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EFFECT OF GIBBERELLIC ACID ON ENHANCING FLOWERING TIME IN CHRYSANTHEMUM MORIFOLIUM

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Abstract

The study was conducted to evaluate the effect of various concentrations of GA_3 on plant height, number of branches, leaves, flowers plant^{-1}, leaf area, days to flowering, blooming period, flower size and flower fresh weight. There were total six treatments of GA_3 concentrations at 0, 50, 100, 150, 200 and 250 mg L^{-1}. Data regarding vegetative and flowering attributes indicated that flowering in *Chrysanthemum morifolium* varied significantly for most of the studied parameters. Application of GA_3 at the rate of 250 mg L^{-1} with plant height (62.0 cm), number of branches (8.65), suckers (8.05), leaves (55.05) plant^{-1}, leaf area (122.35 cm^2), days to flower (110.8 days) and number of flowers (31.9) were significantly different as compared to rest of the treatments and was followed by GA_3 at the rate of 200 mg L^{-1} in flower size (5.49 cm) and flower fresh weight (4.01g). Untreated Chrysanthemum plants had least plant height (47.5 cm), number of branches (6.4), suckers (6.75), leaves (39.2) plant^{-1}, leaf area (96.85 cm^2), days to flower (131.05 days), number of flowers (21.91) plant^{-1}, flower size (4.88 cm) and flower fresh weight (3.44 g). Application of GA_3 @ 250 mg L^{-1} produced flowers earlier (28th September) than the normal season and extended the flowering season up to 22 days.

Key words: Chrysanthemum flowering, Gibberellic acid, Early flowering.

Introduction

Chrysanthemum (*Chrysanthemum morifolium*) is commonly known as Gul-e-Daudi or Queen of the East. It belongs to the family *Asteraceae*. It is highly attractive short day plant, which behaves both as an annual as well as perennial flowering herb (Ghafoor & Khan, 2002). This Attractive flowering plant is extremely popular all over the world. It starts to bloom during autumn season, while in Pakistan, its peak blooming period is month of November and December. In Hazara Division, it blooms from 15th to 25th October. Flowers are attractive, showy and their popularity has increased not only due to their outstanding aesthetic beauty but also due to their excellent potential of export as cut flowers to many countries of world (Erler & Seigmund, 1986). The plant growth regulators are compounds that in minor amounts modify the physiological processes of plants and ultimately alter the yield and quality. Numerous plant growth regulators have been widely used in many flowering plants and their efficacy have been demonstrated for nursery production, foliage plants and many other ornamental plants (Sanap *et al*., 2000). Among the major groups are auxins, cytokinins, abscisic acid, gibberellins, polyamines and ethylene (Salisbury & Ross, 1992). Gibberellin was first recognized in 1926 by a Japanese scientist, Eiichi Kurosawa who was studying bakanae or "foolish seedling" disease in rice (Salisbury & Ross, 1992). Three gibberellins are known as gibberellic acid ($C_{19}H_{22}O_6$), gibberellin A_1 ($C_{19}H_{24}O_6$) and gibberellin A_2 ($C_{19}H_{26}O_6$). The biological activity of all three gibberellins is qualitatively similar. Young and growing meristematic tissues, apical root cells, young fruits and germinating seeds are rich in gibberellins (Brian, 2008).

The most characteristic effects of GA_3 on shoot growth are increase in inter-node extension, increase in leaf-growth, increase in diameter of plant, increase in number of flowers, induce flowering and enhanced apical dominance (Medina & Saavedra, 1999; Taiz & Zeiger, 2004). In its effects on leaf expansion and on some forms of dormancy, GA_3 simulates light. In most photo-periodically sensitive plants, particularly in the form of long-day photoperiod, induces increased shoot growth. GA_3 has a similar effect. There is thus a fundamental unity in the effects of GA_3 on plant development, in which GA_3 closely simulates effects usually induced in nature either by exposure to light or by vernalization (Brian, 2008). It also has stimulant effect on germination (Shohani *et al.*, 2014).

It has been observed that gibberellins cause early flowering in those biennial plants that need a cold period (chilling requirement) before they flower (Hartmann *et al.*, 1981). Gibberellins function as plant growth regulators influencing a range of developmental processes in plants life like stem elongation, germination, breaking dormancy, flowering, sex expression, enzyme induction and leaf and fruit senescence. 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).

Gibberellins initiates early flowering in many ornamental plants and increases the number of flowers. Spraying of GA_3 induced early flowering, increased size of the flowers, fresh weight and dry weight of flowers in Chrysanthemum (Nagarjuna *et al*., 1988); (Koriesh *et al*., 1989). Spraying of GA_3 gave maximum number of flowers per plant, flower weight and flower yield (Kumar *et al*., 2003), while stalk length and spathe length increase with foliar application of GA_3 in anthurium (Dhaduk *et al*., 2007). Whereas, Devadanam *et al*. (2007) observed minimum number of days required for spike emergence maximum spike length with foliar spray of GA_3. Lower

concentrations of GA_3 decreases number of days to 50% flowering, increases number of leaves, spike girth, spike length, rachis length, floret length and floret diameter in marigold and tuberose (Panwar *et al*., 2006; Samruban & Karuppaiah, 2007; Devadanam *et al*., 2007). Keeping in view the above mentioned important properties of the gibberellic acid, this experiment was designed to study the influence of various doses of GA_3 on regulation of flowering time in Chrysanthemum.

Materials and Methods

The studies were carried out during 2010-11 at Hazara Agriculture Research Station Abbottabad Khyber Pakhtunkhwa, Pakistan. The experiment was laid-out in Completely Randomized Design with six doses of GA_3. Terminal cuttings of chrysanthemum cv. Fanfare were taken from the stock and were planted in 7 cm plastic pots separately on 10th June. The clay pots 28 cm size were filled with 2 parts leaf mould and one part silt and plants were transplanted to clay pots separately on 10th July. Fertilizer NPK was applied at the rate of 1.5 g to each pot. GA_3 solutions were sprayed on plants in the morning at 15 and 30 days after transplanting. There were total six treatments including; a control with no GA_3 spray. Other treatments included 5o, 100, 150, 200 and 250 mg L^{-1} of GA_3 were designated as T1, T2, T3, T4, T5 and T6 respectively.

All the cultural practices were kept uniform for all the treatments in the experiment. The experiment with all same inputs and treatments was repeated in 2011 and average data of both years were analyzed at the end using computer statistical software "Statistix 9.0".

The physical traits considered included plant height which was the measure of stem length from the crown to the top of the stem. The number of branches plant $^{-1}$ grown on plant were counted and recoded after the last flower harvested. All the leaves grown on plant were counted and recorded after the last flower harvested. Leaf area was measured with the help of an automatic Leaf Area meter. Days taken to flowering were counted from date of transplanting to small pots (10th June) till the date of flower bud opening. The number of flowers, flower size (diameter) and fresh weight were then taken after harvest. All flowers grown on the main stalk and the side branches were counted up to the last flower harvested. Number of days from flower bud break till its petal fadding were counted. The flower size was recorded by measuring the diameter of the flower in cm. Full bloomed flowers were excised and weighed on electronic balance individually.

Results

Vegetative attributes

Plant height (cm): The data regarding plant height revealed that GA_3 had profound effect on plant height while the year wise as well as GA_3 interaction with year did not affect it. Plant height was (62.0 cm) when GA_3 @ 250 mg L^{-1} was applied, while it was lower (47.5 cm) in untreated plants. Untreated plants were significantly different from those treated with GA_3 @ 50, 100, 150, 200 and 250 mg L^{-1}, while treatments GA_3 @ 150 and 200 mg L^{-1} were non significantly different from each other. Plants treated with GA_3 @ 200 and 250 mg L^{-1} also had non significant difference regarding plant height (Table 1).

Number of branches plant^{-1}: The data in table 1 indicated that GA_3 had pronounced effect on number of branches in Chrysanthemum. Number of branches were more (8.65) when plants were subjected to GA_3 @ 250 mg L^{-1} followed by those plants that were treated with GA_3 @ 200 mg L^{-1} (8.05), while branches were less (6.4) in untreated plants followed by (6.45) GA_3 @ 50 mg L^{-1}. Branches produced in plants treated with control, GA_3 @ 50 and 100 mg L^{-1} were non significantly different from each other. Statistically similar effect was recorded between and GA_3 @ 200 and 250 mg L^{-1}. There was significant difference in branches between untreated plants and plants treated with GA_3 @ 150, 200 and 250 mg L^{-1}.

Table 1. Effect of Gibberellic Acid on plant height, number of branches/plant and number of suckers/ plant in *Chrysanthemum* for year 1 (2010) and year 2 (2011).

GA_3 (ppm)	Plant height (cm)			No. of branches plant^{-1}			No. of suckers plant^{-1}		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Control	46.2 d	48.8 c	47.5 e	7.1 bc	5.7 c	6.40 c	6.8 d	6.7 d	6.75 c
50	54.3 c	49.8 c	52.1 d	6.3 c	6.6 c	6.45 c	6.9 d	6.8 cd	6.85 c
100	54.5 bc	58.2 b	56.1 c	6.7 c	7.3 c	7.00 bc	7.3 cd	7.3 bc	7.30 b
150	58.4 abc	57.7 b	58.2 bc	7.3 bc	7.2 c	7.25 b	7.5 bc	7.6 ab	7.55 b
200	60.2 ab	59.7 b	60.0 ab	7.9 ab	8.2 b	8.05 a	7.9 ab	8.0 a	7.91 a
250	60.5 a	63.5 a	62.0 a	8.8 a	8.5 a	8.65 a	8.1 a	8.0 a	8.05 a
LSD *(p=0.05)*	5.8(**)	3.6(**)	3.2(**)	1.1(**)	0.8(**)	0.7(**)	0.5(**)	0.5(**)	0.4(**)
Year									
2010	--	--	55.69	--	--	7.35	--	--	7.39
2011	--	--	56.24	--	--	7.24	--	--	7.38
LSD (*p=0.05*)	--	--	NS	--	--	NS			NS
GA_3 x year									
LSD*(p=0.05)*	--	--	NS	--	--	NS	--	--	NS

Means followed by similar letters in a column are non significantly different from each other at α 0.05
NS = Non significant
* = Significant at 5% level of probability

Number of suckers plant^{-1}: Table 1 showed pronouncedly increasing trend in number of suckers plant^{-1} with the increase in concentration of GA_3. More number of suckers (8.05) were recorded in plants treated with GA_3@ 250 mg L^{-1} closely followed by (7.91) in the plants treated with GA_3@ 200 mg L^{-1}, while less number of suckers were produced in untreated plants. Number of suckers produced in untreated plants and plants treated with GA_3@ 50 mg L^{-1} were statistically same. Similar trend was observed between GA_3@ 100 mg L^{-1} and GA_3@ 150 mg L^{-1}. GA_3@ 200 mg $L^{-1}$and GA_3@ 250 mg L^{-1}were also at par regarding number of suckers plant^{-1}.

Number of leaves plant^{-1}: There was substantial difference in number of leaves in Chrysanthemum as affected by various concentrations of GA_3. Higher number of leaves (55.05) were recorded in plants treated with GA_3 @ 250 mg L^{-1}, while it was less (39.20) in control. Profound difference was recorded between control and GA_3 @ 100, 150 and 250 mg L^{-1}. The effects of untreated plants and GA_3 @ 50 mg L^{-1} were non-significantly different. Plants treated with GA_3 @ 200 and 250 mg L^{-1} also showed non significant difference with each other (Table 2).

Leaf area (cm^2): Data regarding leaf area indicates considerable difference among various treatments of GA_3 (Table 2). Broader area (122.35 cm^2) was recorded when plants were treated with GA_3 @ 250 mg L^{-1}, while it was smaller (96.85 cm^2) in control. The effect of (control and GA_3 @ 50 mg L^{-1}), (GA_3 @ 200 and 250 mg L^{-1}) were statistically similar in their effects while rest of the treatments were found significantly different from each other.

The interactive effect of GA_3 and year was significant on leaf area (Fig. 1). Broader leaves (125.3 cm^2) were recorded at interaction of year 1 with GA_3@ 250 mg L^{-1} application non significantly followed by (122.3 cm^2) year 1 with GA_3@ 200 mg L^{-1} application, while less leaf area (93.7 cm^2) was recorded at year 1 with control followed non significantly by year 1 (97.9 cm^2) with GA_3 @ 50 mg L^{-1}application. The difference might be attributed to plant height.

Flowering attributes

Number of days to flowering: Foliar application of GA_3 extensively affected number of days to flowering in *Chrysanthemum* (Table 3). Untreated plants took significantly more days to flower (131.05 days) as compared to the plants that were sprayed with 250 mg L^{-1} GA_3 that took less days (110.8 days) to flower. Days to flower were statistically unchanged at control, GA_3 @ 50 and 100 mg L^{-1} treatments on plants. Significant difference was recorded between control and GA_3 @ 150, 200 and 250 mg L^{-1}. Plants treated with GA_3 @ 150 and 200 mg L^{-1} were non significantly different from each other regarding number of days to flowering. Plants treated with GA_3 @ 100 and 150 mg L^{-1} were non significantly different from each other.

Number of flowers plant^{-1}: The data in table 3 indicated that GA_3 deeply affected the number of flowers plant^{-1}. Plants produced more number of flowers (31.9) when treated by GA_3 @ 250 mg L^{-1}, followed by (30.0) GA_3 @ 200 mg L^{-1} as compared to control which produced less (21.91) flowers. Effects of untreated plants were significantly different from GA_3 @ 150, 200 and 250 mg L^{-1}. GA_3 @ 200 and 250 mg L^{-1} had statistically same effect on number of flower. Likewise control and GA_3 @ 50 and 100 mg L^{-1} had similar effect regarding number of flowers plant^{-1}.

The interactive effect of GA_3 and year was also significant on number of flowers plant^{-1} (Fig. 2). Higher number of flowers (32.7) were recorded at interaction of year 1 with GA_3@ 250 mg L^{-1} application closely followed by same year with GA_3@ 200 mg L^{-1} application (32.05), while less (19.5) number of flowers were recorded at year 1 with control followed significantly by same year with GA_3 @ 50 mg L^{-1}application (23.17). The difference might be attributed to seasonal variations.

Table 2. Effect of Gibberellic Acid on number of leaves plant^{-1} and leaf area in *Chrysanthemum*.

GA_3 (ppm)	Number of leaves plant^{-1}			Average leaf area (cm^2)		
	2010	2011	Mean	2010	2011	Mean
Control	36 e	43 b	39.20 e	93.7 d	100.0 c	96.85 d
50	43 cd	37 c	40.00 de	97.9 cd	100.9 c	99.40 d
100	40 de	45 b	42.50 d	102.7 c	110.7 b	106.70 c
150	48 bc	45 b	46.50 c	113.7 b	109.0 b	111.40 b
200	49 b	53 a	51.00 b	127.3 a	113.1 ab	120.20 a
250	56 a	54 a	55.05 a	125.3 a	119.4 a	122.35 a
LSD*(p=0.05)*	4.9(**)	3.8(**)	3.0(**)	5.1(**)	6.9(**)	4.2(**)
Year						
2010	--	--	45.9	--	--	109.28
2011	--	--	46.5	--	--	109.69
LSD (*p=0.05*)	--	--	NS	--	--	NS
GA_3 x Year						
LSD*(p=0.05)*	--	--	NS	--	--	*5.87 (Fig. 1)

Means followed by similar letters in a column are non significantly different from each other at α 0.05
NS = Non significant
* = Significant at 5% level of probability

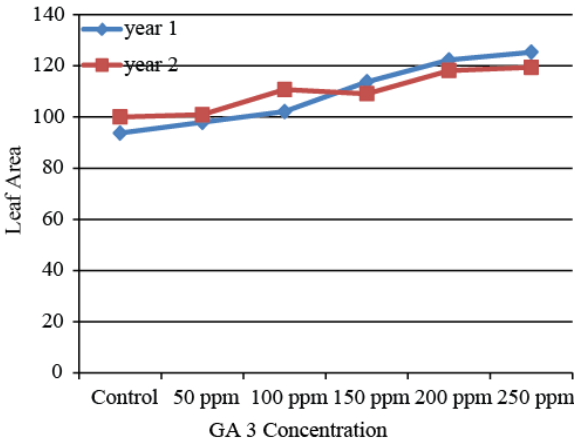

Fig. 1. Interactive effect of GA_3 and Year on leaf area.

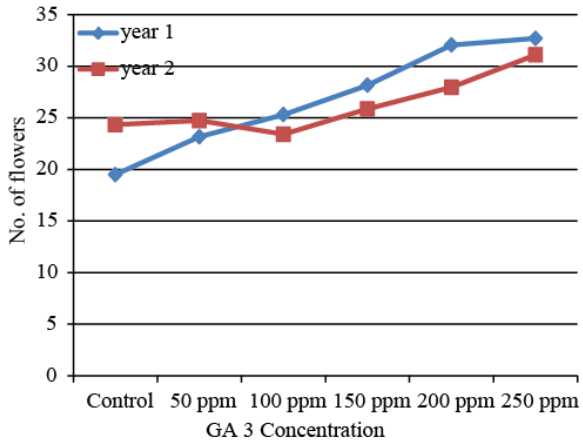

Fig. 2. Interactive effect of GA_3 and year on number of flowers plant^{-1}.

Table 3. Effect of Gibberellic Acid on number of days to flowering, number of flowers/ plant and blooming period in *Chrysanthemum*.

GA_3 (ppm)	Number of days to flowering			Number of flowers plant^{-1}			Blooming period		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Control	132 a	130 a	131.05 a	20 c	24 b	21.91 c	35	38	36.90
50	130 a	125 ab	127.68 a	21 c	27 b	23.95 c	37	36	36.50
100	123 b	118 c	120.40 b	25 b	24 b	24.35 c	38	36	37.00
150	115 c	120 bc	117.48 bc	28 b	26 b	27.00 b	39	36	37.75
200	112 c	116 cd	114.20 cd	35 a	25 b	30.00 a	39	37	37.70
250	111 c	111 d	110.80 d	33 a	31 a	31.90 a	39	37	37.95
LSD *(p=0.05)*	6.3(**)	5.8(**)	4.1(**)	4.0(**)	3.9(*)	4.5(**)	NS	NS	NS
Year									
2010	--	--	120.6	--	--	26.8	--	--	37.9
2011	--	--	119.9	--	--	26.2	--	--	36.7
LSD (*p=0.05*)	--	--	NS	--	--	NS	--	--	NS
GA_3 x Year									
LSD*(p=0.05)*	--	--	NS	--	--	*3.47 (Fig. 2)	--	--	NS

Means followed by similar letters in a column are non significantly different from each other at α 0.05
NS = Non significant
* = Significant at 5% level of probability

Blooming period: The difference regarding flower blooming period against various treatments of GA_3 application was non significant. The parameter was not affected by year and GA_3 interaction. The blooming period was higher (37.95 days) in plants treated with GA_3 @ 250 mg L^{-1} whereas it was lower (36.5 days) in GA_3 @ 50 mg L^{-1}. All concentrations were non-significantly different from each other at 5% level of significance (Table 3).

Flower size (cm): The flower size was remarkably affected by various concentrations of GA_3 (Table 4). Bigger size (5.55 cm) was recorded in GA_3 @ 200 mg L^{-1} followed (5.49 cm) by GA_3 @ 250 mg L^{-1}. Smaller size was recorded in control (4.88 cm). The effects of GA_3 @ 150, 200 and 250 mg L^{-1} were statistically same. Control and GA_3 @ 50 mg L^{-1} exhibited non significant difference regarding flower size. Plants sprayed with GA_3 @ 100 mg L^{-1} recorded non significant difference with those plants treated with GA_3 @ 50 mg L^{-1} but significant difference with rest of the treatments (Table 4).

Flower fresh weight (g): Flower fresh weight was strongly affected by various concentrations of GA_3, while it was not affected by year and interactive effected of year and GA_3 (Table 4). Significantly higher fresh weight (4.16 g) was recorded when GA_3 @ 200 mg L^{-1} was sprayed on plants, while it was less (3.44 g) in control. The effects of GA_3 @ 50, 100 and 150 mg L^{-1} were statistically same. Plants treated with GA_3 @ 200 mgl^{-1} were significantly different from control, GA_3 @ 50, 100 and 150 mg L^{-1}, while they were non significantly different from the plants treated with GA_3 @ 250 mg L^{-1} regarding flower fresh weight.

Discussion

GA_3 treated plants showed remarkable increase in plant height. Taller plants were observed when treated with GA_3 @ 250 mg L^{-1} closely followed by the application of GA_3 @ 200 mg l^{-1}. Significantly less height (47.55 cm) was recorded in control. Plant

height increased with the increasing doses of GA_3. Foliar application of GA_3 might have influenced the stem elongation by stimulating cell division and elongation. These findings are in line with those reported by Talukdar & Paswan (1994) who noticed an increase in plant height with the increase in doses of GA_3 concentrations in chrysanthemum. Schmidt *et al*. (2003) found 16.78% increase in plant height when applied GA_3 at 300 mg L^{-1} on chrysanthemum c.v Viking. Kumar *et al*. (2012) also recorded same trend in carnation.

Number of branches increased with the increasing doses of GA_3 as compared to the control. Foliar application of GA_3 might have influenced the stem elongation by stimulating cell division and elongation that resulted in enhanced branches and vegetative growth. Nagarjuna *et al*. (1988) recorded more number of branches with 200 ppm GA_3 as compared to control in Chrysanthemum. These findings are also in agreement with those of Dabas *et al*. (2001) in marigold and Krishnamoorthy & Madalagery (2000) recorded increased number of branches in Ajovan.

Table 4. Effect of gibberellic acid on flower size and flower fresh weight in *Chrysanthemum*.

GA_3 (ppm)	Flower size (cm)			Flower fresh weight (g)		
	2010	**2011**	**Mean**	**2010**	**2011**	**Mean**
Control	4.8 cd	5.0 c	4.88 c	3.4 c	3.5 b	3.44 c
50	4.7 d	5.3 b	4.99 bc	3.7 b	3.9 a	3.84 b
100	4.9 c	5.4 ab	5.19 b	3.8 b	3.9 a	3.85 b
150	5.4 b	5.5 a	5.42 a	3.9 b	4.0 a	3.95 b
200	5.6 a	5.5 a	5.55 a	4.2 a	4.1 a	4.16 a
250	5.5 ab	5.4 ab	5.49 a	4.1 a	3.9 a	4.01 ab
LSD *(p=0.05)*	0.2(**)	0.2(**)	0.2(**)	0.2(**)	0.4(*)	0.2(**)
Year						
2010	--	--	5.18	--	--	3.84
2011	--	--	5.31	--	--	3.90
LSD (*p=0.05*)	--	--	NS	--	--	NS
GA_3 xYear						
LSD *(p=0.05)*	--	--	NS	--	--	*5.87 (Fig.2)

Means followed by similar letters in a column are non significantly different from each other at α 0.05
NS = Non significant
* = Significant at 5% level of probability

The number of suckers increased with the increase in concentration. Higher number of suckers produced by GA_3 application might be attributed to the increase in number of branches, number of leaves and leaf area, which ultimately increased the translocation of photosynthates to produce more suckers. These findings are in agreement with the findings of Sharifuzzaman *et al*. (2011) who recorded an increase in number of suckers with GA_3 application in *Chrysanthemum*.

Greater number of leaves were recorded at GA_3 @ 250 mg L^{-1}. It might be attributed to the effect of GA_3 which increases cell division, cell elongation and tissue differentiation that resulted in the initiation of more number of leaves. The number of branches were also higher with the application of GA_3 which helped to initiate more leaves. More number of leaves $plant^{-1}$ as compared to control in Chrysanthemum has been reported by Talukdar & Paswan (1988). Sharifuzzaman *et al*. (2011) recorded maximum number of leaves at 150 ppm GA_3 treatment in *Chrysanthemum*. These results are also supported by those of Radives *et al*. (1992) in gladiolus.

Plants showed a significant increase in leaf area. This might be attributed to the fact that GA_3 stimulates the cell division and cell elongation, which ultimately results in an increase in leaf area and also the number of leaves. These results are also in agreement with those of Sharifuzzaman *et al*. (2011) recorded significant increase in leaf length by the application of different concentrations of GA_3 in *Chrysanthemum*. Singh (2003) recorded broader leaves in calendula by GA_3 application.

Chrysanthemum plants produced early flowers in all GA treatments as compared to control. It is the effect of GA_3 that causes flower initiation and early flowering by decreasing the concentration of ABA in plant shoot (Phengphachanh *et al*., 2012). Moreover as the number of leaves was increased, it resulted in more photosynthates to initiate early flowering and complete life cycle of the plant. The findings are in line with those reported by Dutta *et al.* (1993) who noticed early flowering in chrysanthemum when treated plants with GA_3. Sharifuzzaman *et al*. (2011) recorded early flowering with the application of 150 ppm GA_3 as compared to control in chrysanthemum. Kumar *et al*. (2012) noticed earliness in flowering in carnation as affected by all concentrations of GA_3.

The increase in number of flowers by GA_3 application might be due to increase in number of leaves as well as leaf area as compared to control, which might have enhanced the production and accumulation of increased photosynthates that were diverted to the sink and produced more flowers (Sharifuzzaman *et al*., 2011). These results are confirmed from those reported by Kumar *et al*. (2012) who recorded a substantial increase in number of flowers when plants were treated with GA_3 at 150 ppm in carnation. Double application with GA_3

accelerated flower bud development of *Ajania pacifica* (Zalewska & Antkowiak, 2013)

GA_3 treatment of chrysanthemum plants resulted an increase in flower size. The increase in size of flower might be attributed to the increase in number of leaves and leaf area that produced more photosynthates which in turn might have increased the flower size. Spraying of GA_3 at 200 ppm (Nagarjuna *et al.,* 1988) or twice at 100 ppm (Koriesh *et al*., 1989) induced early flowering and increased size of the flowers in *Chrysanthemum*. Bigger sized flowers as a result of GA_3 application have also been reported by Sharifuzzaman *et al*. (2011) in *Chrysanthemum*. Kumar *et al*. (2012) recorded increase in flower size in all GA_3treatments as compared to control in carnation. The findings of all these researchers confirm the findings of the current study.

Application of various concentrations of GA_3 increased the flower fresh weight in Chrysanthemum. The increase in fresh flower weight might be due to an increase in leaf area and number of leaves that resulted in production of more photosynthates which diverted to flowers to increase fresh weight. Kumar *et al*. (2012) recorded significant increase in flower weight in carnation affected by all concentrations of GA^3. Application of GA_3 at 200 ppm or twice at 100 ppm increased the flower fresh weight and dry weight of *Chrysanthemum* flowers (Nagarjuna *et al.,* 1988; Koriesh *et al*., 1989). These findings are also similar with those reported by Singh (2003b) who recorded increase in weight by GA_3 treatment in calendula.

Conclusion

From the results obtained during the study it can be concluded that among various gibberellic acid concentrations, treatment GA_3 @ 250 mg L^{-1} was superior with 22 days early flowering (28th September). This concentration not only helped to increase the flowering time rather it increased the number of branches, leaves and leaf area was also higher. It is further concluded that GA_3 @ 200 mg L^{-1} also showed better performance with higher flower size and flower fresh weight, while it performed close to GA_3 @ 250 mg L^{-1} regarding plant height, number of branches, days to flowering (114 days), number of leaves, leaf area, number of flowers and blooming period.

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