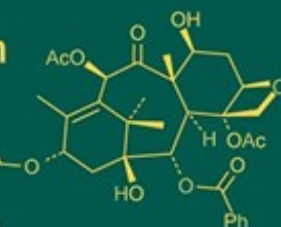
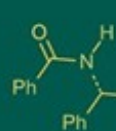


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Effect of pinching, salicylic acid and GA_3 on growth and flowering attributes in *Chrysanthemum*

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ABSTRACT

A field experiment was carried out to know the effect of pinching, gibberelic acid (GA_3) and salicylic acid (SA) on the growth and flowering in annual chrysanthemum. The treatments constituted of two level of pinching i.e. no pinching and pinching, three levels of GA_3 (100 ppm, 200 ppm and 300 ppm), three levels of SA (100 ppm, 150 ppm and 200 ppm) and control (distilled water). The experiment laid in Randomized Block Design with fourteen treatment combinations and replicated thrice. Pinching at 30 DAT significantly increased no. of secondary branches/plant, no. of leaves/plant, leaf area, bud diameter, peduncle length, flower longevity and no. of flowers/plant. However, maximum plant height, early bud initiation and flowering and maximum duration of flowering exhibited with no pinching treatment. GA_3 100 ppm resulted in maximum no. of flowers/plant and flowering duration. Early bud initiation and flowering and maximum fresh weight of flower were recorded with GA_3 200 ppm treatment. GA_3 at 300 ppm produced maximum height of plants, no. of leaves/plant and fresh leaf biomass. Among salicylic acid treatments 100 ppm SA resulted in maximum no. of secondary branches/plant, bud diameter and peduncle length. Whereas maximum dry weight of leaf, flower longevity and flower diameter was recorded with SA 150 ppm. Various growth and flowering parameters were also influenced due to interaction of pinching with GA_3 and SA treatments.

Keywords: *Chrysanthemum*, GA_3 , SA, Pinching, Growth, Flowering

Introduction

Annual chrysanthemum (*Chrysanthemum coronarium*) is popular for its diversity in size, shape and colour of blooms. It is an important flower crop grown in India for its loose flowers. Farmers are growing this flower crop because they are short-lived and yield marketable, attractive and long-lasting flowers. Farmers are looking forward for enhancement of production of its flowers per unit area. Agricultural techniques like pinching and application of growth-promoting chemicals may play pivotal role to increase the production. Pinching entails the removal of the terminal portion of shoots, which aids emergence of quality blooms on lateral branches (Singh, 2006) [1]. GA_3 trigger transitions from meristems to shoot growth, juvenile to flowering (Pradeepkumar, 2019). Salicylic acid is a plant phenolic and signalling molecule, now recognised as a phytohormone (Raskin, 1992) [2]. It takes part in numerous physiological functions of plants like photosynthesis, respiration, transpiration, nutrient uptake, senescence, inducing disease resistance, etc. (Clarke *et al.*, 2004 and Wang *et al.*, 2018) [3]. Hence, in present investigation pinching operation was followed along with foliar application of GA_3 and salicylic acid to find out their response on growth and flowering attributes in annual chrysanthemum.

Materials and Methods

An experiment was carried out to study the effect pinching, salicylic acid (SA) and gibberelic acid (GA_3) on growth and flowering characters in chrysanthemum. The experiment was conducted at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh during 2021-2022. Two levels of pinching (no pinching, single pinching at 30 DAT), three levels of GA_3 (100 ppm, 200 ppm and 300 ppm) and three levels of SA (100 ppm, 150 ppm, 200 ppm) along with control (distilled water) were taken in this investigation. There were fourteen treatment combinations. The experiment was laid out in a Randomized Block design with three replications. Seed sowing was done in the last week of November and one month old seedlings were transplanted at 60 cm row to row and 50 cm plant to plant distance. A single foliar spray of GA_3 and SA was applied 21 days after transplanting. Uniform cultural practices were followed for all the treatments. The data on various growth and flowering attributes were subjected to statistical analysis by using factorial experiment for analysis of variance (ANOVA).

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Results and Discussion

Effect of pinching on growth attributes

All the growth parameters were significantly influenced due to various level of pinching except fresh leaf biomass (Table 1). Maximum no. of secondary branches/plant (166.88), no. of leaves/plant (1649.94), leaf area (9.06 cm²) and dry weight of leaf (0.42 g) was observed with pinching, whereas maximum plant height at 60 DAT (49.16 cm) and at 90 DAT (120.07 cm) was found with no pinching. When pinching is done, it removes the apical bud, lowering the concentration of IAA. This encourages the lateral buds and promotes branching by overcoming apical dominance. Similar results were also reported by Meena *et al.* (2015) [4], Singh *et al.* (2015) [5] in marigold.

Effect of GA₃ and SA on growth attributes

The effect of GA₃ and SA on growth parameters in chrysanthemum was found to be significant (Table 1). Among different levels of growth chemicals maximum no. of leaves/plant (1732.67) and plant height at 60 DAT (53.10 cm) and at 90 DAT (135.07 cm) was found with GA₃ 300 ppm. Similarly, maximum fresh leaf biomass (474.06 g) was found with GA₃ 300 ppm which was found at par with SA 150 ppm (472.97 g) followed by SA 100 ppm (450.78 g). Gibberellins promote growth by affecting either cell expansion or cell division. The similar results were quoted by Pushkar *et al.* (2012) [6] in marigold, Singh *et al.* (2018) [7] in lily and Singh *et al.* (2019) [8] in rose.

Significantly, maximum no. of secondary branches/plant (180.30) was found with SA 100 ppm which was at par with SA 150 ppm (170.80). Maximum leaf area (10.32 cm²) was observed with SA 200 ppm which was at par with SA 150 ppm (9.51 cm²) followed by GA₃ 300 ppm (8.29 cm²) and dry weight of leaf (0.53 g) was observed with SA 150 ppm. The application of SA was attributed to the increase of photosynthetic tissues. Increase in leaf area is due to a positive correlation between photosynthesis and leaf area. Similar findings were reported by Pacheco *et al.* (2013) [9] in pot marigold.

Interaction effect

The data revealed from Table 1 showed the significant effect on all growth attributes except leaf area and plant height at 60 DAT due to interaction of different levels of pinching, GA₃ and SA. Significantly maximum no. of secondary branches/plant (206.60) was found with pinching × SA 100 ppm which was found to be at par with pinching × SA 150 ppm (205.00) similarly fresh leaf biomass (616.48 g) were found with pinching × SA 100 ppm which was at par with pinching × GA₃ 300 ppm (574.61 g) followed by no pinching × SA 150 ppm (555.43 g). Similarly, maximum no. of leaves/plant (1989.00) was found with interaction of pinching and GA₃ 300 ppm and dry weight of leaf (0.67 g) were observed with pinching × SA 150 ppm. Whereas maximum plant height at 90 DAT (141.17 cm) was observed with no pinching × GA₃ 300 ppm. The supply of more nutrients by application of GA₃ and SA were effectively utilised by pinched plants, which might have played some role in augmenting more no. of secondary branches, no. of leaves, fresh leaf biomass and plant height. Present study is in line with the findings of Sharma *et al.* (2016) [10] in chrysanthemum and Chauhan *et al.* (2005) [11] in marigold.

Effect of pinching on flowering attributes

Various flowering parameters were significantly influenced by pinching except flower diameter, fresh and dry weight of flower (Table 2 and Table 3). Earliest bud initiation (46.31 days) and flowering (74.51 days) and longest duration of flowering (46.78 days) were observed with no pinching. Maximum bud diameter (17.22 mm), peduncle length (17.33 cm), flower longevity (8.93 days) and no. of flowers/plant (270.48) were obtained from pinching. This might be because pinching the apical bud suppresses the bud initiation process by blocking cell division in the lateral meristems, preventing flower primordial development in the meantime. Similar findings on various flowering parameters were reported by Singh *et al.* (2014) [12], Singh

et al. (2017a) [13] in marigold and Salve *et al.* (2017) [14] in chrysanthemum.

Effect of GA₃ and SA on flowering attributes

Data recorded on flowering characters were statistically significant for various levels of growth promoting hormones GA₃ and SA except for dry weight of flower (Table 2 and Table 3). Earliest bud initiation (47.07 days) and flowering (76.04 days) were recorded for application of GA₃ 200 ppm. Significantly maximum fresh weight of flower (1.57 g) was recorded with GA₃ 200 ppm. Likewise, significantly maximum no. of flower/plant (285.13) and flowering duration (46.45 days) was found with GA₃ 100 ppm which was at par with GA₃ 200 ppm (275.30 and 45.58 days), respectively. Flowering attributes were noticed to be better with GA₃. This might be due to increase in cell elongation and rapid assimilation of photosynthetic metabolites, which probably influenced floral morphogenesis. Present data on flowering characters are in line with Vijayakumar *et al.* (2017) [15] in China aster, Yadav *et al.* (2015) [16] in marigold, Doraje Rao *et al.* (2012) [17] in chrysanthemum and Singh *et al.*, (2004) [18] in pot marigold.

Maximum diameter of bud (17.96 mm) and maximum peduncle length (17.86 cm) were recorded from SA 100 ppm whereas, minimum values of both bud diameter (16.42 mm) and peduncle length (14.57 cm) were observed for control. Flower longevity is a desired character for chrysanthemum which was highest (9.39 days) with SA 150 ppm and was at par with GA₃ 100 ppm (9.34 days). Maximum diameter of flower (6.99 cm) was recorded with SA 150 ppm which was at par with GA₃ 200 ppm (6.98 cm) followed by GA₃ 100 ppm (6.86 cm). SA exerts stimulatory effects on various physiological processes related to plant growth and development. These results are in close conformity with the results of Kumar *et al.* (2019) [19].

Interaction effect

Interaction effect of pinching and growth promoting hormones like GA₃ and SA on flowering attributes of chrysanthemum (Table 2 and Table 3) were found statistically significant for most of characters except bud diameter, flower longevity, fresh and dry weight of flower and flowering duration. Days to bud initiation and flowering determine the availability of flower in a season. Earliest bud initiation (42.94 days) was observed with no pinching × GA₃ 100 ppm. Similarly earliest days to flowering (70.39) was found with no pinching × GA₃ 300 ppm. Maximum peduncle length (19.57 cm) was recorded with interaction of pinching × SA 100 ppm. Likewise, maximum no. of flower/plant was (294.60) was obtained with pinching × GA₃ 200 ppm which was at par with no pinching × GA₃ 100 ppm (291.87). Significantly maximum diameter (7.09 cm) of flower was observed with interaction of pinching × SA 100 ppm which was at par with no pinching × GA₃ 100 ppm (7.06 cm). Plant growth and flowering were significantly influenced with growth promoting chemicals has been observed by Singh (1999) [20]. This result is in agreement with finding of Singh *et al.* (2017) [21], Singh *et al.* (2018a) [22] and Sarkar *et al.* (2018) [23] in African marigold.

Conclusion

The present investigation demonstrated that pinching, gibberellic acid (GA₃) and salicylic acid (SA), individually as well as in combination, significantly influenced the growth and flowering performance of annual chrysanthemum. Pinching at 30 days after transplanting enhanced vegetative growth by increasing the number of secondary branches, leaves, leaf area and leaf dry weight, and also improved important flowering attributes such as bud diameter, peduncle length, flower longevity and number of flowers per plant. In contrast, plants without pinching exhibited earlier bud initiation and flowering and a longer flowering duration. Among the growth regulators, GA₃ 300 ppm was most effective for plant height, number of leaves and fresh leaf biomass, whereas GA₃ 100 ppm produced the maximum number of flowers per plant and flowering duration. GA₃ 200 ppm promoted early bud initiation and flowering and resulted in the high

est fresh flower weight. Salicylic acid at 100 ppm was effective in enhancing secondary branching, bud diameter and peduncle length, while SA 150 ppm improved leaf dry weight, flower longevity and flower diameter. The interaction between pinching and growth regulators further improved several growth and flowering attributes, with pinching × SA 100 ppm producing maximum secondary branches and

fresh leaf biomass, pinching × GA₃ 300 ppm producing the maximum number of leaves, and pinching × GA₃ 200 ppm producing the highest number of flowers per plant. Thus, the study confirms that appropriate integration of pinching with GA₃ and SA applications can effectively modify plant architecture and improve important flowering and quality attributes of annual chrysanthemum.

Table 1. Effect of pinching, GA₃ and SA on growth attributes of chrysanthemum.

Treatment	No. of secondary branches/plant	No. of leaves/plant	Leaf area (cm ²)	Dry weight of leaf (g)	Plant height (cm)		Fresh leaf biomass (g)
					at 60 DAT	at 90 DAT	
No pinching	129.74	1375.90	7.56	0.37	49.16	120.07	432.34
Pinching	166.88	1649.94	9.06	0.42	32.50	116.06	439.54
CD at 5%	5.96	60.31	1.18	0.04	6.59	2.85	NS
Control	138.85	1534.83	7.35	0.35	32.57	110.83	394.80
GA ₃ 100 ppm	135.50	1566.67	8.31	0.35	47.15	116.98	405.63
GA ₃ 200 ppm	136.38	1508.83	6.61	0.37	44.27	118.32	420.85
GA ₃ 300 ppm	138.32	1732.67	8.29	0.32	53.10	135.07	474.06
SA 100 ppm	180.30	1542.72	7.77	0.40	37.72	110.97	458.78
SA 150 ppm	170.80	1258.19	9.51	0.53	37.70	123.83	472.97
SA 200 ppm	137.41	1336.28	10.32	0.45	33.18	110.43	424.54
CD at 5%	11.14	112.83	2.21	0.08	3.52	5.34	54.66
Interaction							
No pinching × Control	119.53	1625.22	6.50	0.34	42.00	113.36	452.10
No pinching × GA ₃ 100 ppm	127.00	1500.00	7.18	0.33	55.43	120.70	445.40
No pinching × GA ₃ 200 ppm	123.77	1411.67	6.19	0.32	51.00	123.83	484.08
No pinching × GA ₃ 300 ppm	123.30	1476.33	7.65	0.33	62.50	141.17	373.51
No pinching × SA 100 ppm	154.00	1098.44	7.24	0.42	45.83	116.60	301.08
No pinching × SA 150 ppm	136.60	1226.33	8.68	0.40	45.77	123.50	555.43
No pinching × SA 200 ppm	123.72	1318.55	9.51	0.45	41.33	128.30	414.89
Pinching × Control	158.16	1457.00	8.20	0.35	23.13	108.30	337.50
Pinching × GA ₃ 100 ppm	144.00	1633.33	9.44	0.38	38.87	113.27	365.87
Pinching × GA ₃ 200 ppm	149.00	1606.00	7.04	0.42	37.53	112.81	357.62
Pinching × GA ₃ 300 ppm	153.33	1989.00	8.94	0.32	43.70	106.70	574.61
Pinching × SA 100 ppm	206.60	1687.00	8.29	0.38	29.60	105.33	616.48
Pinching × SA 150 ppm	205.00	1290.05	10.34	0.67	29.63	124.17	490.51
Pinching × SA 200 ppm	151.10	1354.00	11.17	0.46	25.03	114.83	434.18
CD at 5%	15.76	159.57	NS	0.11	NS	7.55	77.30

Table 2. Effect of pinching, GA₃ and SA on days to bud initiation, bud diameter, days to flowering, peduncle length, and flower longevity of chrysanthemum.

Treatment	Days to bud initiation	Days to flowering	Bud diameter (mm)	Peduncle length (cm)	Flower longevity (days)
No pinching	46.31	74.51	16.83	15.98	8.19
Pinching	56.12	80.94	17.22	17.33	8.93
CD at 5%	1.23	0.78	0.31	0.24	0.33
Control	53.93	77.68	16.42	14.57	7.93
GA ₃ 100 ppm	49.64	76.34	16.73	16.75	9.34
GA ₃ 200 ppm	47.07	76.04	16.66	17.10	8.90
GA ₃ 300 ppm	49.22	76.13	17.12	17.69	7.99
SA 100 ppm	49.68	77.15	17.96	17.86	8.19
SA 150 ppm	55.00	81.62	16.79	17.20	9.39
SA 200 ppm	54.00	78.97	17.49	15.40	8.16
CD at 5%	2.29	1.46	0.57	0.44	0.62
Interaction					

(continued on next page)

Treatment	Days to bud initiation	Days to flowering	Bud diameter (mm)	Peduncle length (cm)	Flower longevity (days)
No pinching × Control	48.50	75.54	16.05	14.37	9.01
No pinching × GA ₃ 100 ppm	42.94	70.84	16.45	15.60	8.63
No pinching × GA ₃ 200 ppm	45.50	74.31	16.34	16.76	9.07
No pinching × GA ₃ 300 ppm	43.72	70.39	16.83	17.16	7.54
No pinching × SA 100 ppm	43.70	73.01	18.28	16.15	7.48
No pinching × SA 150 ppm	51.33	79.90	16.41	16.96	7.89
No pinching × SA 200 ppm	48.50	76.88	17.43	14.83	7.72
Pinching × Control	59.35	79.82	16.78	14.77	9.77
Pinching × GA ₃ 100 ppm	56.33	81.23	17.01	17.89	10.05
Pinching × GA ₃ 200 ppm	48.64	78.33	16.97	17.43	8.74
Pinching × GA ₃ 300 ppm	54.72	81.88	17.40	18.23	8.44
Pinching × SA 100 ppm	55.67	81.29	17.64	19.57	8.90
Pinching × SA 150 ppm	58.66	83.34	17.16	17.44	7.98
Pinching × SA 200 ppm	59.50	81.05	17.56	15.96	8.61
CD at 5%	3.24	2.07	NS	0.62	NS

Table 3. Effect of pinching, GA₃ and SA on no. of flowers/plant, flower diameter, fresh weight of flower, dry weight of flower and flowering duration of chrysanthemum.

Treatment	No. of flowers /plant	Flower diameter (cm)	Fresh weight of flower (g)	Dry weight of flower (g)	Flowering duration (days)
No pinching	244.42	6.75	1.41	0.21	46.78
Pinching	270.48	6.82	1.46	0.22	39.98
CD at 5%	15.12	NS	NS	NS	2.91
Control	242.27	6.39	1.33	0.21	37.36
GA ₃ 100 ppm	285.13	6.86	1.46	0.22	46.45
GA ₃ 200 ppm	275.30	6.98	1.57	0.22	45.58
GA ₃ 300 ppm	257.38	6.61	1.42	0.21	43.83
SA 100 ppm	243.10	6.84	1.34	0.22	45.22
SA 150 ppm	236.22	6.99	1.35	0.23	41.38
SA 200 ppm	262.73	6.41	1.37	0.22	43.83
CD at 5%	28.29	0.35	0.10	NS	5.44
Interaction					
No pinching × Control	271.50	6.45	1.53	0.20	43.67
No pinching × GA ₃ 100 ppm	291.87	7.06	1.37	0.20	52.83
No pinching × GA ₃ 200 ppm	190.00	7.04	1.45	0.21	47.83
No pinching × GA ₃ 300 ppm	259.70	6.42	1.46	0.23	47.00
No pinching × SA 100 ppm	216.20	6.60	1.39	0.22	45.83
No pinching × SA 150 ppm	244.00	6.94	1.29	0.20	44.27
No pinching × SA 200 ppm	237.67	6.17	1.35	0.20	46.00
Pinching × Control	279.03	6.57	1.61	0.20	31.05
Pinching × GA ₃ 100 ppm	278.40	6.65	1.54	0.24	40.06
Pinching × GA ₃ 200 ppm	294.60	6.95	1.57	0.24	43.33
Pinching × GA ₃ 300 ppm	255.07	6.79	1.38	0.20	40.67
Pinching × SA 100 ppm	270.00	7.09	1.29	0.22	44.61
Pinching × SA 150 ppm	228.43	7.04	1.41	0.22	38.50
Pinching × SA 200 ppm	287.80	6.65	1.40	0.21	41.67
CD at 5%	40.00	0.49	NS	NS	NS

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