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Influence of SA, GA_3 and Pinching on Growth and Flowering in *Verbena*

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ABSTRACT

A field experiment was conducted to find out effect of salicylic acid (SA), GA_3, pinching and their interaction on the growth and flowering attributes of *verbena* × *hybrida*. Three concentration each of GA_3 (100,150 and 200 ppm) and SA (100, 150 and 200 ppm) was foliar sprayed at 21 days after transplanting to run-off stage and pinching was done at 40 days with three replications set in Randomized Block Design. Pinching treatment recorded significantly maximum no. of primary branches/plant, stem diameter, fresh weight and dry weight of leaves, fresh leaf biomass, leaf area, flower longevity, fresh weight of flower, no. of spikes/plant and peduncle length. However, no. pinching treatment recorded maximum plant height, early bud initiation and early flowering. Spraying of GA_3 100 ppm resulted in early bud initiation. GA_3 150 ppm recorded fresh weight of leaves, fresh leaf biomass and bud cluster diameter. However, maximum plant height, leaf area, no. of spikes/plant and peduncle length was observed with GA_3 at 200 ppm. Among various doses of salicylic acid, SA 100 ppm recorded maximum stem diameter. Early flowering, maximum fresh and dry weight of flower was seen with SA 150 ppm. SA 200 ppm resulted in maximum no. of primary branches/plant and flower diameter. Significant effect of interaction between pinching and plant growth chemicals (GA_3 and SA) was observed in most of the growth and flowering attributes.

Keywords *Verbena*, Salicylic acid, GA_3, Pinching, Growth.

INTRODUCTION

Verbena, a genus of the Verbenaceae family, consists of approximately 250 species worldwide. Most of these species are native to temperate, tropical or subtropical regions of South, Central and North America. Numerous horticultural cultivars of *Verbenas* (i.e., *Verbena* × *hybrida*) have been bred by artificial crossing among several species and were popular for hanging basket plants and garden uses because of their wealth of flower colors and broad range of growth habits Kanaya *et al.* (2008). Garden Verbena comes in a variety of forms, from trailing to upright, and is often cultivated as an annual in most regions. It is a versatile plant used for carpet bedding, hanging basket, pot culture, rockery (Singh and Sisodia 2017). Gibberellic acid is essential for shoot elongation, flower induction, flower and seed development, and

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mobilization of storage reserves. Salicylic acid is a naturally occurring phenolic compound found in many plants that has been shown to cause a variety of metabolic and physiological responses in plants, influencing their growth and development Hayat *et al.* (2010). Pinching practice involves removal of terminal portion of shoots that helps in early emergence in side branches with quality flowers (Singh 2006). Pinching and application of growth promoting chemicals significantly improve plant growth and flowering in various flowering plants Chauhan *et al.* (2016), Singh *et al*. (2017), Kapri *et al.* (2018) and Singh *et al*. (2019). Thus, this experiment was conducted to observe the effect of SA, GA_3 and pinching on growth and flowering attributes of *Verbena*.

MATERIALS AND METHODS

A field experiment was conducted at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh to study the effect of SA, GA_3 and pinching on growth and flowering in *Verbena*. The area of experiment was 123.33 meter above sea level (MSL) located 25°10' North latitude and 83°03' East longitude. The experiment was laid out in Randomized Block Design of 6 × 3 m plot size and with planting distance of 60 × 50 cm. The treatment comprises of two level of pinching (no pinching and pinching at 40 days) and three levels of foliar spray of GA_3 (100, 150, 200 ppm) and SA (100, 200, 300 ppm) at 21 days after transplanting to runoff stage. Field preparation, intercultural operations and irrigation were done as per the standard recommendations. The observations of growth and flower characters were recorded and analyzed statistically.

RESULTS AND DISCUSSION

Effect of pinching on growth attributes : It was observed that during all the stages of plant growth i.e., 60 and 90 days after transplanting, number of primary branches (11.05, 17.14) per plant was recorded maximum in plants with pinching whereas plant height (20.55 cm at 60 DAT and 31.95 cm at 90 DAT) was found maximum in plants without pinching. This might be due to the removal of an apical bud during pinching, which led to profuse lateral growth, and apical growth was delayed. Similar result was obtained in China aster by Khobragade *et al.* (2012) and in marigold by Singh *et al.* (2017). Reduction in plant height due to pinching resulted in maximum stem diameter (5.11 mm). Similarly, increase in fresh weight of leaves (1.22 g), fresh leaf biomass (82.99 g) and leaf area (7.21 cm^2) was observed in plants due to pinching. This might be due to superior growth obtained in pinched plants which resulted in increase in leaf area thus resulting in greater biomass accumulation. The results are in accord with the findings of Kumar and Singh (2003) in carnation and Salve *et al.* (2016) in chrysanthemum.

Effect of SA and GA_3 on growth attributes : All the growth parameters were found significant due to various treatment of SA and GA_3. Maximum number of primary branches (12.28 at 60 DAT and 18.75 at 90 DAT) was observed in the treatment SA 200 ppm. Foliar spray of SA 100 ppm resulted in maximum stem diameter (5.39 mm). Salicylic acid is well known for its ability to influence plant growth and development, as well as aid in drought and salt stress tolerance. The results are in close conformity with the findings of Kumar *et al.* (2019) in rose. Plant height (27.01 cm at 60 DAT and 31.73 cm at 90 DAT) was seen maximum in the treatment GA_3 200 ppm. This might be due to increase in cell elongation in apical meristem, which leads to an increase in internodal length by creating greater negative osmotic pressure and turgor pressure in the cells due to the conversion of starch into sugar as it is supported by Sajid *et al.* (2016). The results are in line with the observation made by Mounika *et al.* (2019) in chrysanthemum and Badge *et al.* (2014) in African marigold. Maximum fresh weight of leaves (1.60 g) and fresh leaf biomass (111.66 g) was recorded in treatment GA_3 150 ppm. Leaf area was seen maximum (7.16 cm^2) in plants treated with GA_3 200 ppm which was at par with treatment GA_3 100 ppm (6.90 cm^2). The results are in line with the work of Singh (2004) in French marigold, Sidana *et al.* (2019) in China aster and Singh *et al.* (2018) in lily.

Interaction effect : The data presented on (Table 1) revealed that maximum no. of primary branches at 60 days (14.83) and 90 days (20.33) was recorded in the

Table 1. Influence of SA, GA_3 and pinching on growth attributes of *Verbena*.

Treatment	No. of primary branches/plant		Plant height (cm)		Stem diameter (mm)	Fresh weight of 10 leaves (g)	Fresh leaf biomass (g)	Leaf area (cm^2)
	At 60 DAT	At 90 DAT	At 60 DAT	At 90 DAT				
No pinching	10.75	15.39	20.55	31.95	4.67	1.10	73.85	5.93
Pinching	11.05	17.14	19.63	25.90	5.11	1.22	82.99	7.21
CD at 5%	NS	1.13	0.37	1.51	0.25	0.07	5.63	0.27
Control	10.25	14.94	16.66	28.09	4.79	1.21	78.58	6.05
GA_3 100 ppm	12.08	14.58	18.90	27.84	5.07	1.19	71.67	6.90
GA_3 150 ppm	9.83	14.17	17.80	31.69	4.84	1.60	111.66	6.67
GA_3 200 ppm	11.67	18.42	27.01	31.73	4.55	1.12	73.23	7.16
SA 100 ppm	10.00	16.25	19.90	29.50	5.39	0.85	64.19	6.01
SA 150 ppm	10.17	16.75	18.96	24.94	4.79	1.07	63.74	6.39
SA 200 ppm	12.28	18.75	21.42	28.70	4.81	1.07	85.88	6.80
CD at 5%	1.15	2.11	0.69	2.82	0.46	0.12	10.53	0.50
Interaction								
No pinching × Control	9.83	11.50	17.19	31.60	4.60	1.02	62.08	5.14
No pinching × GA_3 100 ppm	9.33	13.50	16.28	31.95	4.66	1.01	56.37	5.65
No pinching × GA_3 150 ppm	11.50	17.67	18.47	32.63	4.80	1.55	81.09	5.84
No pinching × GA_3 200 ppm	13.33	18.05	23.06	33.67	4.42	1.08	94.62	6.48
No pinching × SA 100 ppm	10.17	15.17	22.51	28.32	5.19	0.83	73.10	5.51
No pinching × SA 150 ppm	9.67	15.33	20.34	29.15	4.53	1.02	56.98	5.95
No pinching × SA 200 ppm	11.39	16.50	28.02	36.36	4.52	1.16	92.69	6.95
Pinching × Control	9.00	11.83	16.13	20.73	4.97	1.40	95.08	6.97
Pinching × GA_3 100 ppm	13.17	15.67	21.52	23.73	5.48	1.36	86.97	8.16
Pinching × GA_3 150 ppm	9.83	16.83	17.14	27.01	4.87	1.65	142.23	7.49
Pinching × GA_3 200 ppm	10.00	19.83	19.77	23.72	4.68	1.17	51.83	7.84
Pinching × SA 100 ppm	9.83	17.33	17.28	30.68	5.59	0.87	55.27	6.50
Pinching × SA 150 ppm	10.67	18.17	17.57	24.58	5.06	1.11	70.50	6.83
Pinching × SA 200 ppm	14.83	20.33	26.00	30.83	5.10	0.98	79.08	6.65
CD at 5%	1.63	2.98	0.97	3.99	NS	0.17	14.89	0.71

interaction of pinching × SA 200 ppm. The diameter of the main stem (5.59 mm) was noted maximum with pinching × SA 100 ppm. Increase in branches and stem diameter might be due to SA exerted stimulatory effects on various physiological processes related to plant growth and development. Beneficial effect of SA in growth attributes was observed by Kumar *et al.* (2019a) in chrysanthemum. Interaction no pinching × GA_3 200 ppm registered maximum plant height at 60 days (28.02 cm) and at 90 days (36.36 cm). Likewise, fresh leaves weight (1.65 g) and fresh leaf biomass (142.23 g) were seen maximum with the interaction of pinching × GA_3 150 ppm. Pinching × GA_3 100 ppm registered maximum leaf area (8.16 cm^2). GA_3 is well known growth regulating chemical which act on cell division and cell elongation and GA_3 combined with pinching showed the best result in the growth of the plant. Similar findings were found in the work of Kumar and Singh (2003) in carnation and Singh *et al*. (2018) in marigold.

Effect of pinching on flowering attributes : The data pertaining to flowering parameters of *Verbena* due to effect of various treatments are presented on (Tables 2 –3). Significant result was found owing to pinching in most of the flowering parameters and some showed insignificant result. Since the apical bud is removed in pinching days to bud initiation (70.99) and days to flowering (85.78) was delayed while there was earlier bud initiation (63.02 days) and flowering (81.83 days)

Table 2. Influence of SA, GA_3 and pinching on flowering attributes of *Verbena*.

Treatment	Days to bud initiation	Days to flowering	Flower longevity (days)	Bud cluster diameter (mm)	Flower diameter (mm)
No pinching	63.02	81.83	2.78	19.56	15.42
Pinching	70.99	85.78	3.25	19.59	15.14
CD at 5%	1.84	1.11	0.25	NS	NS
Control	70.34	85.83	3.17	19.57	15.70
GA_3 100 ppm	63.50	85.33	2.67	19.41	14.87
GA_3 150 ppm	67.17	84.34	3.17	20.97	15.31
GA_3 200 ppm	66.42	83.67	2.83	19.90	14.73
SA 100 ppm	66.75	83.50	2.84	19.11	15.49
SA 150 ppm	70.22	81.34	3.17	18.91	14.93
SA 200 ppm	64.63	82.64	3.28	19.16	15.96
CD at 5%	3.45	2.07	NS	0.48	0.61
Interaction					
No pinching × Control	68.67	84.50	2.83	19.82	16.34
No pinching × GA_3 100 ppm	56.67	81.83	3.17	19.71	15.40
No pinching × GA_3 150 ppm	63.17	81.67	3.00	21.11	15.56
No pinching × GA_3 200 ppm	63.17	80.17	2.67	19.90	15.47
No pinching × SA 100 ppm	65.33	83.67	2.84	18.93	16.09
No pinching × SA 150 ppm	63.44	80.00	2.33	19.19	14.34
No pinching × SA 200 ppm	60.67	81.00	2.61	18.47	14.76
Pinching × Control	72.00	87.17	3.50	19.31	15.06
Pinching × GA_3 100 ppm	70.33	88.83	2.17	19.11	14.33
Pinching × GA_3 150 ppm	71.17	87.00	3.33	20.83	15.06
Pinching × GA_3 200 ppm	69.67	87.17	3.00	19.90	13.98
Pinching × SA 100 ppm	68.17	83.33	2.83	19.28	14.90
Pinching × SA 150 ppm	77.00	82.67	4.00	18.63	15.51
Pinching × SA 200 ppm	68.60	84.28	3.94	19.85	17.15
CD at 5%	4.88	2.93	0.66	0.67	0.86

in no pinching. The results are in close conformity with Singh *et al.* (2017) in marigold. Flower longevity (3.25 days) was observed longest in pinched plants. Similarly pinching registered maximum fresh weight of flowers (0.67 g), number of spikes per plant (128.07) and peduncle length (8.53 cm). Pinching is a common operation followed in flower crops to induce side growth so that maximum yield of good flower quality can be obtained. These results are similar with the findings of Singh *et al.* (2017a) in marigold, Chopde *et al.* (2019) and Gaidhani *et al.* (2020) in China aster.

Effect of SA and GA_3 on flowering attributes : All the flowering parameters varied significantly due to various level of treatments of GA_3 and SA except flower longevity. The earliest days to bud initiation (63.50) was observed in the treatment GA_3 100 ppm which was at par with SA 200 ppm (64.63). The diameter of bud cluster (20.97 mm) was found maximum in the treatment GA_3 150 ppm. Treatment GA_3 200 ppm had positive effect on the increment of no. of spikes per plant (147.25) and peduncle length (9.69 cm). These changes in the flowering attributes by application of GA_3 might be due to its physiological effects like cell division, elongation of cells and improved translocation of metabolites to the flowers. The results are in close conformity with the findings of Singh (2004 a) in California poppy, Kapri *et al.* (2018) in lily and Kumar *et al.* (2010) in African marigold. Blooming of flowers took the least time in treatment SA 150 ppm (81.34 days) which was at par with SA 200 ppm (82.64 days). Maximum flower diameter (15.96 mm) was recorded in treatment SA

Table 3. Influence of SA, GA_3 and pinching on flowering attributes of *Verbena*.

Treatment	Fresh weight of 30 flowers (g)	Dry weight of 30 flowers (g)	No. of buds/ spike	No. of spikes/ plant	Peduncle length (cm)
No pinching	0.63	0.09	30.38	118.67	7.65
Pinching	0.67	0.10	30.45	128.07	8.53
CD at 5%	0.02	NS	NS	5.18	0.64
Control	0.68	0.09	30.05	112.42	6.85
GA_3 100 ppm	0.67	0.09	27.87	103.75	8.01
GA_3 150 ppm	0.66	0.10	27.87	98.75	9.39
GA_3 200 ppm	0.63	0.10	28.93	147.25	9.69
SA 100 ppm	0.60	0.09	28.33	150.50	7.56
SA 150 ppm	0.70	0.11	31.37	119.09	7.05
SA 200 ppm	0.65	0.09	38.50	131.83	8.09
CD at 5%	0.04	0.01	1.65	9.69	1.19
Interaction					
No pinching × Control	0.68	0.11	32.27	102.17	6.73
No pinching × GA_3 100 ppm	0.66	0.09	27.90	82.50	7.45
No pinching × GA_3 150 ppm	0.65	0.10	26.60	92.17	8.67
No pinching × GA_3 200 ppm	0.61	0.09	29.63	149.67	8.18
No pinching × SA 100 ppm	0.54	0.09	27.33	144.83	6.88
No pinching × SA 150 ppm	0.62	0.08	31.50	107.67	7.47
No pinching × SA 200 ppm	0.68	0.10	37.43	134.33	8.19
Pinching × Control	0.67	0.11	27.83	122.67	6.97
Pinching × GA_3 100 ppm	0.68	0.09	27.83	125.00	8.57
Pinching × GA_3 150 ppm	0.67	0.10	29.13	105.33	10.10
Pinching × GA_3 200 ppm	0.64	0.10	28.23	162.17	11.21
Pinching × SA 100 ppm	0.65	0.09	29.33	138.83	8.24
Pinching × SA 150 ppm	0.77	0.12	31.23	130.50	6.63
Pinching × SA 200 ppm	0.63	0.09	39.57	129.33	8.00
CD at 5%	0.06	0.02	2.33	13.71	NS

200 ppm. SA 150 ppm exerted maximum fresh (0.70 g) and dry weight (0.11 g) of flowers. Number of buds per spike (38.50) was significantly increased by the treatment SA 200 ppm. This increase in flower diameter, fresh weight of flower and number of buds per spike might be due to significantly higher water uptake by the plants. The increased water uptake is attributed to SA's acidifying and stress-relieving properties (Bayat and Aminifard 2017). The results are in close conformity with the findings of Kumar *et al.* (2019a) in chrysanthemum.

Interaction effect : Interaction of pinching and growth regulators resulted significant variation in all the flowering characters of *Verbena* plant. Among all the interaction early to bud initiation (56.67) was recorded in no pinching × GA_3 100 ppm and least time to bloom was noted in interaction no pinching × SA 150 ppm (80.00 days) which was at par with no pinching × GA_3 200 ppm (80.17 days). Treatment pinching × SA 150 ppm resulted the maximum flower longevity (4.00 days). Maximum bud cluster diameter (21.11 mm) was observed with interaction of no pinching × GA_3 150 ppm and flower diameter (17.15 mm) was seen with pinching × SA 200 ppm. Significantly maximum fresh weight (0.77) and dry weight (0.12 g) of flower was registered with the interaction of pinching SA 150 ppm. Maximum number of buds per spike (39.57) was found in the interaction of pinching × SA 200 ppm. In the interaction of pinching × GA_3 200 ppm maximum number of spikes per plants (162.17) was recorded. These results are in agreement with the work reported by Pacheco *et al.* (2013) in marigold and Singh *et al.* (2019) in rose.

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