EFFECT OF SPATIAL ARRANGEMENT AND FOLIAR APPLICATION OF GROWTH REGULATING HORMONE ON THE FLOWER HEAD DEVELOPMENT OF COCKSCOMB UNDER THE TROPICAL ARID ENVIRONMENT OF SOUTHERN PUNJAB, PAKISTAN

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ABSTRACT
This investigation was carried out at Experimental Farm, Faculty of Agriculture Science and Technology, Bahauddin Zakariya University, Multan (Pakistan). The objective of this study was to produce high quality Celosia flower head as cut flower under the harsh environmental conditions of southern Punjab by using different plant spacing and different concentrations of Gibberellin (GA_3). The seedlings were grown by seed and then transplanted in the field in the first week of August. Seedlings were irrigated daily and fertilized with 100 ppm NPK solution with alternate irrigation before transplanting. Field was well prepared by irrigation and spading twice and adding about 1.5 kg Diammonium phosphate (DAP) at the rate of 150 kg/hectare as phosphorus source, about 2 kg Muriate of Potash (MOP) at the rate of 200 kg/hectare as potash source and about 1kg urea at the rate of 100 kg/hectare as nitrogen source prior to transplanting. Then, seedlings were transplanted in randomized complete block design. There were three levels/concentrations of GA_3 (0, 25 and 50 mg/l) and three levels of plant spacing (22.50, 30.00 and 37.50 cm) making overall 9 treatments and these treatments were tested in 3 replications. The analysis of variance indicated that best results were achieved when plant spacing of 37.5cm was used in combination with GA_3 application (at the rate of 50 mg/l) where significant increase in chlorophyll contents, leaf area and number of leaves, fresh and dry weight of stem, flower diameter and fresh and dry weight of flower of *Celosia cristata* were found compared to all other treatments tested.

KEYWORDS
Celosia cristata; Cockscomb; Flower head; Gibberellin.

Celosia cristata, a member of amaranth family (Amaranthaceae) is an annual crop grown usually for landscape purpose. Some of its hybrid cultivars are commercially used as cut flowers as well. Celosia is commonly known as “Cockscomb” or "Kalgha" because of its resemblance to roosterhead (Wilkinson *et al.*, 2006).*C. cristata* is known to have a great potential being cut flower. Over the years, the demand of high quality celosia cut flower has increased manifolds owing to its unique appearance and longer shelf life. Thus, to meet such demand, there must be availability of variety of high quality cut flower throughout the year.

The production of high quality *C. cristata* flower head in tropical arid regions like those of Southern Punjab (Pakistan) has been a considerable problem since the harsh environmental conditions pose a significant threat to the appropriate growth and flower head development in cockscomb (Edward *et al.,* 1934). In the current study we did experiment with a range of plant spacing treatments in combination with foliar application of different concentrations of growth regulating hormone to achieve the desired flower head. In fact, plant to plant spacing has been recognized as a pivotal factor to the quality of end product in all agronomic and horticultural crops. It is possible only through optimum plant to plant spacing that maximum and unchecked growth of plants can be achieved. Moreover, it is proved that plant growth regulators including gibberellins contribute in different ways towards better plant growth. Out of many types of gibberellins, gibberellic acid (GA_3) is in active form and is extensively used in agriculture. Mainly, it helps in plant growth by cell elongation (Brian, 2008). Stem length and flower size are known quality factors for better acceptance by the consumers and fetch better price in the market. Hence gibberellic acid is used to achieve these parameters.

Since no significant study has been carried out in the past on cockscomb regarding improvement of its production in less favorable climatic conditions, the current study was aimed at finding out the most appropriate plant spacing as well as dosage of GA3 application on Cockscomb to improve its quality under the harsh tropical arid environment of outher Punjab, Pakistan.

The study therefore aimed at investigating following target areas of Cockscomb field production as cut flower:

– Effect of growth promoter (GA_3) on plant growth and flower head quality of *Celosia cristata* in agro-climatic field conditions of Multan;
– Effect of different plant spacing on plant growth and flower head quality of *Celosia cristata* in agro-climatic field conditions of Multan.

MATERIAL AND METHODS

Site. This study was conducted at the Experimental Farm, Faculty of Agriculture Science and Technology, Bahauddin Zakariya University Multan during the summer 2011.

Collection of Seed and Raising Seedlings. Hybrid seed (F_1) of cockscomb *(Celosia cristata)* was purchased from Pak Seed Co. Lahore, Pakistan. Seeds were sown in pots in the first week of July for raising seedlings. Media in pots comprised of well homogenized soil, silt and well rotten farm yard manure in ratio 1:1:1. After one week's time, seedlings were shifted from pots to plastic bags which were 3 inches in diameter and 8 inches in length. Seedlings were irrigated on daily basis till these were transplanted in the field.

Field Preparation and Transplanting Seedlings. After three weeks' time, seedlings were transplanted to field when seedlings showed two true leaves. Prior to transplanting, field was prepared by irrigation and spading twice and adding about 1.5kg DAP (at the rate of 150kg/hectare), about 2kg MOP (at the rate of 200kg/hectare) and about 1kg urea (at the rate of 100kg/ hectare).

Experimental Design and Treatments. GA_3 and Plant spacing were the two factors in this study. There were three levels of GA_3 (0, 25, 50 mg/l) and three plant spacing (22.50, 30.00, 37.50 cm) making overall 9 treatments (T_1= 0 mg/L × 22.5 cm, $T_{2=}$ 0 mg/L × 30 cm, $T_{3=}$ 0 mg/L × 37.5 cm, $T_{4=}$ 25 mg/L × 22.5 cm, $T_{5=}$ 25 mg/L × 30 cm, $T_{6=}$ 25 mg/L × 37.5 cm. $T_{7=}$ 50 mg/L × 22.5 cm, $T_{8=}$ 50 mg/L × 30 cm, $T_{9=}$ 50 mg/L × 37.5 cm). All treatments were tested in 3 replications in a randomized complete block design (RCBD) with 25 seedlings for each treatment unit.

DATA COLLECTION AND STATISTICAL ANALYSIS

After 90 days, plant responses from all treatments were recorded in terms of leaf chlorophyll content, number of leaves per stem, leaf area, stem length, stem fresh weight, stem dry weight, flower head area, flower head fresh weight and flower head dry weight. The data collected were subjected to statistical analysis as analysis of variance (ANOVA) and Least Significant Difference (LSD) at 5% level of significance as given by Steel *et al*. (1997) using MSTAT-C, computer software (Bricker, 1991).

RESULTS AND DISCUSSION

Effect On Chlorophyll Content. Statistical analysis indicates that maximum chlorophyll content of 83.54 was achieved in treatment $T_9$when plants were spaced at 37.5cm apart and treated with 50mg/L GA_3 and this treatment was significantly different from all other treatments. Minimum chlorophyll content was repor Standard Error=2.83 treatment $T_9$with no GA_3 application. In fact, Gibberellins plays a crucial role in cell elongation of plants. Better growth and increased leaf area which in turn yielded higher number of chlorophyll content has been possible due to ample space available for the plant growth plus the application of 50mg/L GA_3. Similar results were obtained in Lily (Emami *et al*., 2011).

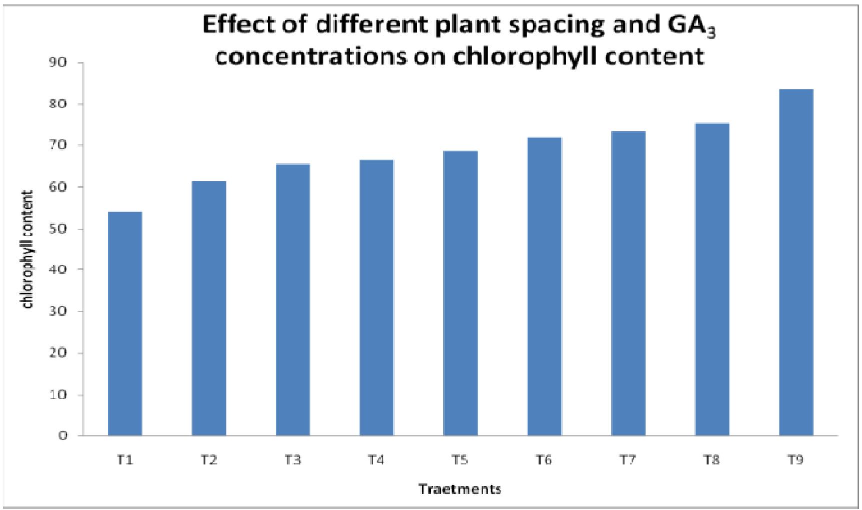

Figure 1 – Effect of different plant spacing and GA_3 concentrations on chlorophyll content

Leaf Area (cm^2). Maximum leaf area of 154.34 cm^2 was achieved when plants were spaced 37.5 cm apart and treated with 50mg/L of GA_3 (T_9) and it was significantly different from all other treatments. The minimum leaf area of 134.85 cm^2 was produced with 22.5 cm plant spacing when no GA_3 was applied (T_1). Greater leaf area allows maximum exposure to light thus causing higher levels of carbohydrates to be fixed in plant. Hence this spacing, in combination with GA_3 (50mg/L) plays a significant role in the growth and development of Cockscomb and ultimately contributes to quality production of flower heads. These findings are in accordance with the findings of Akinfasoye *et al*., (2008) in Celosia; Yarnia*et al*., (2011) in Amaranthus; Chandrappa *et al.* (2006) in Anthurium; Peanav *et al*., (2005) in gladiolus and Khan *et al.* (2003) in Dahlia.

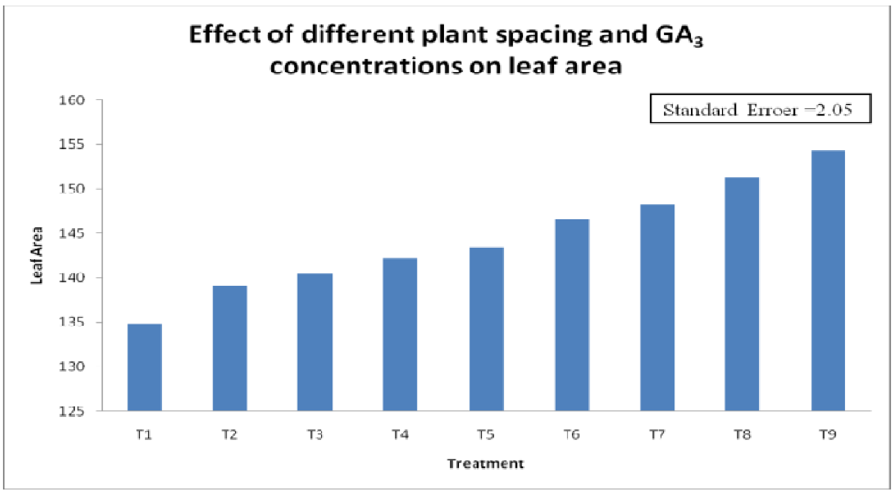

Figure 2 – Effect of different plant spacing and GA_3 concentrations on leaf area

Stem Length (cm). Study has revealed that maximum stem length of 69.30 cm and 65.5 cm was achieved with the application of 50mg/L GA_3 with plant spacing of 37.5 cm and 30.0 cm (T_9 andT_8 respectively), though these were statistically different from one another. On the other extreme, minimum stem length of 51.77 cm was achieved when plants did not receive any GA_3 treatment and were planted at a distance of 22.5cm apart (T_1). It is evident from the data that plant spacing and GA_3 play a vital role in quality production of *celosia cristata*as cut flower. It seems that 37.5cm plant spacing is ideal for better growth where these plants grow without any competition with neighboring plants. GA_3 is also well known for cell elongation and this concentration of (50mg/L) is the most suitable dose for getting appropriate stem length that is well accountable in cut flower production. Similar studies were done on Marigold by Kishan *et la.,* (2007); on Anthurium by Chandrappa *et al.,* (2006); on gladiolus (Bhattacharjee, 1984; Bhushan *et al.,*2006 ;Roychowdhury., 1987 ; Peanava*et al.*, 2005), tuberose (Khalaj*et al.*, 2012 ; Mane *et al.,* 2006) and on Black Iris (Al-Khassawneh *et al.,*(2005).

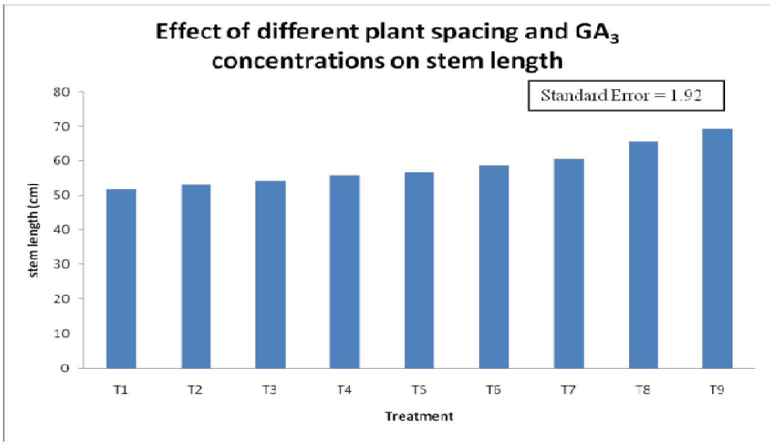

Figure 3 – Effect of different plant spacing and GA_3 concentrations on stem length

Fresh weight of Stem (g). This study shows that the maximum fresh weight of stem (742.99g) was achieved when plant spacing 37.5cm was used with application of 50mg/L GA_3 (T_9). This treatment was followed by combination of 30 cm plant spacing and application of 50mg/L GA_3 (T_8) which produced stem fresh weight of 731.86 g. Minimum stem fresh weight was produced when plant spacing of 22.5cm and 30cm was used (T_1 andT_2 respectively) without any GA_3 application. Fresh weight basically is due to water uptake of plants during development. It seems that this treatment combination (T_9) has helped the plant to establish more number of roots which ultimately helped the plant in updating greater water content. These findings are comparable to the results of Yarnia *et al.*, (2011) in Amaranth; kazaz *et al.*, (2011) in Carnation and Emami *et al.*, (2011) in *Lilium longiflorium*.

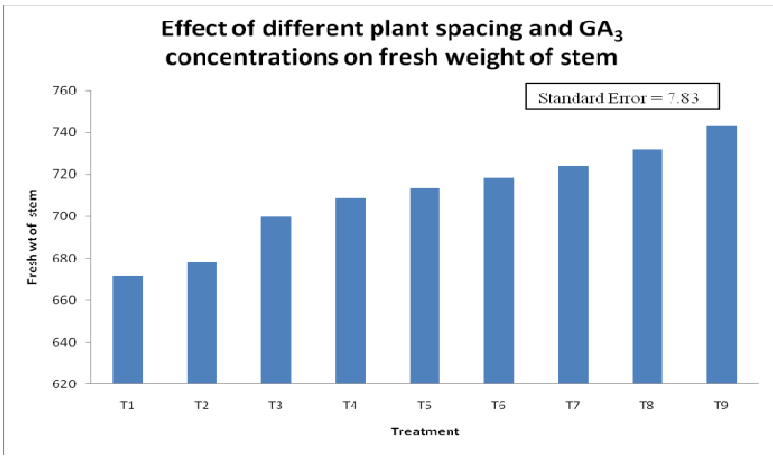

Figure 4 – Effect of different plant spacing and GA_3 concentrations on fresh weight of stem

Dry Weight of Stem (g). It is evident from the data that maximum dry weight of stem (56.44g) was achieved when plant spacing of 37.5 cm was used and 50mg/L GA_3 was applied (T_9). Minimum stem dry weight of 39.36 g was achieved when plant spacing of 22.5 cm was used without GA_3 application (T_1). In fact, dry weight of plants is always dependent on the photosynthetic efficiency of plants. Leaves play a vital role in manufacturing plant food in the presence of optimum daylight. It is clear from the data that more number of leaves and maximum leaf area is produced by the same treatment combination. Hence, this treatment combination in the presence of optimum light produced maximum dry matter in the *Celosia cristata* stem. Kazaz *et al*., (2011) found variable results in stem dry matter of different cultivars of Carnation. Ali *et al*., (2006) found significant increase in shoot dry weight and corm dry weight in Gladiolus with nitrogen and GA_3 treatment.

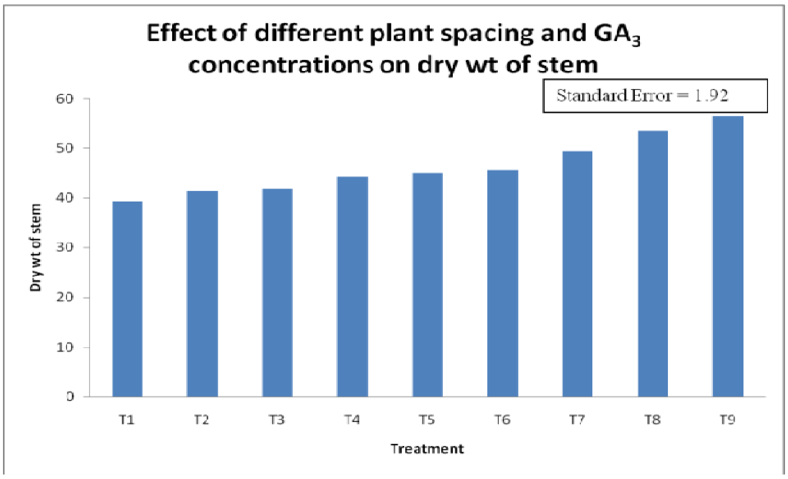

Figure 5 – Effect of different plant spacing and GA_3 concentrations on dry weight of stem

Flower size (cm^2). It is apparent from the data that maximum but statistically insignificant flower sizes of 38.21cm^2, 36.20 cm^2 and 34.57cm^2 were achieved when plant spacing of 37.5 cm, 30 cm, and 22.5cm were used respectively and were treated with 50mg/L GA_3 (T_9, T_8 and T_7 respectively). Minimum flower size of 18.36 cm2 was achieved when plant spacing of 22.5cm was used without any GA_3 application (T_1). This result tells that GA_3 application plays its role in the production of maximum flower size. Gibberellins are well known for cell enlargement of plants growth and development. It is also reported that stem length and total yield/m^2 increased by increasing plant densities, whereas stem diameter, stem weight and flower diameter per plant decreased in Standard Carnations (Kazaz *et al*., 2011). The variation in different vegetative and flower parameters may be due to the different growth requirement of *Celosia cristata* and Carnation for spacing.

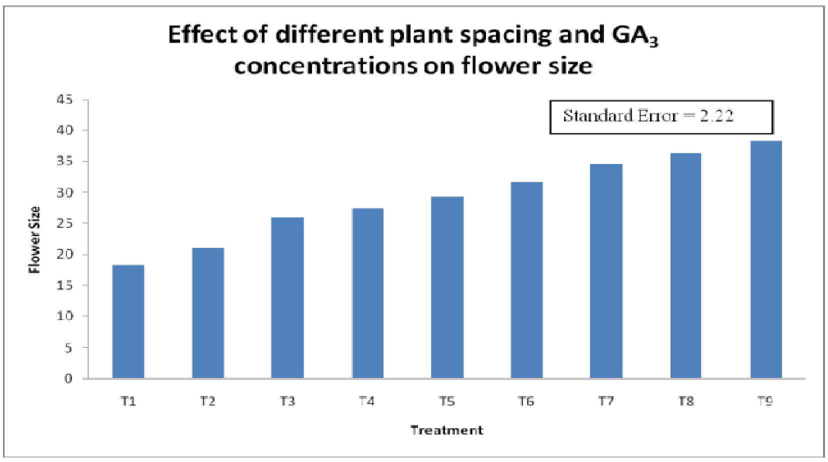

Figure 6 – Effect of different plant spacing and GA_3 concentrations on flower size

Flower Fresh Weight (g). Maximum flower fresh weight of 21.74g was achieved when seedling were planted 37.5cm apart and 50mg/L GA_3 was applied (T_9) against minimum flower fresh weight of 6.08g which was achieved when plant spacing of 22.5cm was used without GA_3 application (T_1). It seems that plant spacing of 37.5 cm or 30 cm in combination with GA_3 at the rate of 50mg/l may help to develop more number of plant roots and these may be helpful in uptake of more water by the plants. Hence, uptake of more water by the roots may be responsible for better fresh flower weight in *Celosia cristata*. The results are comparable to the findings of Kishan *et al.* (2007) who reported maximum fresh weight of single flower in African marigold (Tagetserecta Linn.) cv. PusaNarangiGainda with the application of GA_3 at the rate of 300 ppm. Increase in fresh weight of flower stalk due to the application of GA_3 has already been reported in carnation (Verma *et al*., 2000) and iris (Al-Khassawneh *et al*., 2006).

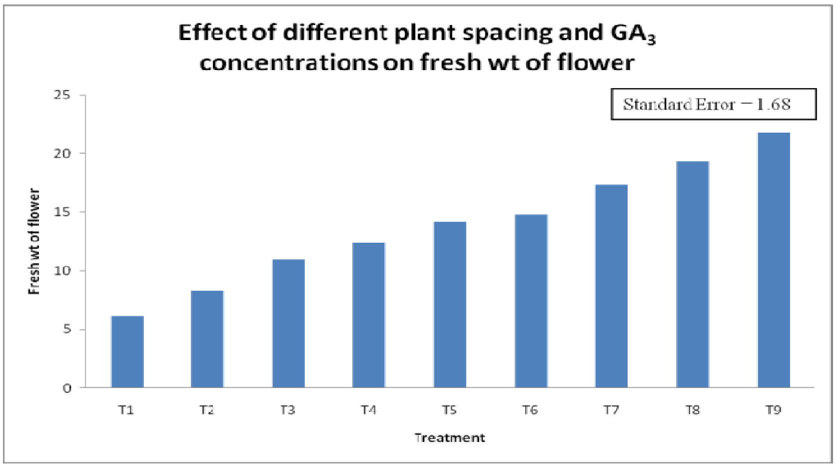

Figure 7 – Effect of different plant spacing and GA_3 concentrations on fresh weight of flower

Flower Dry Weight (g). It is evident from results that maximum flower dry weight of 2.92 g was achieved when plants were spaced at 37.5 cm apart and were treated with 50mg/L GA_3 (T_9) and was statistically highly significant than all other treatments and control. The minimum flower dry weight of 0.69 g was produced when plant spacing of 22.5 cm was used with no GA_3 application (T_1). Plant spacing may provide optimum space for better plant growth and plant may have better share of food nutrients as compared to other treatments. On the other hand, GA_3 also causes an increase in leaf area and number of leaves in this treatment which ultimately may have influenced in the production of more photosynthates which may have translocated to flower head and accumulated as dry matter.

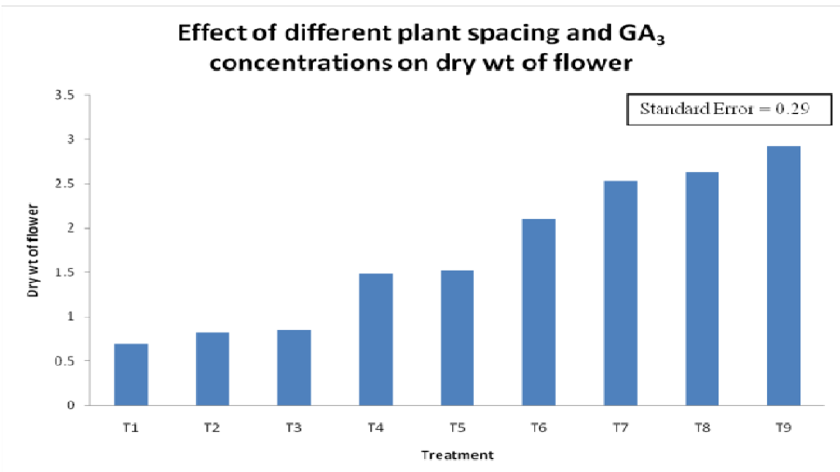

Figure 7 – Effect of different plant spacing and GA_3 concentrations on fresh weight of flower

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