0kg P_2O_5 ha^{-1}) at 15 DAT. At 30 DAT, the highest stem length (35.583 cm) was obtained from medium level of P (P_1: 60kg P_2O_5 ha^{-1}) and the lowest stem length (25.50cm) was obtained from P_0 treatment (0kg $P_2O_5ha^{-1}$). The highest stem length (38.56 cm) was obtained from medium level of P (P_1:60kg $P_2O_5ha^{-1}$) and the lowest stem length

(33.68cm) was obtained fromP_0 treatment (0kg $P_2O_5ha^{-1}$) at 45 DAT. The result revealed that stem length was highest in the medium level of Phosphorus(P_1) and stem length was the lowest where there was no phosphorus applied to bed Phosphorus(P_0). With the increasing doze of phosphorus stem length of cockscomb increased but after a certain level it decreased. Because excessive doze of phosphorus caused toxic condition and plant growth was hampered.

Stem length of cockscomb varied significantly due to foliar application of GA_3 at 15, 30 and 45 DAT (Figure 9 and Appendix IV). The tallest stem (18.46 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the smallest stem (16.31 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 15 DAT. At30 DAT, The tallest stem (34.33 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the smallest stem (29.77 cm) was found in control treatment of G_0 (0 ppm of GA_3). The tallest stem (38.53 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the smallest stem (34.40 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 45 DAT. Results explained that the maximum stem length was obtained from medium level of GA_3 (G_2) and the minimum stem length was found from the control level of GA_3. Because with the increasing doze of GA_3 stem length of cockscomb improved but after a certain level it reduced even it showed lower effect.

Interaction effect between Phosphorus treatment and foliar application of GA_3 on stem length of cockscomb showed significant variation at 15, 30 and 45 DAT (Table 3 and Appendix IV).). It was observed that the tallest stem (21.93 cm) was produced by P_1G_2 (60 kg P_2O_5 with 110 ppm GA_3) and the shortest stem (13.60) was obtained from P_0G_0 (0 kg P_2O_5 $ha^{-1}$with 0 ppm GA_3) at 15 DAT. At30 DAT, the tallest stem (39.33 cm) was produced by P_1G_2 (60 kg $P_2O_5$with 110 ppm GA_3) and the shortest stem (23.33 cm) was obtained from P_0G_0 (0 kg P_2O_5 ha^{-1} with 0 ppm GA_3) .The tallest stem (41.33 cm) was produced by P_1G_2 (60kg $P_2O_5$with 110 ppm GA_3) and the shortest stem (32.26 cm) was obtained from P_0G_0 (0 kg P_2O_5 $ha^{-1}$with 0 ppm GA_3) .So the combination of medium level of Phosphorus with moderate level of GA_3 showed the best performance.

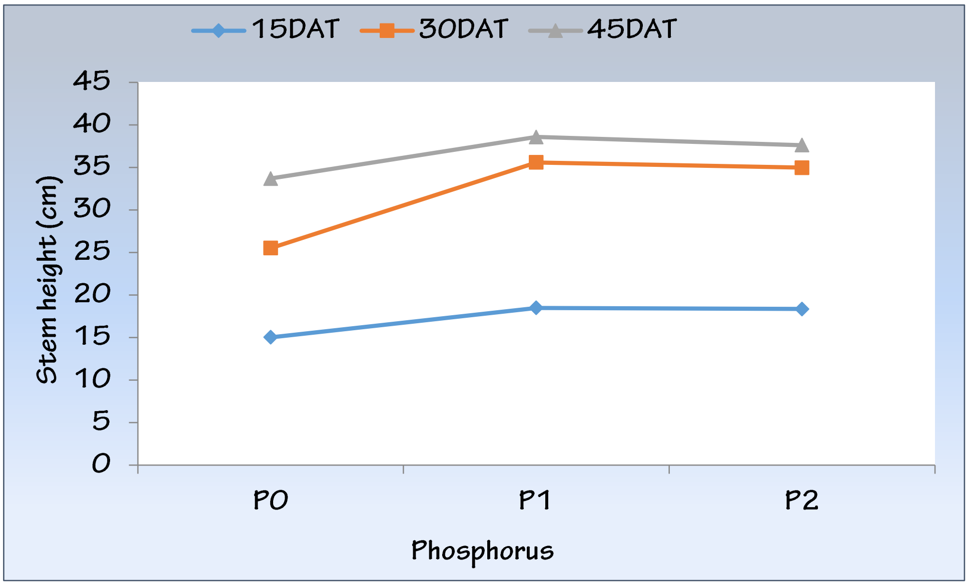


Figure 4. Effect of Phosphorus on Stem height (cm) of cockscomb at different days after transplanting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

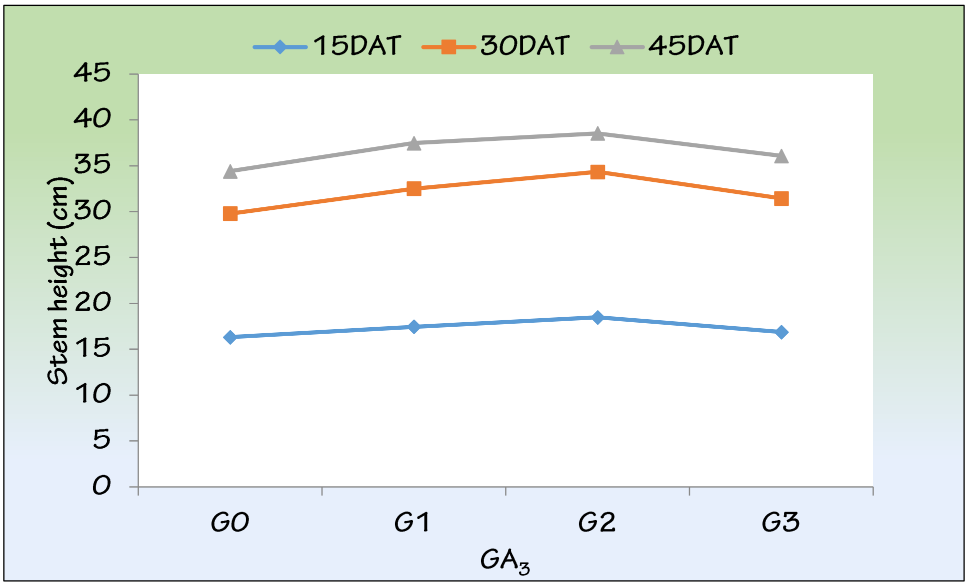


Figure 5. Effect of GA_3 on Stem height (cm) of cockscomb at different days after transplanting. G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 160ppm GA_3.

Table 3. Effect of Phosphorus and GA_3 on Stem height (cm) of cockscomb at different days after transplanting

TREATMENT	15 DAT	30 DAT	45 DAT
P_0G_0	13.60 b	23.33 f	32.26 d
P_0G_1	15.00 cd	26.00 e	35.93 bcd
P_0G_2	16.00 cd	27.33 e	33.53 cd
P_0G_3	15.46cd	25.33 ef	33.00 cd
P_1G_0	17.40 bc	31.66 d	37.20 abc
P_1G_1	17.93bc	34.83 bc	37.40 abc
P_1G_2	21.93a	39.33 a	41.33 a
P_1G_3	16.60bcd	34.00 cd	34.46 bcd
P_2G_0	19.60ab	34.33 bc	38.73 ab
P_2G_1	19.40ab	36.66 b	39.06 ab
P_2G_2	17.46bc	36.33 bc	40.73 a
P_2G_3	16.86bcd	35.00 bc	35.73 bcd
$LSD_{(0.05)}$	1.62	1.27	2.28
CV%	11.50	4.88	7.64

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}

G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

4.3 Leaves Number per Plant

Leaves play important role in the growth of plant because of its photosynthetic activities. Significant variation was recorded for different level of Phosphorus treatment of cockscomb in terms of leaves number per plant at 15, 30 and 45 days after transplanting (Figure 6 and Appendix V). At 15 DAT, the highest number of leaves per plant (17.41) was obtained from P_1 (60 kg P_2O_5 ha^{-1}) and the lowest number of leaves (13.15) was found from P_0 (0kg $P_2O_5ha^{-1}$). At 30 DAT, the highest number of leaves per plant (40.90) was obtained from medium level of Phosphorus which is P_1 (60 kg P_2O_5 ha^{-1}) and the minimum number of leaves per plant (27.05) was found from the P_0 (0 kg $P_2O_5ha^{-1}$). The highest number of leaves per plant (91.43) was found from P_1 (60 kg $P_2O_5ha^{-1}$) and the lowest number of leaves per plant (80.15) was obtained from the control level of Phosphorus P_0 (0kg $P_2O_5ha^{-1}$) at 45 DAT. The leaves number per plant was higher in medium level of Phosphorus treatment (P_1) and lower in control (P_0). The result in respect of leaves number was similar with the results of Smitha *et al.* (2011).

GA_3 increases leaves number of plant even when lack of nutrients in the soil. Number of leaves per plant also showed significant variation due to foliar application of different concentration of GA_3 at 15, 30 and 45 days after transplanting (DAT) (Figure 7 and Appendix V). Results defined that at 15 DAT, the highest number of leaves per plant (17.51) was recorded from medium level of GA_3 (G_2: 110 ppm of GA_3) and the lowest number of leaves per plant (14.15) was recorded from control treatment G_0 (0 ppm of GA_3). The highest number of leaves per plant (38.211) was recorded from medium level of GA_3 (G_2: 110 ppm of GA_3) and the lowest number of leaves per plant (32.64) was recorded from control treatment G_0 (0 ppm of GA_3) at 30 DAT. At 45 DAT, G_2 (110 ppm of GA_3) produced the highest number of leaves (93.86) while the lowest number of leaves per plant (82.05) was produced from control treatment G_0 (0 ppm of GA_3). Maximum leaves number per plant was obtained from medium level of GA_3 (G_2) and minimum leaves number per plant was found from the control level GA_3 (G_0).

Interaction effect of Phosphorus treatment and foliar application of different levels of GA_3 on leaves number per plant of cockscomb showed significant variation at different days after transplanting (DAT) (Table 4 and Appendix V). At 15 DAP, the highest number of leaves per plant (19.01) was recorded from treatment combination of P_1G_2 (60kg P_2O_5 $ha^{-1}$with 110 ppm GA_3) and the lowest number of leaves per plant (11.000) was recorded from treatment combination of P_0G_0 (0kg P_2O_5 ha^{-1} with 0 ppm GA_3). The highest number of leaves per plant (42.46) was recorded from the treatment combination of P_1G_2

and the lowest number of leaves per plant (24.40) was recorded from treatment combination of P_0G_0 (0kg P_2O_5 ha^{-1}0 ppm GA_3) at 30 DAT.

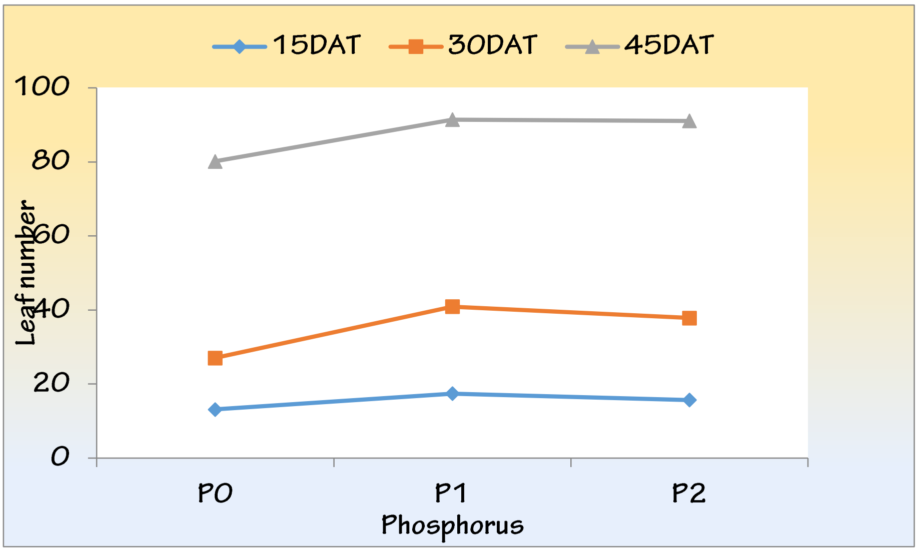


Figure 6. Effect of Phosphorus on leaf number of cockscomb at different days after transplanting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

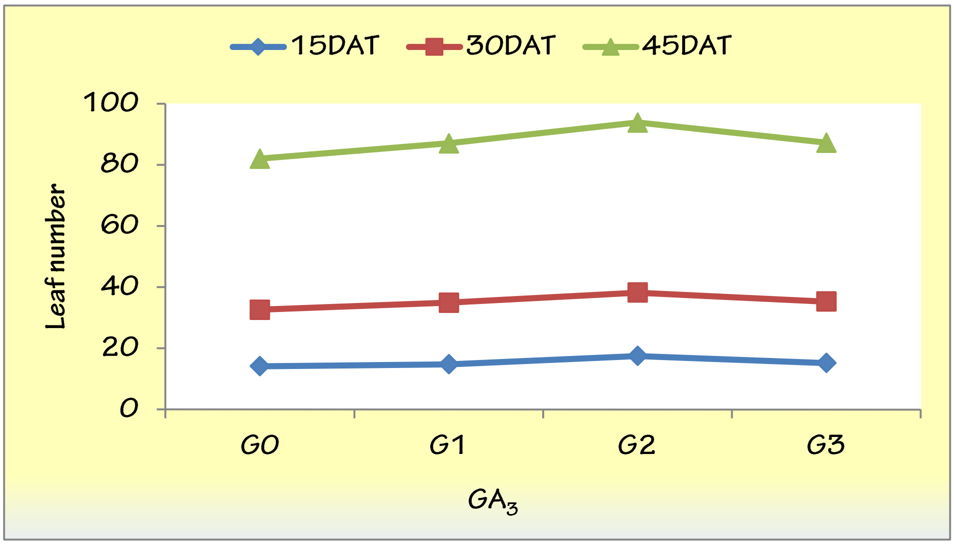


Figure 7. Effect of GA_3 on leaf number of cockscomb at different days after transplanting. G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 -160 ppm GA_3.

The highest number of leaves per plant (97.667) was recorded from treatment combination of P_1G_2 (60kg $P_2O_5ha^{-1}$with 110 ppm GA_3) and the lowest number of leaves per plant (66.33) was recorded from treatment combination of P_0G_0 (0kg P_2O_5 $ha^{-1}$with 0 ppm GA_3) at 45 DAT. From the results of the present study explained that the maximum leaves number per plant was obtained from medium level of Phosphorus treatment along with medium level of GA_3 and the minimum leaves number per plant was obtained from the control treatment of Phosphorus along with 0 ppm of GA_3. Moderate level of Phosphorus treatment with medium level of GA_3 combination might have induced better growing condition which ultimately led to the production of more leaves per plant of cockscomb.

Table 4. Effect of Phosphorus and GA_3 on leaf number of cockscomb at different days after transplanting

TREATMENT	15 DAT	30 DAT	45 DAT
P_0G_0	11.00 f	24.40 f	66.33 c
P_0G_1	12.46 ef	26.73 e	79.30 ab
P_0G_2	15.26 bcd	31.33 d	88.20 ab
P_0G_3	13.86 de	25.73 ef	86.80 b
P_1G_0	14.13 cde	33.20 d	89.33 b
P_1G_1	14.53 cde	36.26 c	90.00 ab
P_1G_2	18.86 a	42.46 a	97.66 a
P_1G_3	15.66 bcd	39.53 b	87.40 b
P_2G_0	17.33 ab	40.33 ab	90.50 b
P_2G_1	17.40 ab	41.76 ab	91.83 ab
P_2G_2	18.40 ab	40.83 ab	95.73 a
P_2G_3	16.06 bc	40.66 ab	87.66 b
$LSD_{(0.05)}$	1.04	1.08	8.99
CV%	8.31	3.78	12.58

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}
G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

4.4 Diameter of Crown

Diameter of crown of Cockscomb showed significant differences due to application of phosphorus (Fig 8 and Appendix VI). Fig.8 represents a gradual increasing trend of crown diameter with days after transplanting for different doses of phosphorus application. The highest diameter of crown of Cockscomb (0.97 cm) was obtained from the medium level of Phosphorus (P_1:60kg P_2O_5 ha^{-1}) and lowest diameter of crown (0.87cm) was obtained from P_0 treatment

(0kg P_2O_5 ha^{-1}) at 15 DAT. At 30 DAT, the highest diameter of crown (1.70 cm) was obtained from medium level of P (P_1: 60kg P_2O_5 ha^{-1}) and the lowest diameter of crown (1.13 cm) was obtained from P_0 treatment (0 kg P_2O_5 ha^{-1}). The highest crown diameter (2.466 cm) was obtained from medium level of P (P_1:60kg P_2O_5 ha^{-1}) and the lowest crown diameter (1.25 cm) was obtained from P_0 treatment (0kg P_2O_5 ha^{-1}) at 45 DAT. The result revealed that diameter of crown was the highest in the medium level of Phosphorus (P_1) and was the lowest where there was no phosphorus applied to bed (P_0).

Significant difference in diameter of crown was found due to variation of GA_3 application at 15, 30 and 45 DAT (Figure 9 and Appendix VI). The highest crown diameter (0.98 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the smallest crown diameter (0.85 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 15 DAT. At 30 DAT, The highest diameter of crown (1.74 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest diameter of crown (1.30 cm) was found in control treatment of G_0 (0 ppm of GA_3). The highest crown diameter (2.61 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest crown diameter (1.63 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 45 DAT. Results explained that the maximum crown diameter was obtained from medium level of GA_3 (G_2) and the minimum crown diameter was found from the control level of GA_3.Because with the increasing doze of GA_3crown diameter of cockscomb improved but after a certain level it reduced even it showed lower effect. (Appendix VI).

Significant difference was observed due to the combined effect of different level of phosphorus and GA_3 application on crown diameter at 20, 30 and 40 DAT (Appendix VI). It was observed that highest diameter of crown (1.06 cm) was produced by P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest diameter of crown (0.72 cm) was obtained from P_0G_0treatment (0kg P_2O_5 ha^{-1} with 0ppm of GA_3)at 15 DAT (Table 5).At 30 DAT, highest diameter of crown (2.03 cm) was found from P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest diameter of crown (1.00 cm) was obtained from P_0G_0 treatment (0kg

P_2O_5 ha^{-1} with 0ppm of GA_3) (Table 4).On the other hand it was observed that highest diameter of crown (3.73 cm) was produced by P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest diameter of crown (1.06 cm) was obtained from P0G0 treatment (0kg P_2O_5 ha^{-1} with 0ppm of GA_3) at 45 DAT (Table 5).

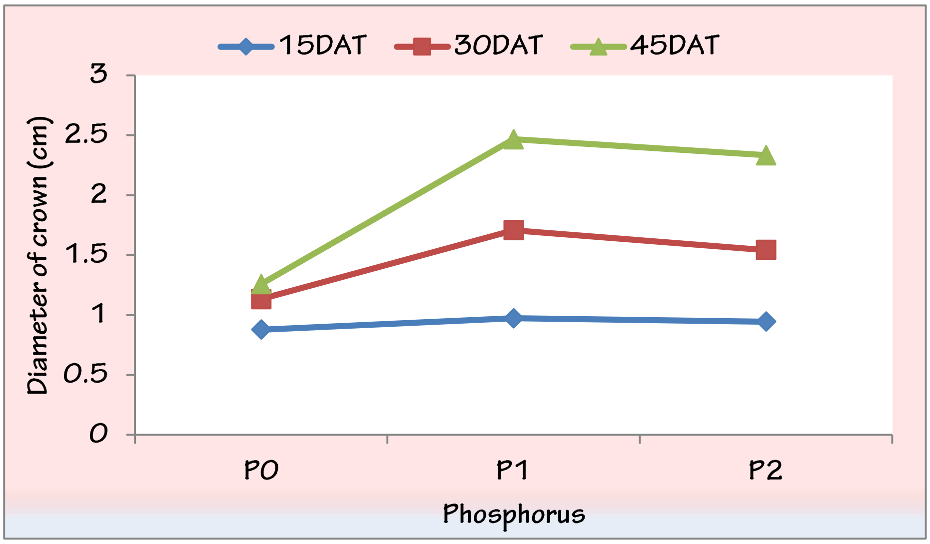


Figure 8. Effect of Phosphorus on Diameter of crown of cockscomb at different days after transplanting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

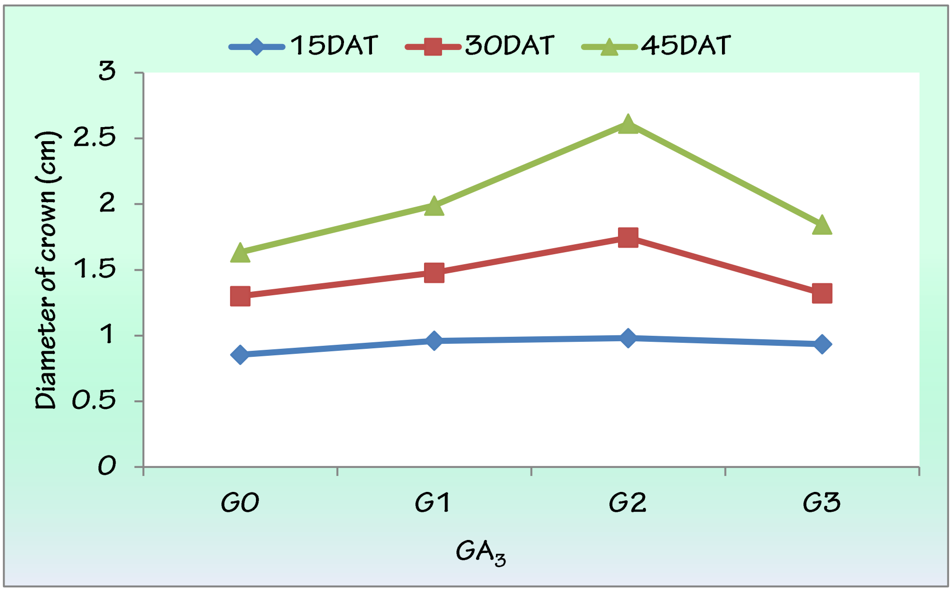


Figure 9. Effect of GA_3 on Diameter of crown of cockscomb at different days after transplanting. G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 - 160ppm GA_3.

Table 5. Effect of Phosphorus and GA_3 on Diameter of crown (cm) of cockscomb at different days after transplanting

TREATMENT	15 DAT	30 DAT	45 DAT
P_0G_0	0.72 b	1.03 de	1.20 e
P_0G_1	0.96ab	1.20 cde	1.30 de
P_0G_2	0.93ab	1.30 cde	1.46 cde
P_0G_3	0.88ab	1.00 e	1.06 e
P_1G_0	0.90ab	1.30 cde	1.46 cde
P_1G_1	0.98ab	1.40 cd	2.10 bc
P_1G_2	1.06a	2.03 a	3.73 a
P_1G_3	0.94ab	1.43 c	2.03 bcd
P_2G_0	0.92ab	1.56 bc	2.23 b
P_2G_1	0.93ab	1.83 ab	2.56 b
P_2G_2	0.94ab	1.90 ab	2.63 b
P_2G_3	0.97ab	1.53 bc	2.43 b
$LSD_{(0.05)}$	0.08	0.18	0.36
CV%	11.44	15.30	21.96

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}

G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

4.5 Spike Length

Spike length of cockscomb varied significantly for different level of Phosphorus at 15, 30 and 45 DAT (Figure 10 and Appendix VII). The highest spike length (2.64 cm) was obtained from medium level of Phosphorus (P_1:60 kg P_2O_5 ha^{-1}) and the lowest spike length (2.43 cm) was obtained from of P_0 (0 kg $P_2O_5ha^{-1}$) at 15 DAT. At 30 DAT, the highest spike length (7.16 cm) was obtained from medium level of Phosphorus (P_1: 60 kg P_2O_5 ha^{-1}) and the lowest spike length (4.02 cm) was obtained from P_0 (0 kg $P_2O_5ha^{-1}$). The highest spike length (7.67 cm) was obtained from P_1 (60 kg $P_2O_5ha^{-1}$) and the lowest spike length (6.64 cm) was obtained from P_0 (0 kg P_2O_5 ha^{-1}) at 45 DAT. The result indicated that the spike length was higher in P_1 and lower in P_0. Spike length of cockscomb showed significant differences due to foliar application of different levels of GA3 at 15, 30 and 45 DAT (Figure 11 and Appendix VII). The tallest spike (2.66 cm) was recorded from G2 (110 ppm of GA3) treated plant and the lowest spike length (2.4667 cm) was found in control treatment of G0 (0 ppm of GA3) at 15 DAT. At 30 DAT, the highest spike length (6.8444 cm) was recorded from G2 (110 ppm of GA3) treated plant and the lowest spike length (4.81 cm) was found in control treatment of G0 (0 ppm of GA3). The highest spike length (8.11 cm) was recorded from G2 (110 ppm of GA3) treated plant and the lowest spike length (6.8667 cm) was found in control treatment of G0 (0 ppm of GA3) at 45 DAT. The longest spike length was obtained from medium level of GA3 (G2) and the shortest spike length was found from the control level of GA3. This result is also similar with the findings of Deva danam et al. (2007). Significant difference was observed due to the combined effect of different level of phosphorus and GA3 application on Spike length at 20, 30 and 40 DAT (Appendix VII). It was observed that highest spike length (2.84 cm) was produced by P1G2 (60 kg P2O5 ha-1 with 110 ppm of GA3) and lowest Spike length (2.36 cm) was obtained from P0G0 treatment (0kg P2O5 ha-1 with 0ppm of GA3)at 15 DAT (Table 6).At 30 DAT, highest spike length (8.06 cm) was found from P1G2 (60 kg P2O5 ha-1 with 110 ppm of GA3) and lowest Spike length (3.1000 cm) was obtained from P0G0 treatment (0kg P2O5 ha-1 with 0ppm of GA3) (Table 6).On the other hand it was observed that highest Spike length (8.70 cm) was produced by P1G2 (60 kg P2O5 ha-1 with 110 ppm of GA3) and lowest (6.16 cm) was obtained from P0G0 treatment (0kg P2O5 ha-1 with 0ppm of GA3)at 45 DAT (Table 6) Spike length of cockscomb showed significant differences due to foliar application of different levels of GA_3 at 15, 30 and 45 DAT (Figure 11 and Appendix VII). The tallest spike (2.66 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest spike length (2.4667 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 15 DAT. At 30 DAT, the highest spike length (6.8444 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest spike length (4.81 cm) was found in control treatment of G_0 (0 ppm of GA_3). The highest spike length (8.11 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest spike length (6.8667 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 45 DAT. The longest spike length was obtained from medium level of GA_3 (G_2) and the shortest spike length was found from the control level of GA_3. This result is also similar with the findings of Deva danam *et al.* (2007). Significant difference was observed due to the combined effect of different level of phosphorus and GA_3 application on Spike length at 20, 30 and 40 DAT (Appendix VII). It was observed that highest spike length (2.84 cm) was produced by P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest Spike length (2.36 cm) was obtained from P_0G_0 treatment (0kg P_2O_5 ha^{-1} with 0ppm of GA_3)at 15 DAT (Table 6).At 30 DAT, highest spike length (8.06 cm) was found from P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest Spike length (3.1000 cm) was obtained from P_0G_0 treatment (0kg P_2O_5 ha^{-1} with 0ppm of GA_3) (Table 6).On the other hand it was observed that highest Spike length (8.70 cm) was produced by P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest (6.16 cm) was obtained from P_0G_0 treatment (0kg P_2O_5 ha^{-1} with 0ppm of GA_3)at 45 DAT (Table 6)

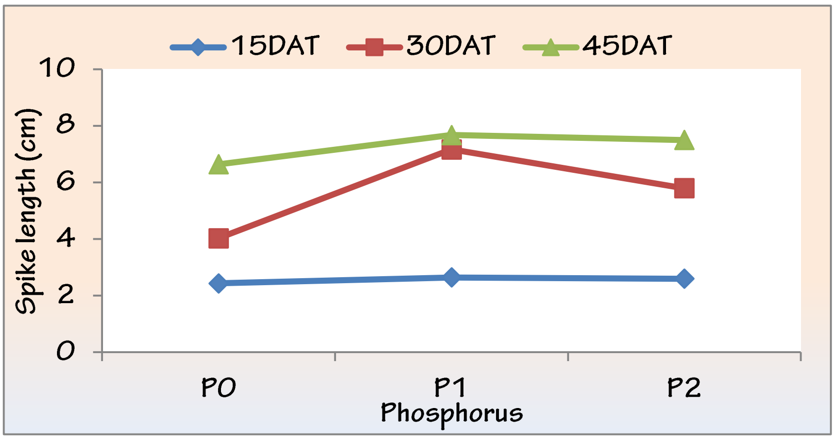


Figure 10. Effect of Phosphorus on spike length (cm) of cockscomb at different days after transplanting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg $P_2O_5ha^{-1}$

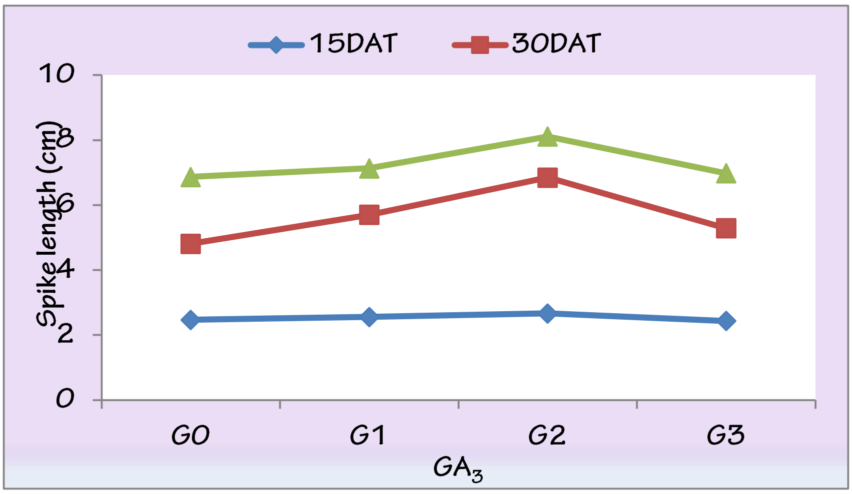


Figure 11. Effect of GA_3 on spike length (cm) of cockscomb at different days after transplanting. G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3,G_3-160 ppm GA_3.

Table 6. Effect of Phosphorus and GA_3 on spike length (cm) of cockscomb at different days after transplanting

TREATMENT	15 DAT	30 DAT	45 DAT
P_0G_0	2.36b	3.10d	6.16e
P_0G_1	2.52ab	4.33cd	6.60cde
P_0G_2	2.52ab	4.50cd	7.46bc
P_0G_3	2.32 b	4.16cd	6.33de
P_1G_0	2.41ab	4.60cd	7.16bcde
P_1G_1	2.68ab	5.33bc	7.46bc
P_1G_2	2.84a	8.06a	8.70a
P_1G_3	2.63ab	5.16bc	6.66 cde
P_2G_0	2.62ab	6.73ab	7.60bc
P_2G_1	2.76ab	7.43ab	7.33bcd
P_2G_2	2.64ab	7.96ab	8.16ab
P_2G_3	2.35ab	6.53abc	7.60bc
$LSD_{(0.05)}$	0.24	0.90	0.50
CV%	11.90	19.51	8.43

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}

G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

Plate 9. Effect of Phosphorus and GA3 on spike length (cm) of Cockscomb at 45 Days after transplanting

4.6 Spike Tip Breadth

Significant difference in breadth of tip of spike was found due to variation of Phosphorus application at 15, 30 and 45 DAT (Fig 12 and Appendix VIII).The highest spike tip breadth (1.00 cm) was obtained from medium level of Phosphorus (P_1: 60 kg P_2O_5ha^{-1}) and the lowest spike tip breadth (0.82 cm) was obtained from of P_0 (0 kg P_2O_5 ha^{-1}) at 15 DAT. At 30 DAT, the highest spike tip breadth (3.95 cm) was obtained from medium level of Phosphorus (P_1: 60 kg P_2O_5 ha^{-1}) and the lowest spike tip breadth (2.47) was obtained from P_0 (0 kg P_2O_5 ha-^{1}). The highest spike tip breadth (6.02 cm) was obtained from P_1 (60 kg P_2O_5 ha^{-1}) and the lowest spike tip breadth (4.12 cm) was obtained from P_0 (0 kg P_2O_5 ha$^{-1)}$ at 45 DAT. The result indicated that the spike length was higher in P_1 and lower in P_0.

Spike tip breadth of cockscomb showed significant differences due to foliar application of different levels of GA_3 at 15, 30 and 45 DAT (Figure 13 and Appendix VIII). The highest spike tip breadth (1.00cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest spike tip breadth (0.86 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 15 DAT. At 30 DAT, the highest spike tip breadth (3.88 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest spike tip breadth (3.0889 cm) was found in control treatment of G_0 (0 ppm of GA_3). The highest spike tip breadth (6.16 cm) was recorded from G_2 (110 ppm of GA_3) treated plant and the lowest spike tip breadth (4.85 cm) was found in control treatment of G_0 (0 ppm of GA_3) at 45 DAT. The longest spike tip breadth was obtained from medium level of GA_3 (G_2) and the shortest spike tip breadth was found from the control level of GA_3.

Significant difference was observed due to the combined effect of different level of phosphorus and GA_3 application on Spike tip breadth at 20, 30 and 40 DAT (Appendix VIII). It was observed that highest spike tip breadth (1.18 cm) was produced by P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest Spike tip breadth (0.71 cm) was obtained from P_0G_0 treatment (0kg P_2O_5 ha^{-1}

with 0ppm of GA_3) at 15 DAT (Table 4). At 30 DAT, highest spike tip breadth (4.40 cm) was found from P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest Spike tip breadth (1.93 cm) was obtained from P_0G_0 treatment (0 kg P_2O_5 ha^{-1} with 0ppm of GA_3) (Table 7).On the other hand it was observed that highest Spike tip breadth(7.26 cm) was produced by P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm of GA_3) and lowest (3.93 cm) was obtained from P_0G_0 treatment (0 kg P_2O_5 ha^{-1} with 0ppm of GA_3) at 45 DAT (Table 7).

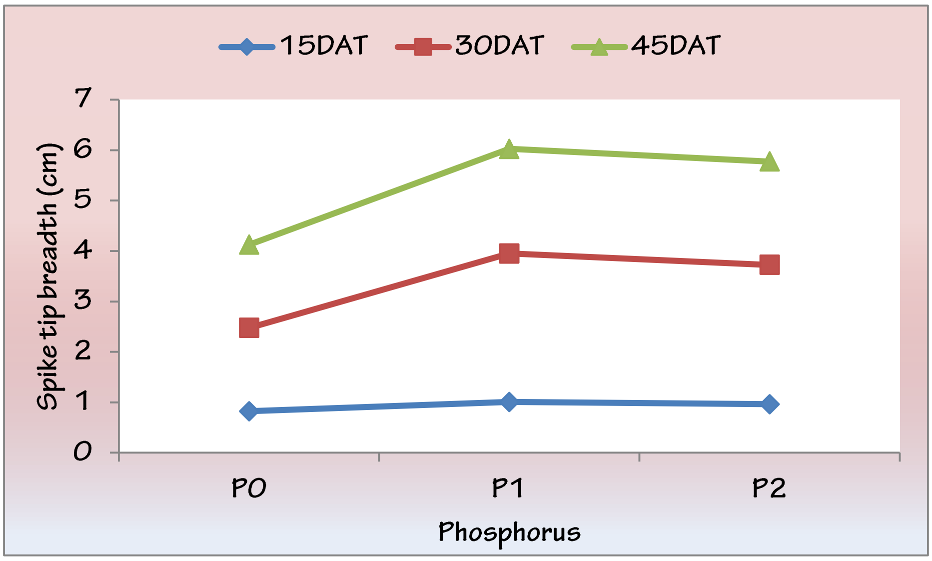


Figure 12. Effect of Phosphorus on spike tip breadth (cm) of cockscomb at different days after transplanting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

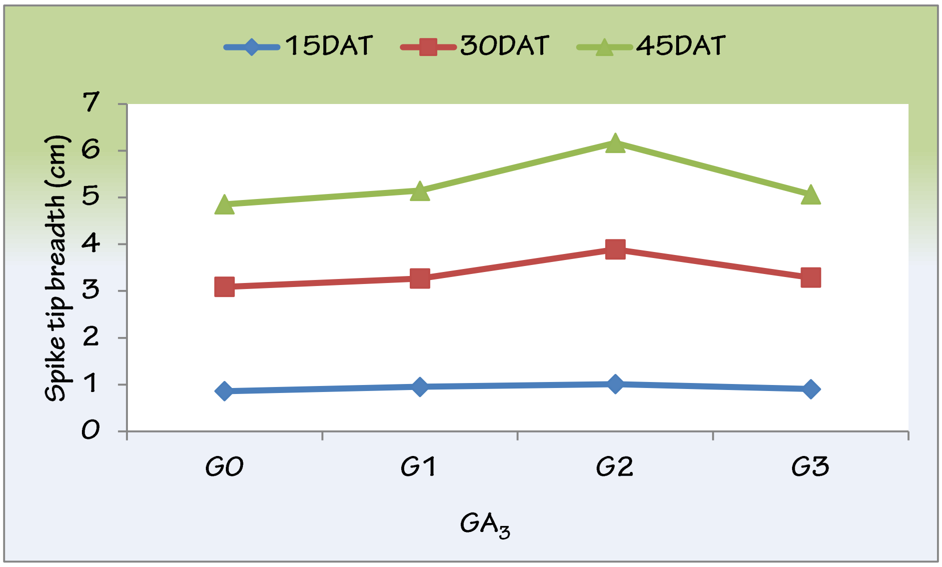


Figure 13. Effect of GA_3 on spike tip breadth (cm) of cockscomb at different days after transplanting. G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 -160 ppm GA_3.

Table 7. Effect of Phosphorus and GA_3 on spike tip breadth (cm) of cockscomb at different days after transplanting

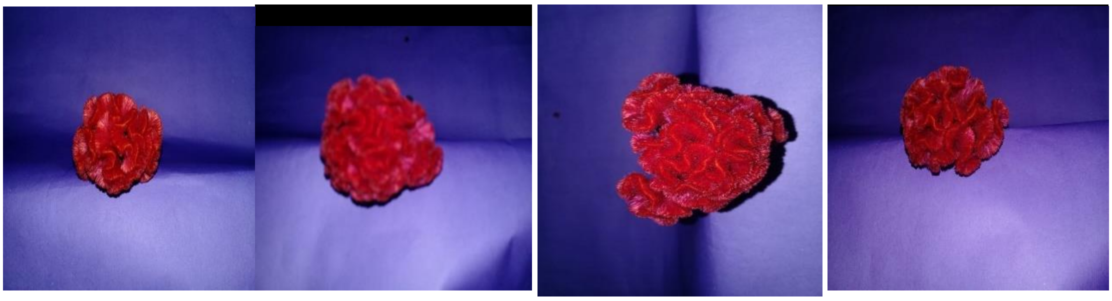
TREATMENT	15 DAT	30 DAT	45 DAT
P_0G_0	0.71 d	1.93e	3.93 g
P_0G_1	0.81 cd	2.30de	4.06 g
P_0G_2	0.87 bcd	3.16 bcd	4.73 f
P_0G_3	0.88 bcd	2.50 cde	3.76 g
P_1G_0	0.90 bcd	3.43 abc	5.00 ef
P_1G_1	1.01 abc	3.46abc	5.30 de
P_1G_2	1.18 a	4.40 a	7.26 a
P_1G_3	0.94 bc	3.60 ab	5.53 cde
P_2G_0	0.96 bc	3.90 ab	5.63 cd
P_2G_1	1.02 ab	4.03ab	6.06 bc
P_2G_2	0.97 bc	4.10ab	6.50 b
P_2G_3	0.88 bcd	3.76 ab	5.90 c
$LSD_{(0.05)}$	0.09	0.47	0.26
CV%	13.11	17.15	6.19

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}

G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

P_0 (4.12 cm) **P_1 (6.02 cm)** **P_2 (5.77 cm)**

Plate 10. Effect of Phosphorus on spike tip breadth (cm) of cockscomb at 45days after transplanting



G_0 (6.8667cm) **G_1 (7.1333cm)** **G_2 (8.111cm)** **G_3 (6.9778cm)**

Plate 11. Effect of GA_3 on spike tip breadth (cm) of cockscomb at 45 days after transplanting

4.7 Branch Number per Plant

Significant variation was recorded for branch number per plant of cockscomb because of different level of Phosphorus application at 15, 30 and 45 days after transplanting (Figure 14 and Appendix IX).The highest number of branches per plant (2.80) was obtained from medium level of Phosphorus (P_1: 60 kg $P_2O_5ha^{-1}$) and the lowest number of branches per plant (2.00) was obtained from of P_0 (0 kg P_2O_5 ha^{-1}) at 15 DAT. At 30 DAT, the highest number of branches per plant (8.05) was obtained from medium level of Phosphorus (P_1: 60 kg P_2O_5 ha^{-1}) and the lowest number of branches per plant (5.53) was obtained from P_0 (0 kg P_2O_5 ha^{-1}). The highest number of branches per plant (13.95) was obtained from P_1 (60 kg P_2O_5 ha^{-1}) and the lowest number of branches per plant (9.45) was obtained from P_0 (0 kg P_2O_5 ha^{-1}) at 45 DAT. The result indicated that branch number per plant of cockscomb was higher in P_1 and lower in P_0.

GA_3 can stimulate rapid branching by inducing mitotic division. The branch number per plant also varied significantly due to foliar application of different concentration of GA_3 at 15, 30 and 45 days after transplanting (DAT) (Figure 15 and Appendix IX). From the study it was found that the maximum number of branches per plant (3.01) was recorded from medium level of GA_3 (G_2: 110 ppm of GA_3) and the minimum number of branches per plant (2.21) was recorded from control treatment of G_0 (0 ppm of GA_3) at 15 DAT.

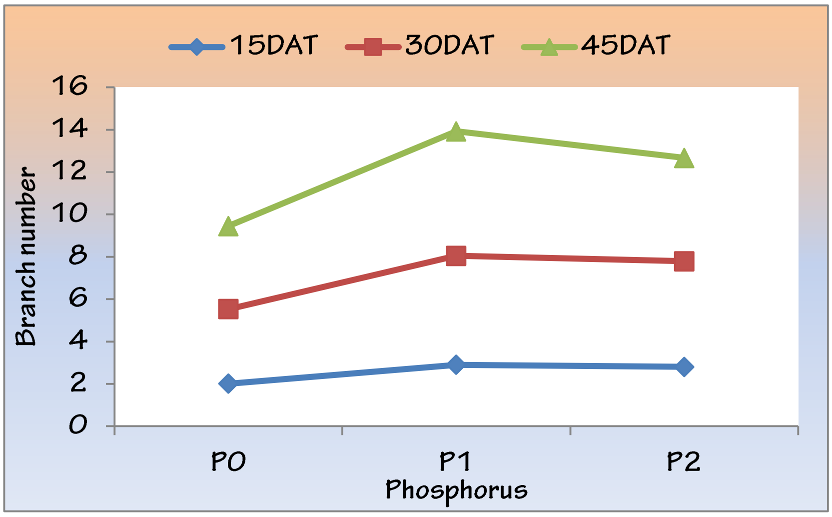


Figure 14. Effect of Phosphorus on Branch number of cockscomb at different days after transplanting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

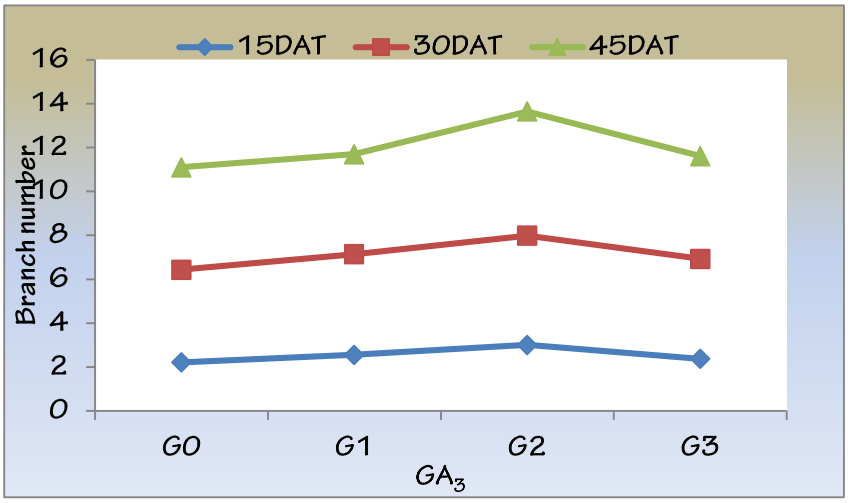


Figure 15. Effect of GA_3 on Branch number of cockscomb at different days after transplanting. G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 -160 ppm GA_3.

The maximum number of branches per plant (7.98) was recorded from medium level of GA_3 (G_2: 110 ppm of GA_3) and the minimum number of branches per plant (6.43) was recorded from control treatment of G_0 (0 ppm of GA_3) at 30 DAT. At 45 DAT, the maximum number of branches per plant (13.64) was recorded from medium level of GA_3 (G_2: 110 ppm of GA_3) and the minimum number of branches per plant (11.10) was recorded from control treatment of G_0 (0 ppm of GA_3). The maximum branch number per plant was obtained from medium level of GA_3 (G_2) and the minimum branch number per plant was found from the control level of GA_3 (G_0). Similar results were found from Reddy (1978).

Interaction effect between Phosphorus and foliar application of different levels of GA_3 on branch number per plant of cockscomb was significant at different days after transplanting (DAT) (Table 8 and Appendix IX). At 15 DAP, the highest number of branches per plant (3.66) was recorded from treatment combination of P_1G_2 (60 kg P_2O_5 $ha^{-1}$with 110 ppm GA_3) and the lowest number of branches per plant (1.56) was recorded from treatment combination of P_0G_0 (0 kg P_2O_5 ha^{-1} with 0 ppm GA_3).The highest number of branches per plant (9.10) was recorded from the treatment combination of P_1G_2 (60 kg P_2O_5 $ha^{-1}$with 110 ppm GA_3) and the lowest number of branches per plant (5.16) was recorded from the treatment combination of P_0G_0 (0 kg P_2O_5 $ha^{-1}$with 0 ppm GA_3) at 30 DAT. The highest number of branches per plant (16.167) was recorded from treatment combination of P_1G_2 (60 kg P_2O_5 $ha^{-1}$with 110 ppm GA_3) and the lowest number of branches per plant (8.96) was recorded from treatment combination of P_0G_0 (0 kg P_2O_5 $ha^{-1}$with 0 ppm GA_3) at 45 DAT. Results explained that the maximum branch number per plant was found in the minimum plant population along with medium level of GA_3. It can be said branches number per plant increased with increasing rate of Phosphorus application. On the other hand GA_3 plays important role in several physiological processes, viz, photosynthesis, respiration, energy store, transfer, cell division which significantly enhances the axillary stalk or branching of plant. But after a certain stage branches number decreased with increasing rate of Phosphorus and GA_3 .It can be explained that higher doses of Phosphorus and GA_3 can hamper growth of branches due to toxic effect of excess application.

Table 8. Effect of Phosphorus and GA_3 on Branch number of cockscomb at different days after transplanting

TREATMENT	15 DAT	30 DAT	45 DAT
P_0G_0	1.56e	5.16f	8.97 i
P_0G_1	2.06de	5.60ef	9.50 hi
P_0G_2	2.36cd	6.36de	10.16 jh
P_0G_3	2.03de	5.00f	9.16hi
P_1G_0	2.40cd	6.53d	10.66fg
P_1G_1	2.66bc	7.66c	11.50ef
P_1G_2	3.66a	9.10a	16.16a
P_1G_3	2.50bcd	7.86bc	12.33de
P_2G_0	2.66 bc	7.60c	13.66 bc
P_2G_1	2.93bc	8.16bc	14.10bc
P_2G_2	3.00 b	8.50ab	14.60 b
P_2G_3	2.60bcd	7.93bc	13.33cd
$LSD_{(0.05)}$	0.28	0.37	0.55
CV%	13.96	6.49	5.63

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}

G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

4.8 Number of harvested spike per plant

Number of harvested spike per plant was found statistically significant due to different Phosphorus application after harvesting (Figure 16 and Appendix X). From the experiment it was found that the highest number of spike per plant (1.76) was recorded from medium level of P (P_1: 60 kg P_2O_5 ha^{-1}) and the lowest number of spike per plant (1.26) was recorded from control level of P (P_0: 0 kg P_2O_5 ha^{-1}).

Different GA_3 levels significantly influenced number of spike per plant of cockscomb after harvesting (Figure 17 and Appendix X). From the experiment it was found that the highest number of spike per plant (1.76) was recorded from medium level of GA_3 (G_2: 110 ppm of GA_3) and the lowest number of spike per plant (1.28) was achieved from control G_0 (0 ppm of GA_3). Due to control dose of GA_3 plant could not get proper nutrition. Similar results also reported from Moond and Rakesh (2006).

Significant variation was found by interaction effect of Phosphorus and foliar application of GA_3 on number of spike per plant of cockscomb after harvesting (Table 9 and Appendix X). From the experiment it was found that the highest number of spike per plant (2.03) was found in P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm GA_3) and the lowest number of spike per plant (1.03) was achieved from P_0G_0 (0 kg $P_2O_5$with 0 ppm GA_3). Results clarified that the maximum spike number per plant was found in moderate level of Phosphorus along with medium level of GA_3 and the lowest was found from the control level of Phosphorus with 0 ppm GA_3.

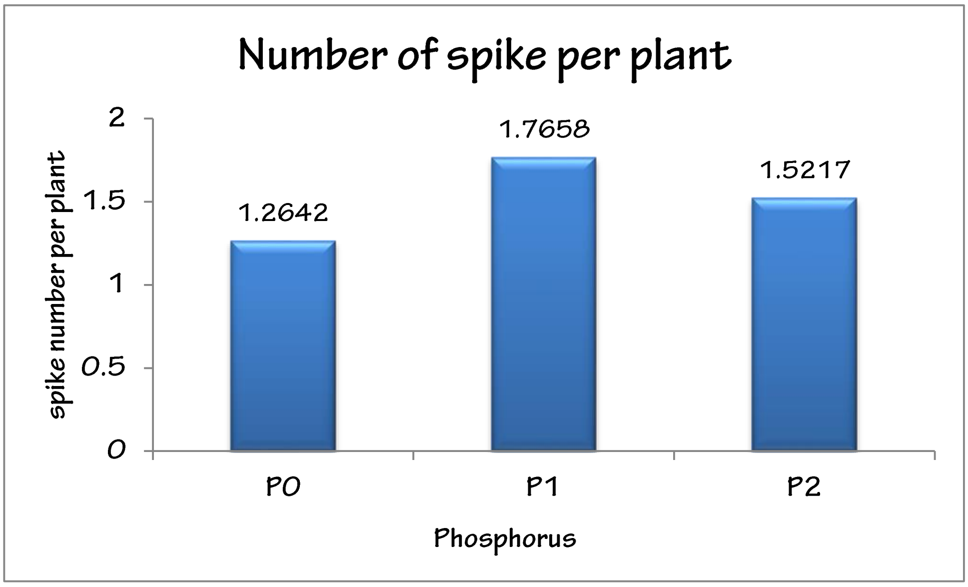


Figure16. Effect of Phosphorus on number of spike per plant of cockscomb after harvesting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

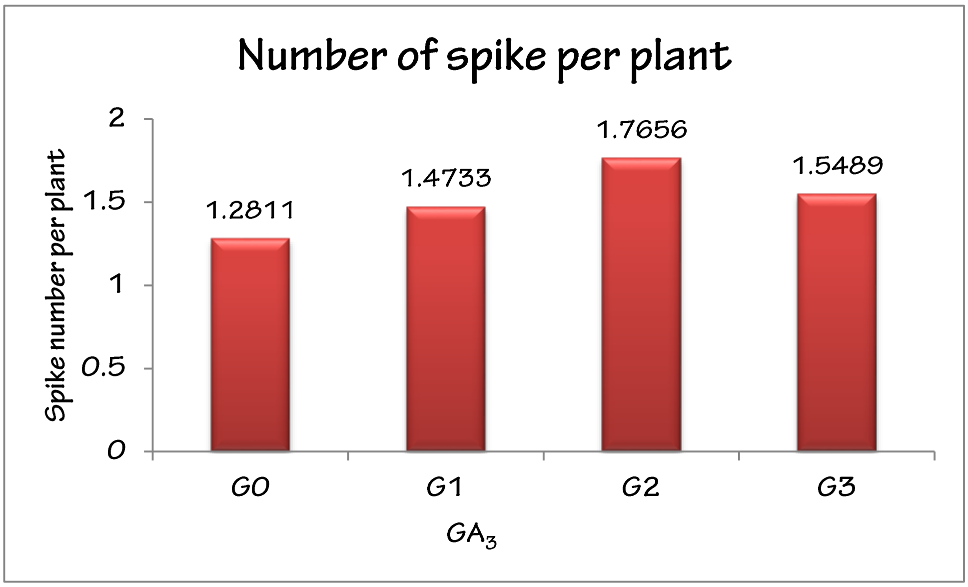


Figure17. Effect of GA_3 on number of spike per plant of cockscomb after harvesting.G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3,G_3 -160ppm GA_3.

4.9 Number of Harvested Spike per Plot

Number of harvested spike per plot showed significant variation due to different Phosphorus application after harvesting (Figure 18 and Appendix X). From the study it was found that the highest number of spike per plot (28.25 after harvesting) was recorded from medium level of P (P_1:60 kg P_2O_5 ha^{-1}). Again, the lowest number of spike per plot (20.22 after harvesting) was recorded from control level of P (0kg $P_2O_5ha^{-1}$).

Significant variation among different GA_3 levels on number of spike per plot of cockscomb was found after harvesting (Figure 19 and Appendix X). From the experiment it was found that the highest number of spike per plot (28.24) was recorded from medium level of GA_3 (G_2: 110 ppm 0f GA_3). Again, the lowest number of spike per plot (20.49) was achieved from control G_0 (0 ppm of GA_3). Similar results were found from Bharti and Ranjan (2009).

Interaction effect of Phosphorus and foliar application of GA_3 varied significantly on number of spike per plot of cockscomb after harvesting (Table

9 and Appendix X). The highest number of harvested spike per plot (32.53) was found in P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm GA_3).On the other hand the lowest number of harvested spike per plot (16.58) was achieved from P_0G_0 (0kg P_2O_5 with 0 ppm GA_3). It was observed that highest number of spike per plot was found from medium level of Phosphorus and GA_3 application. Lowest result was found from control level of Phosphorus and GA_3. On the other hand excessive doses of Phosphorus and GA_3 showed lower spike per plot due to toxic effect of plants.

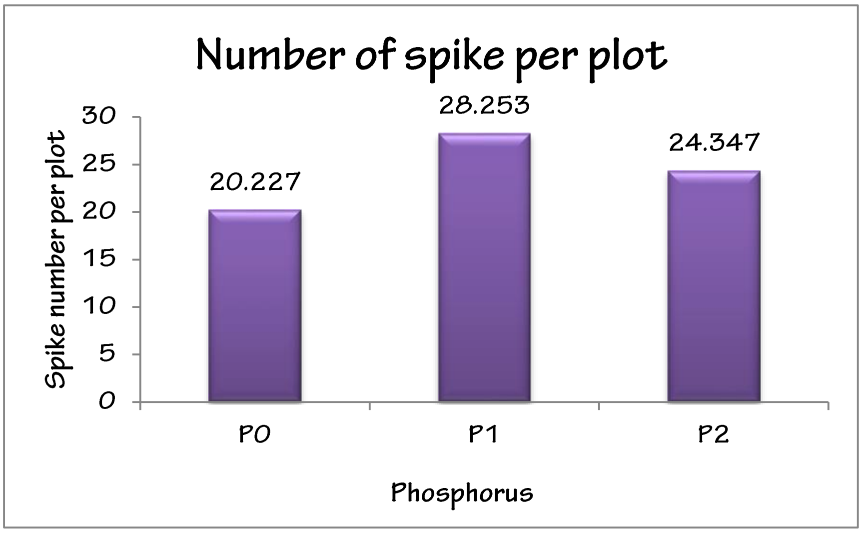


Figure 18. Effect of Phosphorus on number of spike per plot of cockscomb after harvesting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2- 110 kg P_2O_5 ha^{-1}

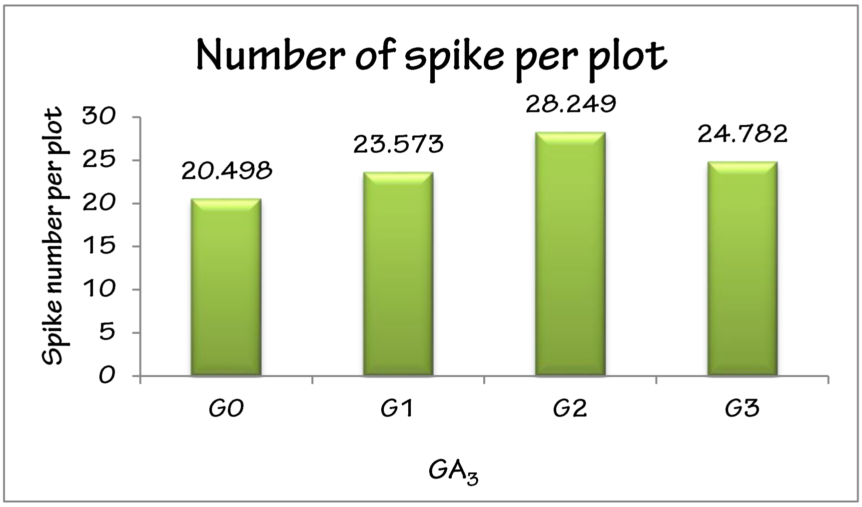


Figure 19. Effect of GA_3 on number of spike per plot of cockscomb after harvesting.G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 -160 ppm GA_3

4.10 Number of Harvested Spike per Hectare

Significant variation was revealed for yield per ha (number of spike per ha) of cockscomb by different Phosphorus application after harvesting (Figure 18 and Appendix X). Results showed that the highest number of spike per ha (353167) was recorded from P1 (60 kg $P_2O_5ha^{-1}$). Again, the lowest number of spike per ha (252833) was recorded from P_0 (0kg $P_2O_5ha^{-1}$). The highest number of spike was obtained from medium application of Phosphorus. On the other hand the lowest number of spike was found from control application of Phosphorus. The result under the present study in respect of yield per hectare was similar with the result of Parvin *et al*. (2009).

Different GA_3 levels showed Significant influence on number of spike per ha of cockscomb (Figure 19 and Appendix X). Results specified that the highest number of spike per ha (353111) was recorded from medium level of GA_3 (G_2: 110 ppm of GA_3). Again, the lowest number of spike per ha (256222) was observed from G_0 (Control) treatment. Spike number per Ha increased with increasing level of GA_3.But after a certain level spike number decreased with increasing level of GA_3. It can be explained that plants with high GA_3 was not good for yield of spike. High dose of GA_3 may be toxic for spike production of cockscomb.

Combined effect of Phosphorus (P_2O_5) and foliar application of GA_3 on number of spike per ha of cockscomb showed significant variation after harvesting (Table 9 and Appendix X). Results exposed that the highest number of spike per ha (40667) was found in P_1G_2 (60 kg P_2O_5 ha^{-1} with 110 ppm GA_3). On the other hand the lowest number of spike per ha (207333) was found from P_0G_0. So, the maximum yield was found from medium Phosphorus with moderate doses of GA_3.On the other hand lowest yield was achieved from control level of Phosphorus and GA_3.

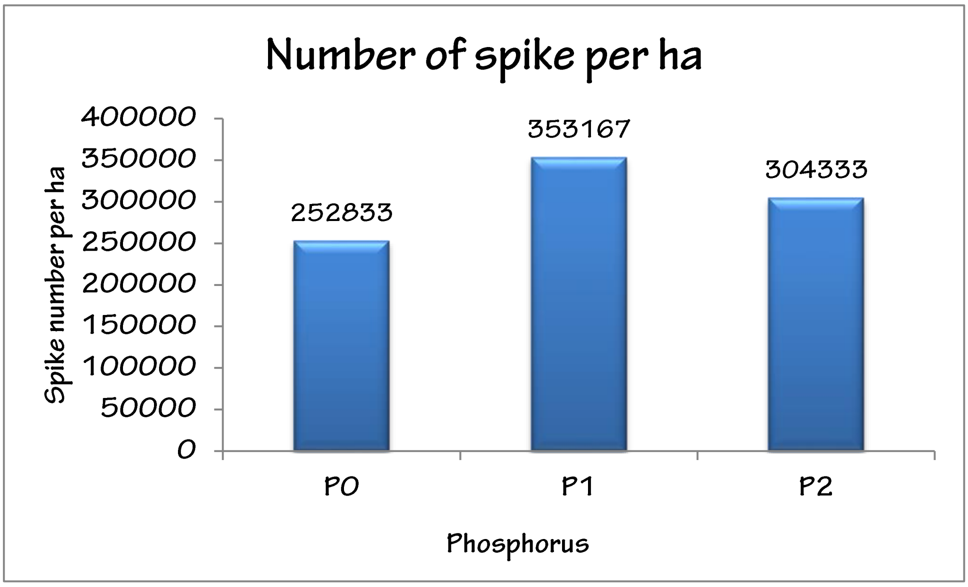


Figure 20. Effect of Phosphorus on number of spike per ha of cockscomb after harvesting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2- 110 kg P_2O_5 ha^{-1}

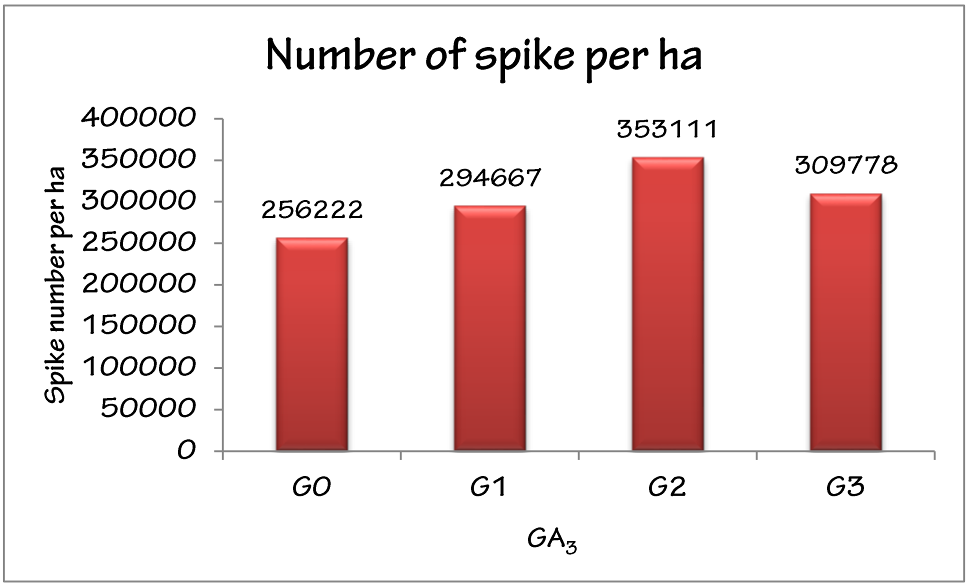


Figure 21. Effect of GA_3 on number of spike per ha of cockscomb after harvesting.G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 -160 ppm GA_3

Table 9. Effect of Phosphorus and GA_3 on spike number of cockscomb after harvesting

TREATMENT	SPIKE NUMBER $plant^{-1}$	SPIKE NUMBER $plot^{-1}$	SPIKE NUMBER ha^{-1}
P_0G_0	1.03 i	16.58 i	207333 i
P_0G_1	1.20h	19.30h	241333 h
P_0G_2	1.47ef	23.573 ef	294667 ef
P_0G_3	1.34g	21.440 g	268000 g
P_1G_0	1.56de	24.960 de	312000 de
P_1G_1	1.77b	28.320 b	354000 b
P_1G_2	2.03 a	32.533 a	406667 a
P_1G_3	1.70bc	27.200 bc	340000 bc
P_2G_0	1.24 gh	19.947 gh	249333 gh
P_2G_1	1.44f	23.093 f	288667 f
P_2G_2	1.79b	28.640 b	358000 b
P_2G_3	1.60cd	25.707 cd	321333 cd
$LSD_{(0.05)}$	0.04	0.79	9938.90
CV%	4.01	4.01	4.01

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}
G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

4.11 Dry Weight of Spike

Significant variation on dry weight of spike of cockscomb was found due to different plant population after harvesting (Figure 22 and Appendix XI). The highest dry weight of spike (22.45 g) was obtained from medium level of Phosphorus (P_2: 60kg P_2O_5 ha^{-1}) and lowest dry weight of spike (15.17 g) was obtained from controlled level of Phosphorus (P_0: 0kg P_2O_5 ha^{-1}) after harvesting.

Dry weight of spike of cockscomb showed significant differences due to foliar application of GA_3 after harvesting (Figure 23 and Appendix XI). The highest dry weight of spike (22.45 g) was recorded from G_3 (110 ppm of GA_3) treated plant and the lowest dry weight of spike (17.04 g) was found in G0 (0 ppm GA_3) treatment after harvesting.

The combined effect of Phosphorus and foliar application of GA3 on dry weight of spike of cockscomb showed significant difference after harvesting (Table 10 and Appendix XI).). It was observed that the highest dry weight of spike (26.43 g) was produced by P_1G_2 (medium level of Phosphorus with 110 ppm GA_3) and lowest dry weight of spike (13.33g) was obtained from P_0G_0 (0kg P_2O_5 $ha^{-1}$with 0 ppm GA_3) treatment after harvesting. Results explained that the dry weight of spike was higher in medium Phosphorus level with 110 ppm GA_3 and lower in controlled level of Phosphorus with 0 ppm GA_3.

It can be explained that higher doses of Phosphorus and GA_3 can hamper growth of spike due to toxic effect of excess application. So dry weight of spike became low. On the other hand medium level of Phosphorus and GA_3 encourage growth of spike. So dry weight of spike also increased.

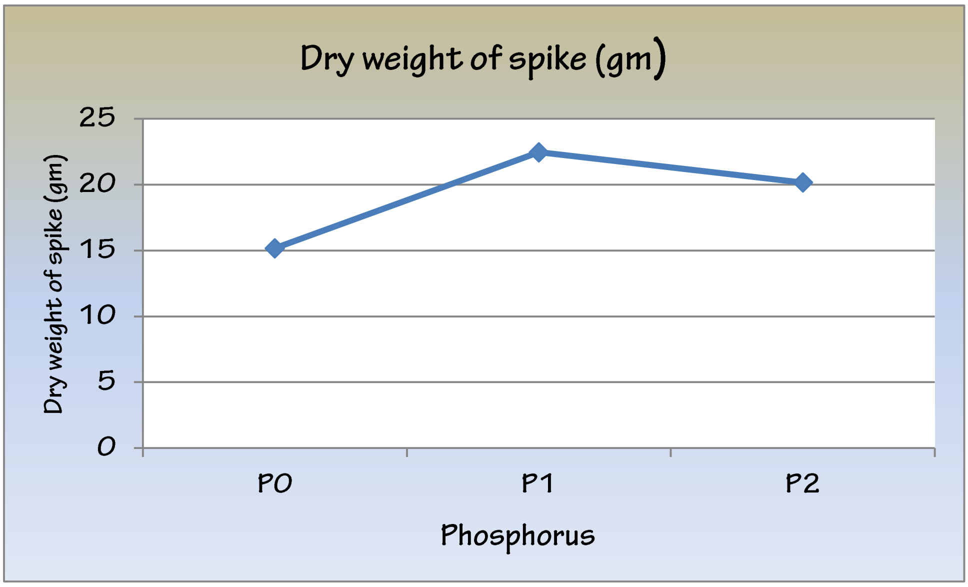


Figure 22. Effect of Phosphorus on dry weight (g) of spike of cockscomb after harvesting.P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

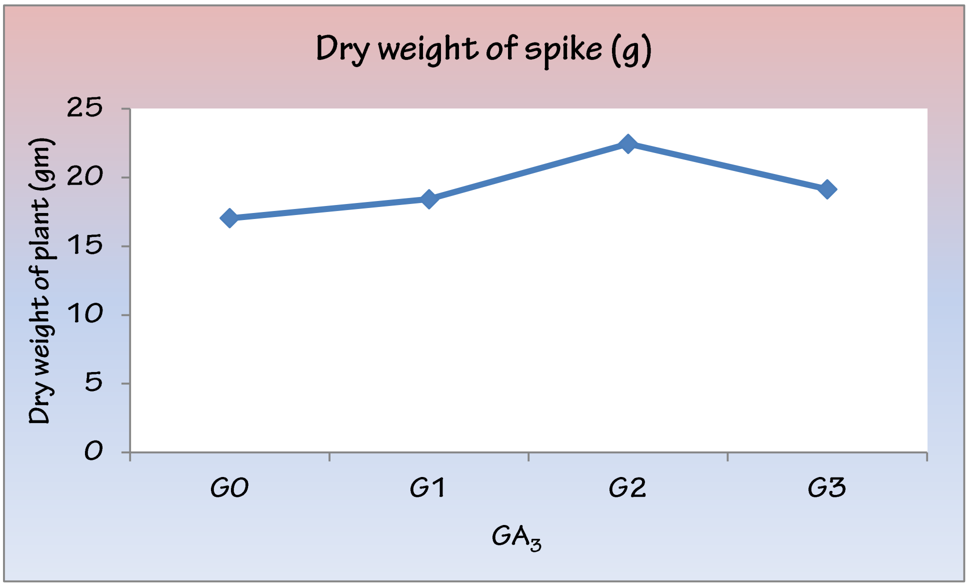


Figure 23. Effect of GA_3 on dry weight of spike (g) of cockscomb after harvesting.G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 -160 ppm GA_3.

4.12 Dry Weight of Plant

Dry weight of plant of cockscomb varied significantly for different plant population after harvesting (Figure 24 and Appendix XI). The highest dry weight of plant (198.82 g) was obtained from medium level of Phosphorus (P_1:60kg $P_2O_5ha^{-1}$) and the lowest dry weight of plant (172.32 g) was obtained from controlled level of Phosphorus (P_0: 0kg $P_2O_5ha^{-1}$) after harvesting. Plants which got more phosphorus dose became healthier. Its height, breadth, elements in stem, branch number, leaf number, number of flowers increased with increasing dose of phosphorus. So the dry weight of plant also increased. But after a certain level of Phosphorus treatment the plants showed decreasing character with increasing dose of Phosphorus. This may be the toxic effect of high doses of Phosphorus. So then the dry weight of plant also decreased.

Application of different level of GA_3 showed significant differences on dry weight of plant of cockscomb after harvesting (Figure 25 and Appendix XI). The highest dry weight of plant (199.37g) was recorded from medium level of

GA_3 (G_2: 110 ppm of GA_3) treated plant and the lowest dry weight of plant (177.48 g) was found in control treatment G_0 (0 ppm of GA_3) after harvesting.

Significant variation was observed due to the combined effect of Phosphorus and foliar application of GA_3 on dry weight of plant after harvesting (Table 10 and Appendix XI). It was observed that highest dry weight of plant (216.00 g) was produced by P_1G_2 (60kg P_2O_5 ha^{-1} with 110 ppm GA_3) and lowest dry weight of plant (160.23 g) was obtained from P_0G_0 (controlled level of Phosphorus with 0 ppm GA_3) treatment after harvesting. The plant which had highest plant height, stem height, more leaves, more branches, more flowers they had also highest dry weight.

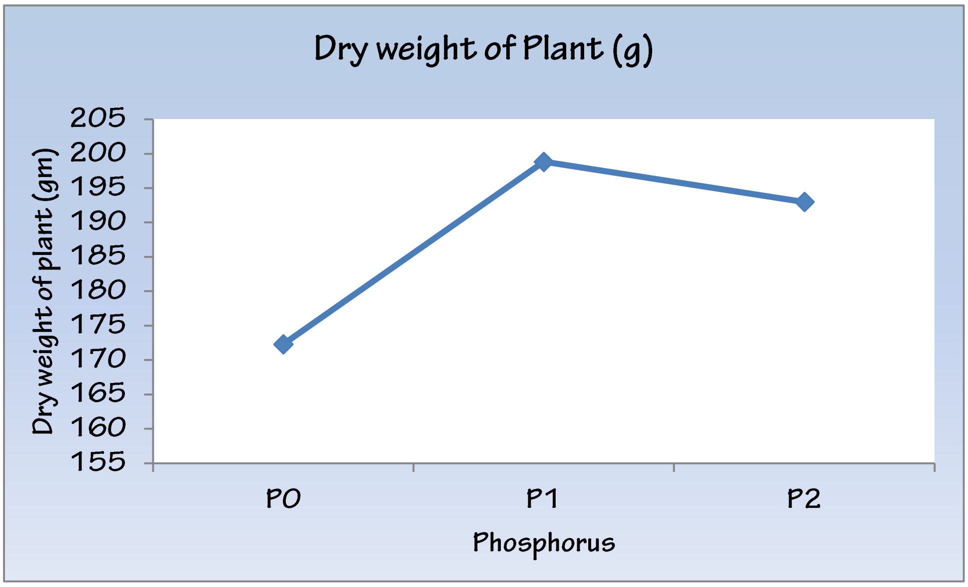


Figure 24. Effect of Phosphorus on dry weight (g) of plant of cockscomb after harvesting. P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 kg P_2O_5 ha^{-1}

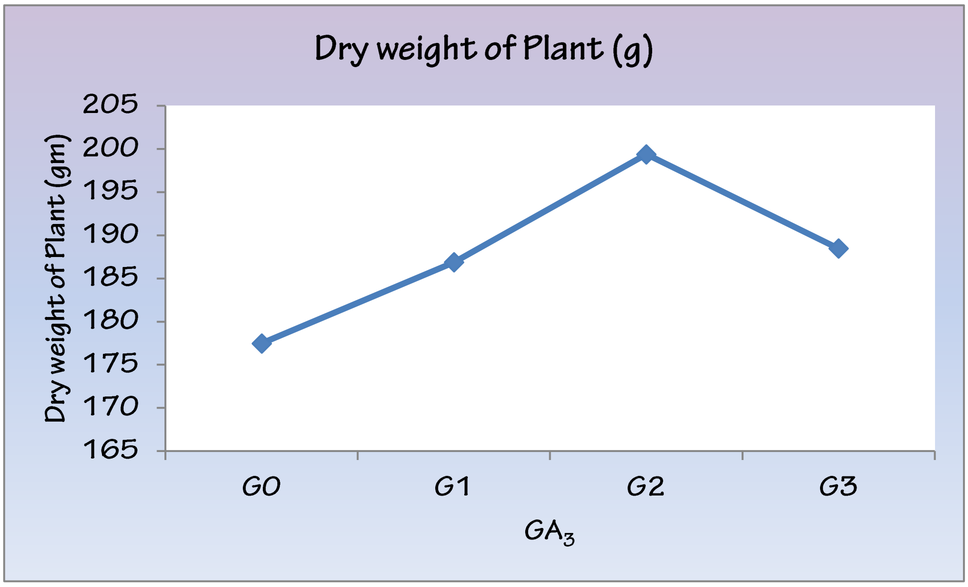


Figure 25. Effect of GA_3 on dry weight of plant (g) of cockscomb after harvesting.G_0 - Control, G_1 - 60 ppm GA_3, G_2 - 110 ppm GA_3, G_3 -160 ppm GA_3.

Table10. Effect of Phosphorus and GA_3 on dry weight of spike (g) of cockscomb after harvesting

TREATMENT	DRY WEIGHT OF SPIKE	DRY WEIGHT OF PLANT
P_0G_0	13.33 i	160.23 e
P_0G_1	15.56gh	174.07 e
P_0G_2	16.80 fg	179.50 de
P_0G_3	15.00 hi	175.47 de
P_1G_0	16.96fg	177.60 de
P_1G_1	17.60f	185.00 cd
P_1G_2	26.43 a	216.00 a
P_1G_3	19.66e	193.33 bc
P_2G_0	20.83 de	194.60 bc
P_2G_1	22.10cd	201.50 b
P_2G_2	24.13b	202.60 b
P_2G_3	22.76 bc	196.57 b
$LSD_{(0.05)}$	0.85	160.23
CV%	5.41	3.07

Here, P_0-0 kg P_2O_5 ha^{-1}, P_1-60 kg P_2O_5 ha^{-1}, P_2-110 P_2O_5 ha^{-1}
G_0-0 ppm GA_3, G_1-60 ppm GA_3, G_2-110 ppm GA_3, G_3-160 ppm GA_3

4.13. Economic Analysis

The cost of production was analyzed in order to find out the most economic combination of different level of Phosphorus doses and GA_3 application. Input costs on land preparation, seed costs, irrigation, fertilizer, insecticide, plant growth regulator and labor were required for all the operations from seed sowing to harvesting of cockscomb were calculated for unit plot and converted into cost per hectare (Appendix XII). Prices of cockscomb spikes were considered as per local market rate. The economic analysis was done to find out the gross return, net return and the benefit cost ratio and these are presented under the following headings.

4.13.1 Gross return

The combination of Phosphorus and foliar application of GA_3 showed different values in terms of gross return under the trial (Table 10 & Appendix X). The highest gross return (TK. 15,69,778 ha^{-1}) was obtained from the treatment combination of medium level of Phosphorus along with moderate level of GA_3 (P_1G_2) and the lowest gross return (TK. 5,65,333.3 ha^{-1}) was record from the treatment combination of controlled level of Phosphorus with along with 0 ppm GA_3 (P_0G_0).

4.13.2 Net return

In case of net return, different treatment combination showed different levels of net return (Table 10). In the combination of different Phosphorus and GA_3 application, the highest net return (TK. 7,37,060 ha^{-1}) was observed from the treatment combination of medium level Phosphorus along with medium level of GA_3 (P_1G_2) and the lowest net return (TK. 1,735.1 ha^{-1}) was found from the treatment combination of controlled Phosphorus along with 0 ppm GA_3 (P_0G_0).

4.13.3 Benefit cost ratio

The combination of Phosphorus and foliar application of GA_3 for benefit cost ratio was different in all treatment combination (Table 10). The highest benefit cost ratio (2.0) was found from the treatment combination of medium level Phosphorus along with medium level of GA_3 (P_1G_2). The lowest benefit cost ratio (1.0) was record from P_2G_0 and P_2G_1. The result revealed that the treatment combination of P_1G_2 was more profitable in comparison with the other treatment combinations.

Table 11. Economic performances of cockscomb flower production income return showing benefit cost ratio (BCR)

Treatment	Cost of production ha^{-1}	Yield ha-1 (Number of spike)	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
P_0G_0	206,096.43	207,333	207,333	15,197.3	1.0
P_0G_1	219,393.63	241,333	241,333	17,818.4	1.1
P_0G_2	245,555.83	294,667	294,667	637,060	1.2
P_0G_3	214,400	268,000	268,000	160,156	1.25
P_1G_0	240,000	312,000	312,000	1,635.1	1.3
P_1G_1	236,000	354,000	354,000	42,722	1.5
P_1G_2	203,333.5	406,667	40,6667	600,992	2.0
P_1G_3	212,500	340,000	340,000	151,916	1.6
P_2G_0	178,095	249,333	249,333	8,984	1.4
P_2G_1	217,042.8	288,667	288,667	2,615.3	1.33
P_2G_2	293,442.6	358,000	358,000	634,358	1.22
P_2G_3	292,120.9	321,333	321,333	112,231.6	1.1

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the field of the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2017 to February 2018 to investigate the effect of different levels of Phosphorus and Gibberellic acid (GA_3) and their combined effect on growth and flowering of Cockscomb. The experiment comprised three levels of phosphorus application like i) P_0 - Control (0 kg P_2O_5 ha^{-1}); ii) P_1 -60 kg P_2O_5 ha^{-1}; iii) P_2-110 kg P_2O_5 $ha^{-1}$and four levels of GA_3 like i) G_0 - 0 ppm GA_3; ii) G_1 = 60 ppm GA_3; iii) G_2 - 110 ppm GA_3 and iv) G_3 - 160 ppm GA_3. Phosphorus was applied from TSP and GA_3 is a type of Gibberellic acid. They were applied to the experimental plot during final land preparation as per treatments. The experiment was laid out in a two factor Randomized Complete Block Design and there were three replications (R_1, R_2, R_3).Total numbers of treatments were twelve and the number of plots were thirty six. Seeds of cockscomb were collected from Barisal Nursery, Savar, Dhaka. Data were collected on different parameters like plant height, stem height, number of leaves per plant, number of branch per plant, length of spike, spike tip breadth, diameter of crown, number of spike per plant, number of spike per plot, number of spike per hectare, dry weight of plant and dry weight of spike by number.

The effect of phosphorus levels on morphological characters of plant such as plant height, stem height, spike length etc. was significant at three growth stages of 15, 30 and 45 days after planting (DAP).The highest plant height (24.33, 49.98, 53.30 cm at 15DAT, 30DAT and 45DAT,respectively), Stem height (18.46, 35.58, 38.56 cm at 15DAT,30DAT and 45DAT, respectively), leaf number (17.41, 40.90, 91.43 at 15DAT, 30DAT and 45DAT, respectively), diameter of crown (0.9733, 1.70, 2.46 cm at 15DAT, 30DAT and 45DAT, respectively), Spike length (2.64, 7.16, 7.67 cm at 15DAT, 30DAT and

45DAT, respectively), spike tip breadth (1.00, 3.95, 6.02 cm at 15DAT, 30DAT and 45DAT, respectively), branch number (2.90, 8.05, 13.92 at 15DAT, 30DAT and 45DAT, respectively), Number of spike per plant (1.76 after harvesting), Number of spike per plot (28.25 after harvesting), Number of spike per ha (353167 after harvesting), Dry weight of spike (22.45 g after harvesting), Dry weight of plant(198.82 g after harvesting)was recorded from medium level of Phosphorus (P_1-60kg P_2O_5 ha^{-1}). On the other hand lowest plant height(20.54, 31.77, 42.458 cm at 15DAT, 30DAT and 45DAT, respectively), stem height (15.01, 25.50, 33.68 cmat 15DAT, 30DAT and 45DAT, respectively), leaf number (13.15, 27.05, 80.15 at 15DAT, 30DAT and 45DAT, respectively), diameter of crown (0.87, 1.13, 1.25 cm at 15DAT, 30DAT and 45DAT, respectively), spike length (2.43, 4.02, 6.64 cm at 15DAT, 30DAT and 45DAT, respectively), spike tip breadth (0.82, 2.47, 4.12 cm at 15DAT, 30DAT and 45DAT, respectively), branch number (2.00, 5.53, 9.45 at 15DAT, 30DAT and 45DAT, respectively),Number of spike per plant (1.26 after harvesting), Number of spike per plot (20.22 after harvesting),),Number of spike per ha (252833 after harvesting), Dry weight of spike (15.176 g after harvesting),Dry weight of plant (172.32 g after harvesting) was recorded from control level of Phosphorus (0kg P_2O_5 ha^{-1}).

Different level of GA_3 showed significant differences on morphological character of cockscomb. Results revealed that the highest plant height (24.200, 45.911, 51.944 cm at 15DAT, 30DAT and 45DAT respectively), stem height (18.467, 34.333, 38.533 cm at 15DAT, 30DAT and 45DAT respectively), leaf number (17.5111, 38.211, 93.867 at 15DAT, 30DAT and 45DAT respectively), diameter of crown (0.9800, 1.7444, 2.6111 cm at 15DAT, 30DAT and 45DAT respectively),spike length (2.6667, 6.8444, 8.1111 cm at 15DAT, 30DAT and 45DATrespectively), spike tip breadth (1.0089, 3.8889, 6.1667 cm at 15DAT, 30DAT and 45DAT respectively), branch number(3.0111, 7.9889, 13.644 at 15DAT, 30DAT and 45DAT, respectively), Number of spike per plant(1.7656 after harvesting), Number of spike per plot(28.249 after harvesting), Number of spike per ha(353111 after harvesting),Dry weight of spike (22.457 g after harvesting),Dry weight of plant (199.37 g after harvesting)was recorded from optimum level of GA_3(G_2-110 ppm GA_3).On the other hand lowest plant height(21.356, 38.256, 45.078 cm at 15DAT, 30DAT and 45DAT, respectively), stem height(16, 29.778, 36.067 cm 15DAT, 30DAT and 45DAT, respectively), leaf number(14.156, 32.644, 82.056 at 15DAT, 30DAT and 45DAT, respectively), diameter of crown(0.8533, 1.3000, 1.6333 cm 15DAT, 30DAT and 45DAT, respectively),spike length(2.4667, 4.8111, 6.8667 cm at 15DAT, 30DAT and 45DAT, respectively), spike tip breadth(0.8600, 3.0889, 4.8556 cm at 15DAT, 30DAT and 45DAT, respectively), branch number(2.2111, 6.4333, 11.100 at 15DAT, 30DAT and 45DAT, respectively),Number of spike per plant (1.28 after harvesting), Number of spike per plot(20.498after harvesting), Number of spike per ha(256222 after harvesting), Dry weight of spike(17.04after harvesting), Dry weight of plant(177.48after harvesting) were recorded from control level of GA_3(G_0- 0 ppmGA_3).

Combined effect of Phosphorus and GA_3 significantly influenced the parameters at 15, 30 and 45 days after transplanting. It was found that highest plant height 26.867, 53.333, 56.500 cm was found at 15DAT, 30DAT and 45DAT, respectively. The highest stem height (21.93, 39.33, 41.33 cm at 15DAT, 30DAT and 45DAT, respectively) ,leaf number (19.01, 42.46, 97.66 at 15DAT, 30DAT and 45DAT, respectively), diameter of crown (1.06, 2.03, 3.73 cmat 15DAT, 30DAT and 45DAT, respectively),spike length (2.84, 8.06, 8.70 cm at 15DAT, 30DAT and 45DAT, respectively), spike tip breadth (1.180, 4.40, 7.26 cm at 15DAT, 30DAT and 45DAT), branch number (3.66, 9.10, 16.16 at 15DAT, 30DAT and 45DAT, respectively), Number of spike per plant (2.03 after harvesting), Number of spike per plot (32.53 after harvesting), Number of spike per ha (406667 after harvesting), Dry weight of spike(26.43after harvesting), Dry weight of plant(216.00after harvesting) were found from moderate level of Phosphorus and GA_3 application (P_1G_2-60 kg

P_2O_5 ha^{-1} with 110 ppm GA_3). On the contrary lowest plant height (19.40, 30.73, 37.50 cm at 15DAT, 30DAT and 45DAT respectively), stem height (13.60, 23.33, 32.26 cm at 15DAT, 30DAT and 45DAT respectively), leaf number (11.00, 24.40, 66.33 at 15DAT, 30DAT and 45DAT respectively), diameter of crown (0.72, 1.00, 1.06 cm at 15DAT, 30DAT and 45DAT, respectively), spike length (2.36, 3.10, 6.16 cm at 15DAT, 30DAT and 45DAT, respectively), spike tip breadth (0.71, 1.93, 3.93 cm at 15DAT, 30DAT and 45DAT, respectively), branch number (1.56, 5.00, 8.96at 15DAT, 30DAT and 45DAT, respectively), Number of spike per plant (1.0367 after harvesting), Number of spike per plot (16.587 after harvesting), Number of spike per ha (207333 after harvesting), Dry weight of spike (13.33 garter harvesting), Dry weight of plant (160.23 garter harvesting) were collected from control level of Phosphorus and GA_3 (0kg P_2O_5 ha^{-1} with 0 ppm GA_3).

Conclusion

From the above study we can conclude that

- Medium level of Phosphorus (P_1-60 kg P_2O_5 ha^{-1} gave the best result than control level of Phosphorus (P_0-0kg P_2O_5 ha^{-1}) or highest level of Phosphorus (110kg P_2O_5 ha^{-1}).
- Optimum dose of GA_3 (110ppm GA_3) showed better result than control level of GA_3 (0ppm GA_3) or higher level of GA_3 (160ppm GA_3).
- Treatment combination (P_1G_2- 60 kg P_2O_5 ha^{-1} with 110 ppm GA_3) gave the best result in all parameters at 15, 30 and 45 DAT.
- Considering the study further experiment should be done in different agro-ecological zones (AEZ) of Bangladesh for spreading this cockscomb variety as cut flower and economic development of farmers who cultivate flowers.

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APPENDICES

Appendix I

Monthly average Temperature, relative humidity and total rainfall and sunshine of the experiment site during the period from October, 2017 to February 2018

Month	Air temperature (0C)		Relative humidity (%)	Rainfall(mm)
	Maximum	**Minimum**	81	22
October,2017	26.5	19.4		
November,2017	25.8	16.0	78	00
December,2017	22.4	13.5	74	00
January,2018	24.5	12.4	68	00
February,2018	27.1	16.7	67	30

Source: Bangladesh Meteorological Department

(Climate and weather division) Agargoan, Dhaka-1212

Appendix II

Morphological, physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site.

A. Morphological characteristics of the experimental field

MORPHOLOGICAL FEATURE	CHARACTERISTICS
Location	Horticulture Garden, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil type	Shallow red brown terrace soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level Drainage
Drainage	Well drained

B. Physical and chemical properties of the initial soil

CHARACTERISTICS	VALUE
Particle size analysis	
Sand%	27
Silt%	43
Clay%	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III

Effect of Phosphorus and application of GA_3 on plant height of cockscomb at different days after transplanting

Sources of variation	Degrees of freedom	Mean square of plant height (cm)		
		15DAT	30DAT	45DAT
Factor A	2	49.1736 **	1049.32**	411.787**
Factor B	3	13.6610**	117.54*	91.586**
AB	6	2.2344**	57.81**	9.360**
Error	24	1.7181	16.29	2.753

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix IV
Effect of Phosphorus and application of GA_3 on stem height of cockscomb at different days after transplanting

Sources of variation	Degrees of freedom	Mean square of stem height (cm)		
		15DAT	30DAT	45DAT
Factor A	2	45.8411**	383.049*	80.2433*
Factor B	3	7.6337**	32.822**	28.8367*
AB	6	9.0559**	5.030**	7.8389*
Error	24	3.9422	58.500	7.8267

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix V
Effect of Phosphorus and application of GA_3 on leaf number of cockscomb at different days after transplanting

Sources of variation	Degrees of freedom	Mean square of leaf number		
		15DAT	30DAT	45DAT
Factor A	2	55.2533**	636.048**	493.914**
Factor B	3	19.2130**	46.999*	211.237**
AB	6	2.9541*	14.806*	92.131**
Error	24	1.6400	1.777	121.430

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix VI
Effect of Phosphorus and application of GA_3 on Diameter of crown (cm) of cockscomb at different days after transplanting

Sources of variation	Degrees of freedom	Mean square of Diameter of crown(cm)		
		15DAT	30DAT	45DAT
Factor A	2	0.02842*	1.05028**	5.26694**
Factor B	3	0.02785*	0.37741**	1.89213*
AB	6	0.00993*	0.05880**	0.72102**
Error	24	0.01137	0.05000	0.19667

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix VII
Effect of Phosphorus and application of GA_3 on spike length of cockscomb at different days after transplanting

Sources of variation	Degrees of freedom	Mean square of spike length (cm)		
		15DAT	30DAT	45DAT
Factor A	2	0.14670	29.7636**	3.67028**
Factor B	3	0.13527*	6.7885**	2.92259**
AB	6	0.04153*	1.4521**	0.34843**
Error	24	0.09257	1.2200	0.37556

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix VIII
Effect of Phosphorus and application of GA_3 on spike tip breadth of cockscomb at different days after transplanting

Sources of variation	Degrees of freedom	Mean square of spike tip breadth(cm)		
		15DAT	30DAT	45DAT
Factor A	2	0.11279**	7.57750**	12.7900**
Factor B	3	0.03679*	1.09444*	3.0810**
AB	6	0.01888*	0.19861*	0.4819*
Error	24	0.01491	0.33667	0.1081

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix IX
Effect of Phosphorus and application of GA_3 on branch number of cockscomb at different days after transplanting

Sources of variation	Degrees of freedom	Mean square of branch number		
		15DAT	30DAT	45DAT
Factor A	2	2.53361**	23.0008**	63.9119**
Factor B	3	1.07000**	3.7855*	11.2640*
AB	6	0.19583**	0.5405**	4.0956*
Error	24	0.12556	0.2136	0.4581

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix X

Effect of Phosphorus and application of GA_3 on spike number of cockscomb after harvesting

Sources of variation	Degrees of freedom	Mean square		
		Spike number $plant^{-1}$	Spike number plot-1	Spike number $hectare^{-1}$
Factor A	2	1.62211**	415.260**	16.488**
Factor B	3	0.73113**	187.169**	12.925**
AB	6	0.20024*	51.261*	17.010*
Error	24	0.01654	4.233	14.614

** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Appendix XI

Effect of Phosphorus and application of GA_3 on dry weight of cockscomb after harvesting

Sources of variation	Degrees of freedom	Mean square (g)	
		Dry weight of spike	Dry weight of plant
Factor A	2	166.390**	2326.78**
Factor B	3	47.527**	724.29**
AB	6	10.359**	180.47**
Error	24	1.085	33.24

** Significant at 0.01 level of probability