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EFFECT OF PINCHING AND GROWTH PROMOTING CHEMICALS ON GROWTH AND SEED ATTRIBUTES IN VERBENA (*Verbena hybrida*)

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ABSTRACT

The purpose of this study was to investigate the impact of pinching and growth promoting chemicals on the growth and seed attributes in verbena flower crop. Specifically, the study aimed to identify the effect of GA_3 and salicylic acid at varying concentrations on plant growth and seed yield as well as determine the impact of pinching on these factors. Hence, an experiment was conducted to find out the effect of pinching and growth promoting chemicals on the growth and seed attributes of verbena. Growth promoting chemicals used in the experiment were GA_3 and Salicylic Acid (SA) @ 100, 150 and 200 ppm each. The chemicals were foliar sprayed at 21 days after transplanting followed by pinching at 40 days after transplanting. Healthy seedlings were transplanted in plots of size 6 × 3 m with spacing of 60 × 50 cm. The trial was conducted using Randomized Block Design with three replications. in each treatment. The findings suggest that pinching at 40 days after transplanting can significantly improve the growth and seed attributes, where, pinching resulted in significantly greater plant spread, secondary branches, dry weight of leaves, leaf are index, seed yield/shoots and seed yield/plant. Meanwhile, GA_3 at 200 ppm produced the highest test weight. The use of SA at 200 ppm also showed promising results in terms of growth and leaf area index in verbena. Present study highlights the positive impact of pinching and growth promoting chemicals at varying concentrations. It also suggests that incorporating pinching and growth promoting chemicals in cultivation of verbena can significantly improve the crop yield and quality.

Keywords: GA_3, Growth, Pinching, Salicylic acid, Seed, Verbena

Verbena hybrida, commonly known as garden verbena, is a popular plant in the floriculture and landscaping industry. Its attractive flowers and long flowering period make it a desirable addition to gardens, landscapes and containers. One of the main reasons for its popularity is its versatility in design. Garden verbena comes in a variety of colours and can be used to create colourful borders, mass plantings and mixed plantings. It also looks great in hanging baskets and window boxes. In addition to its aesthetic appeal, garden verbena is easy to grow and maintain. It is relatively disease and pest-resistant, and requires minimal watering and fertilization. It can tolerate a wide range of soil conditions and thrives in full sunlight.

Although garden verbena is an excellent pot plant, its period of beauty lasts only three months from January to March in north India, where the plants dry up by April. Pinching, a practice that involves removing the terminal portion of shoots, can aid in the early blooming of excellent flowers on side branches, leading to profuse flowering and bushy plants. Whereas, growth promoting chemicals, such as gibberellins and salicylic acid, can also regulate plant growth and physiology, affecting plant responses from seed germination to senescence. GA_3 is particularly effective in promoting seed germination, stem elongation and increasing flower size and quality. Salicylic acid on the other hand, is known for its ability to enhance plant defences against biotic and abiotic stressors, resulting in healthier and more robust plants. The use of these growth regulators can lead to increased yield, improved quality and overall enhanced performance of ornamental flower crops. While these practices are not common in annual flower crops, thus, studying their effects on specific crops such as verbena can provide valuable insights into their impact on plant growth and seed production. These findings can then be used to improve cultivation practices, which are particularly important for verbena, given its popularity as a garden and landscape plant. Improved cultivation practices can also help to develop more efficient, sustainable and environmentally friendly methods of growing this attractive plant. Therefore, this study's findings on the effects of pinching and growth promoting chemicals on verbena growth and seed attributes can provide valuable information for the horticultural industry and gardeners alike, leading to better cultivation practices and improved plant growth and development.

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MATERIALS AND METHODS

An experiment was carried out in the Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during 2021-22. 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 carried out in a Randomized Block Design with three replications. Healthy and disease free seeds of verbena were obtained from the Department of Horticulture, Institute of Agricultural sciences, BHU. Raised nursery beds were prepared for sowing of verbena seeds. Since, the seeds of verbena are very small, therefore mixed with sand and then sowing is done in line at a depth of 2 cm. A light covering of rice husk was done followed by light irrigation. Germination starts 8-10 days after sowing, Proper care and maintenance were done to ensure quality planting material. Bavistin @ 2g/lt was applied to protect the seedlings from damping off disease. When seedlings attain 2-4 leaf stage then, healthy seedlings with uniform growth habit were transplanted 30 DAS in 6×3 m plot size. The spacing was maintained at 60 × 50 cm. The standard recommendations for field preparation, intercultural activities and irrigation were followed to raise a healthy crop. Treatments were given with different concentrations of SA and GA_3 @ 100, 150, 200 ppm each in the form of foliar spray 21 days after transplanting and pinching was practiced at 40 days after transplanting. The observations of various growth and seed parameters *viz.*, plant spread, secondary branches, leaves/plant, dry weight of leaves, leaf area index, days to seed maturity, test weight, number of seeds/shoot, seed yield/shoot and seed yield/plant were recorded and statistically examined

RESULTS AND DISCUSSION

Effect of pinching on growth attributes

In present study it was found that pinching had a significant effect on the growth parameters of verbena, with the pinched plants exhibiting maximum plant spread (20.55 cm at 60 days and 55.32 cm at 90 days), while minimum plant spread was recorded with control (19.63 cm) a higher number of secondary branches per plant (124.19), whereas, control recorded the minimum (103.02). It was also noticed that maximum dry weight of leaves (0.32 g), and leaf area index (1.61) was found with pinched plants whereas, the minimum was noticed in control plants (0.28 g and 1.37, respectively). This is in line with previous studies on other ornamental plants, such as marigold, chrysanthemum, and China aster, which have also shown the positive effects of pinching on lateral growth, resulting in increased number of branches, leaves, and overall plant size. This is because when a plant is pinched, the removal of the apical meristem triggers the activation of dormant lateral buds, which can result in the development of multiple stems or branches from the pinched stem. This branching effect can increase the plant’s spread and the number of secondary branches, leading to a bushier and more compact plant with a higher leaf area index. Additionally, pinching can stimulate the growth of new leaves and increase the overall leaf area of the plant. This can lead to an increase in photosynthesis and ultimately, an increase in dry leaf weight. Srivastava *et al*. (2002) studied the effect of pinching on marigold plants and found that pinched plants produced more flowers and had a higher flower yield. Similarly, Khandelwal *et al*. (2003) reported that pinching resulted in increased number of branches and flowers, as well as improved flower quality in marigold. Similar findings have been reported by Salve *et al*. (2016) in chrysanthemum. The authors also noted that pinching reduced the time to flowering, resulting in earlier and more consistent flowering. These findings support the use of pinching as a cultivation practice for improving the growth and quality of chrysanthemum plants and Khobragade *et al*. (2012) in China aster.

Effect of GA_3 ad SA on growth attributes

Present finding revealed that salicylic acid (SA) at 200 ppm recorded the maximum plant spread (27.01 cm, 64.92 cm at 60 and 90 days respectively), followed by GA_3 200 ppm (21.42 cm at 60 days) and SA 100 ppm (54.63 cm at 90 days), number of secondary branches (123.59) followed by GA_3 150 ppm (122.84) and SA 100 ppm (121.50). Maximum leaf area index was recorded with SA 200 ppm (1.82) followed by GA_3 150 ppm (1.58), whereas, maximum number of leaves/plant (802.75) was noticed in SA 200 ppm followed by SA 100 ppm (758.00) whereas, the minimum number of secondary branches (92.50) was recorded with treatment GA_3 100 ppm. However, lowest number of leaves (596.84) and leaf area index (1.82) were noticed in treatment SA 150 ppm. This is attributed to the fact that SA reduces ethylene production while stimulating plant growth. Ethylene is a plant hormone that can cause various responses including leaf abscission, senescence, and inhibition of growth. Therefore, by reducing ethylene production, SA can stimulate plant growth, leading to an increase in growth parameters such as plant spread, number of secondary branches, and leaf area index. SA has also been shown to have a positive effect on photosynthesis and chlorophyll content, which can contribute to the increase in growth parameters observed in the study. This is in agreement with the findings of Basit *et al*. (2018) in marigold, Pacheco *et al*. (2013) in calendula, and Kumar *et al*. (2019) in rose. On the other hand, the dry weight of leaves was maximum in the treatment of GA_3 at 150

Table 1. Effect of pinching and growth promoting chemicals on growth attributes in verbena.

Treatment	Plant spread (cm)		Number of secondary branches per plant	Number of leaves/plant	Dry weight of leaves (g)	Leaf area index
	At 60 DAT	At 90 DAT				
No pinching	19.63	52.65	103.02	671.18	0.28	1.37
Pinching	20.55	55.32	124.19	687.21	0.32	1.61
CD at 5%	0.37	1.68	4.30	NS	0.01	0.10
Control	16.66	52.62	111.81	645.14	0.29	1.31
GA_3 100 ppm	18.90	48.18	92.50	598.17	0.28	1.39
GA_3 150 ppm	17.80	50.56	122.84	692.59	0.38	1.58
GA_3 200 ppm	21.42	54.33	113.84	660.92	0.31	1.53
SA 100 ppm	19.90	54.63	121.50	758.00	0.23	1.50
SA 150 ppm	18.96	52.68	109.17	596.84	0.30	1.28
SA 200 ppm	27.01	64.92	123.59	802.75	0.29	1.82
CD at 5%	0.69	3.14	8.05	48.93	0.03	0.19
Interaction						
No Pinching × Control	16.13	54.67	101.17	679.11	0.34	1.05
No Pinching × GA_3 100 ppm	21.52	53.10	115.33	639.50	0.32	1.05
No Pinching × GA_3 150 ppm	17.14	43.19	105.00	862.00	0.41	1.02
No Pinching × GA_3 200 ppm	19.77	52.17	65.00	443.00	0.34	1.90
No pinching × SA 100 ppm	17.28	49.92	108.33	635.33	0.23	1.62
No pinching × SA 150 ppm	17.57	51.52	100.17	635.17	0.35	1.10
No pinching × SA 200 ppm	28.02	64.00	126.17	804.17	0.26	1.86
Pinching × Control	17.19	50.58	122.45	611.17	0.25	1.57
Pinching × GA_3 100 ppm	16.28	43.25	69.67	556.83	0.25	1.74
Pinching × GA_3 150 ppm	18.47	57.92	140.67	523.17	0.35	2.15
Pinching × GA_3 200 ppm	23.06	56.50	162.67	878.83	0.28	1.16
Pinching × SA 100 ppm	22.51	59.33	134.67	880.67	0.23	1.38
Pinching × SA 150 ppm	20.34	53.83	118.17	558.50	0.25	1.45
Pinching × SA 200 ppm	26.00	65.83	121.00	801.33	0.32	1.78
CD at 5%	0.97	4.44	11.39	69.19	0.04	0.26

ppm is consistent with the previous study by Singh *et al.* (2018) in marigold. GA_3 is a synthetic plant hormone that can promote cell division, elongation, and differentiation. The application of GA_3 at an appropriate concentration can increase the rate of photosynthesis, leading to an increase in dry weight of leaves. Additionally, GA_3 can induce stem elongation and promote plant growth by reducing apical dominance, which can result in the development of more lateral branches and an increase in growth parameters such as plant spread and number of secondary branches. This finding suggests that GA_3 can be used as a growth regulator in ornamental flower crops to enhance the vegetative growth and development of plants.

Interaction effect

The interaction of pinching and growth-promoting chemicals, *viz.*, SA and GA_3, had significant effects on various growth parameters of verbena. No pinching × SA 200 ppm registered maximum plant spread at 60 days (28.02 cm) while at 90 days (65.83 cm) it was found maximum with pinching × SA 200 ppm. Maximum number of leaves per plant (880.67) was observed in the interaction of pinching × SA 100 ppm. Maximum number of leaves/plant (880.67) was observed with interaction of pinching × SA 100 ppm. Significant interaction was found in treatment pinching × GA_3 200 ppm with maximum number of secondary branches/plant (162.67). Pinching × GA_3 150 ppm registered maximum dry weight of leaves (0.35 g) which was at par with no pinching × SA 150 ppm (0.35 g). Significant leaf area index (2.15) was found maximum with the interaction of pinching × GA_3 150 ppm. However, interaction of no pinching× control recorded the minimum in most of

Table 2. **Effect of pinching and growth promoting chemicals on seed attributes of verbena.**

Treatment	Days to seed maturity	Test weight (g)	No. of seeds/ shoot	Seed yield/ shoot (g)	Seed yield/ plant (g)
No pinching	112.30	1.89	76.81	0.14	18.29
Pinching	115.94	1.90	76.52	0.16	18.55
CD at 5%	1.37	NS	NS	0.002	1.72
Control	112.67	1.93	75.20	0.13	14.78
GA_3 100 ppm	112.50	1.96	66.47	0.14	14.50
GA_3 150 ppm	115.00	1.88	66.47	0.14	14.23
GA_3 200 ppm	115.83	2.15	70.73	0.15	22.48
SA 100 ppm	114.50	1.89	68.32	0.15	21.73
SA 150 ppm	113.92	1.71	80.46	0.14	16.04
SA 200 ppm	114.42	1.74	109.00	0.19	25.19
CD at 5%	NS	0.15	6.58	0.004	NS
Interaction					
No Pinching × Control	111.00	2.06	66.33	0.13	15.42
No Pinching × GA_3 100 ppm	108.17	2.02	66.33	0.14	17.16
No Pinching × GA_3 150 ppm	115.33	1.94	71.53	0.14	14.85
No Pinching × GA_3 200 ppm	114.50	2.08	67.93	0.14	20.56
No pinching × SA 100 ppm	114.67	2.01	72.32	0.15	20.87
No pinching × SA 150 ppm	109.00	1.58	79.92	0.12	16.22
No pinching × SA 200 ppm	113.44	1.54	113.28	0.18	22.95
Pinching × Control	114.33	1.80	84.07	0.14	14.14
Pinching × GA_3 100 ppm	116.83	1.89	66.60	0.14	11.83
Pinching × GA_3 150 ppm	114.67	1.81	61.40	0.15	13.60
Pinching × GA_3 200 ppm	117.17	2.21	73.53	0.16	24.40
Pinching × SA 100 ppm	114.33	1.77	64.32	0.14	22.60
Pinching × SA 150 ppm	118.83	1.84	81.00	0.15	15.86
Pinching × SA 200 ppm	115.39	1.94	104.72	0.20	27.43
CD at 5%	3.62	0.21	9.30	0.006	2.44

the growth parameters. Pinched plants used nutrients provided by GA_3 and SA more efficiently, which may have contributed to increased number of secondary branches and leaf area index. The results suggest that pinching helped the plants to use the nutrients provided by the growth-promoting chemicals more efficiently, which contributed to the increased number of secondary branches and leaf area index. This is supported by the findings of similar studies in chrysanthemum, carnation, and African marigold. The study also found that the interaction of pinching and growth-promoting chemicals had a significant effect on the timing of maximum growth parameters. The result is in close conformity with the findings of (Mounika *et al*., 2019) in chrysanthemum, Kumar and Singh (2003) in carnation and (Singh *et al*., 2017a) in African marigold.

Effect of pinching on seed attributes

The data presented in Table 2 indicate a statistically significant effect of pinching on several seed parameters, such as days to seed maturity, seed yield/shoot, seed yield/plant etc. However, test weight and number of seeds/shoot were found to be statistically insignificant. Treatment no pinching reported minimum days to seed maturity (112.30 days), whereas, maximum days to seed maturity (115.94) were observed in pinched plants due to the delayed initiation of buds and flowering. The application of pinching also resulted in a significant increase in seed yield/shoot (0.16 g) and seed yield/ plant (18.55 g) whereas, lower seed yield/shoot (0.14 g) and seed yield/plant (18.29 g) was noticed in control treatment (no pinching). The research findings suggest that pinching significantly affects seed parameters.

Pinching delays bud initiation and flowering, resulting in an increased number of days to seed maturity. However, this delay in flowering allowed for more time for seed development, which led to an increase in seed yield/shoot and per plant. The increase in seed yield may also be due to the allocation of more resources towards seed production by the plant, stimulated by the pinching process which could explain the higher seed yield observed in the pinched plants.). These findings are consistent with the results reported by Singh *et al*. (2018) and Singh *et al*. (2017b) in marigold which also showed that pinching increased seed yield. It is worth noting that pinching did not significantly affect the test weight and number of seeds/shoot in this study. This may be due to the fact that the pinching process did not affect the size or weight of the individual seeds or the number of seeds produced per shoot. However, the increased seed yield/shoot and per plant observed in the pinched plants may compensate for any potential decrease in the test weight or number of seeds/shoot.

Effect of GA_3 and SA on seed attributes

Different concentration of GA_3 and SA also showed significant variation in some of the seed attributes of verbena (Table 2). GA_3 200 ppm registered maximum test weight (2.15 g) which is consistent with the findings of previous studies in calendula (Singh and Sharma, 2004), China aster (Kumar *et al*., 2015) and French marigold (Singh, 2004). This may be because GA_3 and SA can improve seed vigour which is the ability of seeds to germinate and grow into healthy seedlings. By improving seed vigour, GA_3 and SA may increase the overall weight of seeds and result in a higher test weight. Here, the highest test weight indicates that the seeds are larger and more vigorous which could potentially result in better germination and plant growth. The treatment with SA at 200 ppm resulted in the maximum number of seeds/shoot (109.00). This is likely due to the ability of SA to stimulate plant resistivity to pathogen and stress, resulting in better seed yield and seed numbers. Overall the use of GA_3 and SA at different concentrations could have a significant impact on seed attributes in verbena and other ornamental plants.

Interaction effect

Due to interaction of pinching and growth hormones all the seed characters varied significantly. Pinching × SA 150 ppm registered maximum days taken to seed maturity (118.83) while minimum days was taken by no pinching × SA 150 ppm (109.00). Maximum test weight (2.21 g) was found in the interaction of pinching × GA_3 200 ppm. Number of seed per shoot (113.28) was observed maximum with the treatment no pinching × SA 200 ppm followed by pinching × SA 200 ppm (104.72). Seed yield per shoot (0.20 g) and seed yield per plant (27.43 g) was recorded maximum in the interaction of pinching × SA 200 ppm. (Massoud *et al*., 2021) in chrysanthemum reported that foliar application of salicylic acid increased the number of flowers per plant which would eventually influence the seed yield.

Authors' contribution

Conceptualization of research work and designing of experiments (AS, AKS); Execution of field/lab experiments and data collection (UB, AK); Analysis of data and interpretation (KB); Preparation of manuscript (MP, UB).

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