

Studies on the impact of spacing, pinching and growth retardants on vegetative growth and flowering behaviour of Salvia

Abstract:

The present investigated entitled “Studies on the impact of spacing, pinching and growth retardants on vegetative growth and flowering behaviour of Salvia” was conducted at College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha during December 2021 to April 2022. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications, comprising of 12 treatment combinations which includes the first factor spacing with two levels i.e., S₁ (20 cm x 25 cm) and S₂ (25 cm x 25 cm), second factor pinching with two levels i.e., P₀ (no pinching) and P₁ (pinching) and the third factor application of growth retardants with three levels i.e., G₀ (control), G₁ (CCC @500ppm) and G₂ (MH @100ppm). The findings revealed that pinching and the application of growth retardants had a greater impact on critical flowering attributes than the spacing experimented with in this study. Treatment combination S₂P₁G₁ i.e., T₁₁ was proved to be better and yielded significant improvements. Based on the results it was concluded that pinching and application of CCC resulted in better growth and development in salvia regarding vegetative and flowering characters. Thus, the treatment combination S₂P₁G₁ i.e., T₁₁ was found to be superior for vegetative growth characters like plant height, the number of branches, the number of leaves and flowering characters like the number of flower spikes per plant, length of flower spike, and length of florets.

Key words: vegetative growth, red salvia flowers, flowering behaviour, growth retardants

1.Introduction

“Ornamental flowering annuals are highly valued for their attractive look and appearance and enhance the beauty of gardens. Salvia is indigenous to Brazil but it is also found in India as a seasonal flowering plant. Red salvia flowers are grown as annual plants in temperate zones, but they are damaged by hard frosts and do not survive through cold winters. Salvia requires a sunny area with a loamy and well-drained soil rich in organic matter for proper growth”[19-21]. This genus is a member of the "Lamiaceae" family, which is well-known for producing several aromatic and therapeutic plants. Salvia is known to contain the chemicals "salviarin" and "splendidin," which are chemically comparable to "salvinorin," as well as a "neoclerodane diterpene" that is supposed to be sedative and calming. Salvia splendens L. is a popular bedding plant that is primarily used to bring a burst of vibrant color to landscapes. It can be cultivated by sowing seeds from August to the beginning of October, blooms from winter to spring, and can carry its spikes until the next summer.

Spacing influences the compactness of plants. Pinching is one of the most suitable tactics for the successful cultivation of cut flowers as well as potted ornamental plants. In flower crops viz., chrysanthemum, China aster, carnation, marigold, etc., flowering depends on the number

of flowers bearing branches, which can be manipulated by arresting vertical growth and encouraging lateral branches through pinching. Pinching removes the source of apical dominance and assimilates are diverted into lateral buds that encourage branching to produce a bushy growth with a greater number of flowers. The application of plant growth retardants is generally done in horticultural and agricultural crops. These retardants are applied for obtaining vigorous lateral growth of plants which are of small stature and is achieved by reducing the process of stem elongation (Quattrini *et al.*, 1995; Lewis *et al.*, 2004). They stimulate the plant branching habit that results in compact plants with reduced internodal length (Donald and Arnold, 2001; Meijon *et al.*, 2009). Growth retardants also influence plant flowering behavior, resulting in early flowering or more flowers per plant (Banko, 2003; Marsoz and Matysiak, 2005), enhancing the hue intensity of leaves and bracts (Banon *et al.*, 2001), and improving the plant's ability to withstand various stresses encountered during transport and handling (Mackay and Sankhla, 2006). The current study was conducted to determine the influence of spacing, pinching, and growth retardants on *Salvia* growth and flowering behaviour in order to generate beautiful pot plants by manipulating growth and promoting flowering by cultural or chemical approaches.

2. Materials and methods

The experiment was carried out from December 2021 to April 2022 at the College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications.

List 1: Treatment combinations

S.NO	Treatments	Treatment Symbols	Details of treatment
1.	T ₁	S ₁ P ₀ G ₀	20cm x 25 cm + no pinching + control
2.	T ₂	S ₁ P ₀ G ₁	20cm x 25cm + no pinching + CCC@500ppm
3.	T ₃	S ₁ P ₀ G ₂	20cm x 25cm + no pinching + MH @100ppm
4.	T ₄	S ₁ P ₁ G ₀	20cm x 25cm + pinching + control
5.	T ₅	S ₁ P ₁ G ₁	20 cm x 25 cm + pinching + CCC@500ppm
6.	T ₆	S ₁ P ₁ G ₂	20cm x 25cm + pinching+ MH @100ppm
7.	T ₇	S ₂ P ₁ G ₀	25cm x 25 cm + no pinching + control
8.	T ₈	S ₂ P ₁ G ₁	25cm x 25 cm+ no pinching + CCC@500ppm
9.	T ₉	S ₂ P ₁ G ₂	25cm x 25 cm+ no pinching + MH @100ppm

10.	T ₁₀	S ₂ P ₁ G ₀	25cm x 25 cm+ pinching + control
11.	T ₁₁	S ₂ P ₁ G ₁	25cm x 25 cm+ pinching + CCC@500ppm
12.	T ₁₂	S ₂ P ₁ G ₂	25cm x 25 cm+ pinching+ MH @100ppm

In the present investigation two levels of spacing viz., S₁ (20 cm x 25 cm), S₂ (25 cm x 25 cm), as main plot treatments and two levels of pinching viz., P₀ (No pinching), P₁ (Single pinching i.e., 15 days after transplanting) and application of growth retardants viz., G₀ (control), G₁ (CCC@500ppm) and G₂ (MH @100ppm) as sub plot treatments under each main plot treatment were included which were replicated thrice. Plant growth indicators were recorded, such as the height of the plant, the number of branches per plant, the number of leaves per plant, and the number of flower spikes per plant, length of flower spikes, and the number of florets per spike. All of the data pertaining to different flowering aspects and growth factors was statistically analyzed. A variance analysis table was generated. At the 5% level of significance, the "F" test was used for assessing treatment effects. To compare treatment means, the critical difference at the 5% level was calculated.

3.Results and Discussion

Vegetative characters:

Plant height

From the perusal of data presented in table 1, it was found that no significant difference was recorded for factor levels of spacing. However, the treatments S₁ (18.61cm) and S₂ (18.68cm) were recorded similar plant height. The treatment pinching exhibited the significant difference. The lowest plant height was recorded for plants where pinching was done i.e., P₁ (17.93cm), whereas the highest plant height was observed in treatment where pinching was not done i.e., P₀ (19.36cm). The treatments of growth retardants exhibited significant difference and they are significantly different from each other. The highest plant height was obtained for control G₀ (21.35cm), followed by MH G₂ (18.16cm) and the lowest plant height was recorded for treatment CCC G₁ (16.43cm). The decreased plant height was due to the application of growth retardants, CCC and MH is because the growth retardants inhibit cell division (Luckwill and Cutting, 1968) and act as an antagonist to gibberellin, due to which the vegetative attributes like apical growth and cell elongation are reduced and the reduction in plant height as a result of growth retardant application may be correlated with the formation of shorter internodal length as reported by Hashemabadi *et al.* (2012) in calendula, Sasikumar *et al.* (2015) in marigold and Chikte *et al.* (2017) in marigold.

Number of branches

Analyzing the data in Table 2, it was found that there were no significant variations in the treatments spacing levels. However, the treatments S₁ (13.32) and S₂ (13.45) were recorded similar number of branches per plant. The treatment pinching exhibited significant difference

where the maximum number of branches per plant were recorded for plants where pinching was done i.e., P_1 (15.58) whereas the minimum number of branches per plant were recorded in treatment where pinching was not done i.e., P_0 (11.19). The treatments of growth retardants exhibited significant difference and they were statistically significant where the maximum number of branches per plant were recorded for treatment CCC G_1 (14.50) followed by MH G_2 (12.90) over control G_0 (12.77). The interaction between spacing and pinching revealed statistically significant results. The minimum number of branches per plant were recorded for treatment S_1P_0 (10.86) and the maximum number of branches per plant were recorded for treatment S_1P_1 (15.78) which remained statistically at par with S_2P_1 (15.38). The $S \times G$ interaction revealed significant results where the minimum number of branches $plant^{-1}$ were recorded for S_1G_0 (12.46) and the maximum number of branches per plant were recorded for treatment S_2G_1 (14.81). The $P \times G$ interaction was found to be significant. The minimum number of branches per plant were recorded for treatment P_0G_0 (10.61), whereas the maximum number of branches per plant were recorded for treatment P_1G_1 (17.26). The interaction $S \times P \times G$ also yielded significant results where the minimum number of branches per plant were recorded for treatment $S_1P_0G_0$ (10.13) and the maximum number of branches per plant were recorded for treatment $S_2P_1G_1$ (17.76). The maximum number of branches recorded under pinching might have resulted due to breaking apical dominance. As a result of which there was enhanced cell division, increased cell size as well as leaf area and thus greater photosynthetic activity and it was evident that pinching results in production of more branches from the research findings of Rathore *et al.* (2010) in marigold and Singh *et al.* (2019) in chrysanthemum.

Number of leaves

Examining the data in Table 3, it was found that there was no statistically significant difference in the treatment spacing levels. However, the treatments S_1 (53.63) recorded maximum number of leaves per plant and S_2 (52.95) recorded minimum number of leaves per plant. The treatment pinching exhibited significant difference where the maximum number of leaves per plant were recorded for plants where pinching was done i.e., P_1 (59.47), whereas the minimum number of leaves per plant were recorded in treatment where pinching was not done i.e., P_0 (47.10). The treatments of growth retardants also exhibited significant difference and they were statistically significant where the maximum number of leaves per plant were recorded for treatment CCC G_1 (55.87) over control G_0 (52.05). The interaction between spacing and pinching showed non-significant. However, the minimum number of leaves per plant were recorded for treatment S_1P_0 (46.92) and the maximum number of leaves per plant were recorded for treatment S_1P_1 (60.33). The $S \times G$ interaction revealed significant results where the minimum number of leaves per plant were recorded for S_2G_1 (49.33) and the maximum number of leaves per plant were recorded for treatment S_1G_1 (56.02). The $P \times G$ interaction was also found to be significant where the minimum number of leaves per plant were recorded for treatment P_0G_2 (45.75), whereas the maximum number of leaves per plant were recorded for treatment P_1G_1 (63.03).

The interaction S x P x G was also found to be significant where the minimum number of leaves per plant were recorded for treatment S₁P₀G₂ (45.20) and the maximum number of leaves per plant were recorded for treatment S₂P₁G₁ (63.16). The increase in metabolic activity, photosynthetic activity, and cell division might be the cause for the higher number of leaves per plant at various pinching intervals. These results corroborated with the research findings Habiba *et al.* (2012) in chrysanthemum and Jamal *et al.* (2015) in Lisianthus.

Flowering characters:

Number of flower spikes per plant:

A considerable difference was seen between the various spacing levels following a review of the data in Table 4. The average number of flower spikes per plant was significantly greater in treatment S₂ (8.45) than in treatment S₁ (7.33), although they were not statistically similar. Additionally, significant results were obtained from pinching plants in P₁ (8.66), which produced more flower spikes per plant than P₀ (7.12), which were not pinched. Significant results were obtained as well with the growth retardant treatments, regarding the treatment CCC G₁ (8.72) producing more flower spikes than the control G₀ (7.25). “However, the interactions between S x P and S x P x G was found to be non-significant. But the interactions between S x G and P x G were statistically significant where more number of flower spikes were produced in treatment S₂G₁ (9.80), P₁G₁ (10.05) respectively and least number of flower spikes per plant were produced in treatment S₁G₀ (6.06), P₀G₀ (6.70) respectively”. [22] According to studies by Subhendu *et al.* (2021) in chrysanthemum and Singh *et al.* (2019) in marigold, this increase in flower spikes as a result of pinching could have been due to restriction of terminal growth, which produced more lateral branches and could have led to lateral bud initiation from where flowers originate.

Length of flower spikes:

After reviewing the data provided in Table 5, it was observed that there were no notable variations across the various spacing levels. A considerable variation was noted between the pinching levels, with P₁ (18.36 cm) recording a maximum spike length greater than P₀(17.05 cm). However, there are also notable differences between the growth retardant treatments, with the treatment CCC G₁ (19.79cm) exhibiting a maximum spike length greater than MH G₂ (16.01cm) and the control G₀ (17.30cm). It was discovered that there was no considerable interaction between S x P, S x G and P x G, and S x P x G. Better availability of carbohydrates and other nutrients for floral development may be the reason for this spike length improvement. As reported by Singh *et al.* (2019) in marigold and Ashvini *et al.* (2020) in china aster, “this might be the consequence of delayed flower bud initiation and can be associated with the previous vegetative characteristics, such as number of branches and leaves, which may have made the treated plants more sturdy and fresh for a longer period of time. This could have sustained the supply of flowering inducing hormones for a longer period of time and might have prolonged the duration of flowering”.

Number of florets per spike:

Significant differences were found between the various levels of spacing after looking through the data in Table 6. The number of florets per spike was higher in treatment S₂ (66.48) than in treatment S₁ (60.33). Another interesting finding from pinching was that, compared to plants that were not pinched P₀ (58.33), pinched plants P₁ (68.48) produced more florets per spike. In addition, there are significant variations between the growth retardant treatments i.e., CCC G₁ (68.33) generated more flower spikes than control G₀ (58.80). It was discovered that the interaction between S and P was not significant. However, the interaction between S x G, P x G and S x P x G were found to be significant and the treatment S₂G₁ (74.53), P₁G₁ (77.93), S₂P₁G₁ (82.40) recorded maximum number of florets per spike respectively and the minimum number of florets per spike were recorded in S₁G₀ (55.06), P₀G₀ (52.26), S₁P₀G₀ (45.60) respectively. This increase in number of florets per spike might be correlated with increase in number of flowers and spike length as reported by Vinayak *et al.* (2017) in *Salvia*.

Table 1. Impact of spacing, pinching and growth retardants and their interaction on plant height (cm) in *Salvia*

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control (G ₀)	CCC 500ppm (G ₁)	MH 100ppm (G ₂)		
20 cm x 25 cm (S ₁)	No pinching (P ₀)	21.90	17.16	18.32	19.13	
	Pinching (P ₁)	20.75	16.02	19.06	18.09	
	Mean	21.33	16.59	17.90		
25 cm x 25 cm (S ₂)	No pinching (P ₀)	21.39	19.06	18.34	19.60	
	Pinching (P ₁)	21.34	13.48	18.48	17.70	
	Mean	21.37	16.27	18.41		
Pinching(P)	No pinching (P ₀)	21.65	18.11	18.33		19.36
	Pinching (P ₁)	21.05	14.75	17.98		17.93
	Grand Mean	21.35	16.43	18.16		
Effects				SE(m)±	CD at 5%	
Spacing (S)				0.154	NS	
Pinching (P)				0.154	0.452	
Growth retardants (G)				0.189	0.554	
Interactions						
Spacing x Pinching (S x P)				0.218	NS	
Spacing x Growth retardants (S x G)				0.267	NS	
Pinching x Growth retardants (P x G)				0.267	0.783	
Spacing x Pinching x Growth retardants (S x P x G)				0.378	1.108	

Table 2. Impact of spacing, pinching and growth retardants and their interaction on number of branches per plant in *Salvia*

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control (G ₀)	CCC 500ppm (G ₁)	MH 100ppm (G ₂)		
20 cm x 25 cm (S ₁)	No pinching (P ₀)	10.13	11.60	10.86	10.86	13.32
	Pinching (P ₁)	14.80	16.76	15.80	15.78	
	Mean	12.46	14.18	13.33		
25 cm x 25 cm (S ₂)	No pinching (P ₀)	11.10	11.86	11.60	11.52	13.45
	Pinching (P ₁)	15.06	17.76	13.33	15.38	
	Mean	13.08	14.81	12.46		
Pinching(P)	No pinching (P ₀)	10.61	11.73	11.23		11.19
	Pinching (P ₁)	14.93	17.26	14.56		15.58
	Grand Mean	12.77	14.50	12.90		
Effects				SE(m)±	CD at 5%	
Spacing (S)				0.175	NS	
Pinching (P)				0.175	0.512	
Growth retardants (G)				0.214	0.628	
Interactions						
Spacing x Pinching (S x P)				0.247	0.725	
Spacing x Growth retardants (S x G)				0.303	0.888	
Pinching x Growth retardants (P x G)				0.303	0.888	
Spacing x Pinching x Growth retardants (S x P x G)				0.428	1.255	

Table 3. Impact of spacing, pinching and growth retardants and their interaction on number of leaves per plant in *Salvia*

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control (G ₀)	CCC 500ppm (G ₁)	MH 100ppm (G ₂)		
20 cm x 25 cm (S ₁)	No pinching (P ₀)	45.33	49.14	46.30	46.92	53.63
	Pinching (P ₁)	55.23	62.90	62.86	60.33	
	Mean	50.28	56.02	54.58		
25 cm x 25 cm (S ₂)	No pinching (P ₀)	48.40	48.26	45.20	47.28	52.95
	Pinching (P ₁)	59.23	63.16	53.46	58.62	
	Mean	53.81	55.71	49.33		
Pinching(P)	No pinching (P ₀)	46.86	48.70	45.75		47.10

	Pinching (P ₁)	57.23	63.03	58.16		59.47
	Grand Mean	52.05	55.87	51.95		
Effects				SE(m)±	CD at 5%	
Spacing (S)				0.407	NS	
Pinching (P)				0.407	1.194	
Growth retardants (G)				0.499	1.463	
Interactions						
Spacing x Pinching (S x P)				0.576	NS	
Spacing x Growth retardants (S x G)				0.705	2.069	
Pinching x Growth retardants (P x G)				0.705	2.069	
Spacing x Pinching x Growth retardants (S x P x G)				0.997	2.926	

Table 4. Impact of spacing, pinching and growth retardants and their interaction on number of flower spikes per plant in *Salvia*

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control (G ₀)	CCC 500ppm (G ₁)	MH 100ppm (G ₂)		
20 cm x 25 cm (S ₁)	No pinching (P ₀)	6.06	6.33	7.13	6.51	7.33
	Pinching (P ₁)	7.53	8.96	8.00	8.16	
	Mean	6.80	7.65	7.56		
25 cm x 25 cm (S ₂)	No pinching (P ₀)	7.33	8.46	7.40	7.73	8.45
	Pinching (P ₁)	8.06	11.13	8.30	9.16	
	Mean	7.70	9.80	7.85		
Pinching(P)	No pinching (P ₀)	6.70	7.40	7.26		7.12
	Pinching (P ₁)	7.80	10.05	8.15		8.66
	Grand Mean	7.25	8.72	7.70		
Effects				SE(m)±	CD at 5%	
Spacing (S)				0.102	0.300	
Pinching (P)				0.102	0.300	
Growth retardants (G)				0.125	0.367	
Interactions						
Spacing x Pinching (S x P)				0.145	NS	
Spacing x Growth retardants (S x G)				0.177	0.519	
Pinching x Growth retardants (P x G)				0.177	0.519	
Spacing x Pinching x Growth retardants (S x P x G)				0.250	NS	

Table 5. Impact of spacing, pinching and growth retardants and their interaction on length of the flower spikes in *Salvia*

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control (G ₀)	CCC 500ppm (G ₁)	MH 100ppm (G ₂)		
20 cm x 25 cm (S ₁)	No pinching (P ₀)	14.90	19.13	15.07	16.36	17.14
	Pinching (P ₁)	17.63	19.11	17.04	17.93	
	Mean	16.26	19.12	16.05		
25 cm x 25 cm (S ₂)	No pinching (P ₀)	17.86	19.46	15.86	17.73	18.26
	Pinching (P ₁)	18.83	21.48	16.06	18.79	
	Mean	18.35	20.47	15.96		
Pinching(P)	No pinching (P ₀)	16.38	19.30	15.46		17.05
	Pinching (P ₁)	18.23	20.29	16.55		18.36
	Grand Mean	17.30	19.79	16.01		
Effects				SE(m)±	CD at 5%	
Spacing (S)				0.400	NS	
Pinching (P)				0.400	1.173	
Growth retardants (G)				0.490	1.436	
Interactions						
Spacing x Pinching (S x P)				0.565	NS	
Spacing x Growth retardants (S x G)				0.692	NS	
Pinching x Growth retardants (P x G)				0.692	NS	
Spacing x Pinching x Growth retardants (S x P x G)				0.979	NS	

Table 6. Impact of spacing, pinching and growth retardants and their interaction on number of florets per spike in *Salvia*

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control (G ₀)	CCC 500ppm (G ₁)	MH 100ppm (G ₂)		
20 cm x 25 cm (S ₁)	No pinching (P ₀)	45.60	50.80	68.40	54.93	60.33
	Pinching (P ₁)	64.53	73.46	59.20	65.73	
	Mean	55.06	62.13	63.80		
25 cm x 25 cm (S ₂)	No pinching (P ₀)	58.93	66.66	59.60	61.73	66.48
	Pinching (P ₁)	66.13	82.40	65.20	71.24	
	Mean	62.53	74.53	62.40		
Pinching(P)	No pinching (P ₀)	52.26	58.73	64.00		58.33

	Pinching (P ₁)	65.33	77.93	62.20		68.48
	Grand Mean	58.80	68.33	63.10		
Effects				SE(m)±	CD at 5%	
Spacing (S)				0.499	1.464	
Pinching (P)				0.499	1.464	
Growth retardants (G)				0.611	1.793	
Interactions						
Spacing x Pinching (S x P)				0.706	NS	
Spacing x Growth retardants (S x G)				0.864	2.535	
Pinching x Growth retardants (P x G)				0.864	2.535	
Spacing x Pinching x Growth retardants (S x P x G)				1.222	3.585	



Fig. 1 Pinched plants at 45 DAT



Fig. 2 Non pinched plants at 45 DAT

Conclusion:

In accordance to the results, spacing had no noticeable effect on the majority of the characteristics. However, the behavior of salvia plants during flowering was significantly affected by pinching and the application of growth retardants, specifically cycocel. Pinching contributed to an upsurge in flowering efficiency. Similarly, application of growth retardants resulted in delayed flower bud initiation due to suppression activity of growth retardants. Hence, from the present experiment it can be concluded that the treatment combination S₂P₁G₁ i.e., T₁₁ of spacing 25 cm × 25 cm + pinching + CCC@500 ppm was found to be best for most of the vegetative growth and flowering parameters including plant height (13.48cm), number of branches (17.76), number of leaves (63.16), number of flower spikes per plant (11.13), length of the spike (21.48cm) and number of florets per spike (82.40) in salvia.

Future Scope:

Impact of different levels of pinching in salvia should be further standardized. Effect of different levels of various growth retardants can also be studied. By conducting further research, you can gain a deeper understanding of the S₂P₁G₁ combination's effects and determine its suitability for widespread recommendation to farmers.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

- 1.
- 2.
- 3.

References:

1. Ashvini, G., Dalal, S. R. and Nagre, P. K. (2020). Effect of different planting dates and pinching on growth and flowering of China aster. *International Journal of Chemical Studies*, 8(2), 1120-1124.
2. Banko TJ. 2003. Promotion of Camellia flower bud set with plant growth regulators. *SNA Research Conference*. **48**(8): 264-66.
3. Banon, A. S., Antonio, J., Leemhuis, F., Fernandez, J. A., Ochoa, J. and Benaente, A. G. (2001). Growth and leaf colour responses of oleander (*Nerium oleander* L.) to pinching and chlormequat chloride treatment. *Acta Horticulturae*, 559.
4. Chikte, J., Collis, J. P. and Bhosle, A. R. (2017). Effect of different plant growth retardant on plant growth, flowering and yield of African marigold (*Tagetes erecta* L.) Pusa Basanti. *Indian Journal of Chemical Studies*, 5(2), 201-204.

5. Donald GV and Arnold MA. 2001. Paclobutrazol and Uniconazole applications affect production quality and subsequent landscape performance of blue Plumbago. *Horticulture Science*. **36**(1): 431.
6. Habiba S U, Islam M S, Uddin A J. 2012. Influence of Terminal Bud Pinching on Growth and Yield of Chrysanthemum, (*Chrysanthemum Indicum* L). *Journal of Bangladesh Academy of Sciences*. **36**(2): 251-255.
7. Jamal U A F M, Shahrin S, Ahmad H, Rahman S and Shimasaki K. 2015. Influence of terminal bud pinching on growth and flowering of Lisianthus (*Eustoma grandiflorum*). *International Journal of Business, Social and Scientific Research*. **4**(1):37-40.
8. Lewis PK, Faust JE, Sparkman JD and Grimes LW. 2004. The effect of daminozide and chlormequat on the growth and flowering of Poinsettia and Pansy. *Horticulture Science*. **39**(6): 1315-18.
9. Luckwill, LC and Cutting CV. 1968. Growth retardants, chlormequat having a pronounced influence on apical dominance control of growth and fruit fullness of apple tree. *Physiology of Tree crops*. 239.
10. Mackay, W. A. and Sankhla, N. (2006). Current and potential uses of plant growth regulators in floriculture and ornamental plants. Plant Growth Regulation Society of America, 34(2), 29.
11. Marsoz A and Matysiak B. 2005. Influence of growth retardants on growth and flower bud formation in Rhododendron and Azalea. *Dendrobiology*. **54**(6): 35-40.
12. Meijon M, Rodriguez R, Canal MJ and Feito I. 2009. Improvement of compactness and floral quality in azalea by means of application of plant growth regulators. *Scientia Horticulturae*. **119**(5): 169-76.
13. Quattrini E, Venezia A and Casarotti D. 1995. Dwarfing effect of chlormequat on gardenia (*Gardenia jasminoides* Ellis). *Colture Protette*. **24**(7-8): 75-78.
14. Rathore I, Mishra A, Moond SK and Bhatnagar P. 2010. Studies on effect of pinching and plant bio-regulators on growth and flowering of marigold (*Tagetes erecta* L.) cv. Pusa Basanti Gaiinda. *Progressive Horticulture*. **43**(1): 52-55.
15. Sasikumar, K., Baskaran, V. and Abirami, K. (2015). Effect of pinching and growth retardants on growth and flowering of african marigold cv. Pusa Narangi Gaiinda. *Journal of Horticultural Science*, 10(1), 1-3.
16. Singh, R., Meena, M. L., Verma, S., Mauriya, S. K., Yadav, S., Kumar, V., Singh, V., Kumar, L. and Maurya, S. K. (2019). Effect of Pinching on Growth, Flowering and Flower Yield of Marigold, *Indian Journal of Pure Applied Biosciences*, 7(4), 493-501.
17. Subhendu, J., Mohanty, C.R., Chakradhar, P. and Rudra, M. D. (2021). Effect of pinching on growth and flowering of annual chrysanthemum (*Chrysanthemum coronarium* L.). *Journal of Pharmacognosy and Phytochemistry*, 10(2), 1042-1045.
18. Vinayak K, Prasad V M, Sindhuja M, Rajawade V B and singh D. 2017. Response of spacing and nitrogen levels on growth and flowering of salvia (*Salvia splendens* L.). *Journal of Pharmacognosy and Phytochemistry*. **6**(4): 2059-2062.

19. Shinde , Sharmila, R. T. Gaikwad, and P. B. Khaire. 2024. “Effect of Time of Transplanting and Spacing on Tulsi (*Ocimum Sanctum*)”. *Journal of Advances in Biology & Biotechnology* 27 (5):464-70. <https://doi.org/10.9734/jabb/2024/v27i5807>.
20. Datta, Himadri S, P.C. Barua, U. Kotoky, R. Das, H. Saikia, and H.K.D Nath. 2024. “Impact of Plant Spacing and Mulch on Growth Parameters of Strawberry (*Fragaria X Ananassa Duch.*)”. *Journal of Experimental Agriculture International* 46 (5):926-36. <https://doi.org/10.9734/jeai/2024/v46i52448>.
21. Wani T, Banday N, Nazki IT, Mir SA, Bhat MS, Khan FA. Plant architecture manipulation and growth retardants influencing the Pot presentability of China aster (*Callistephus chinensis L. Nees*). *Vegetos*. 2024 Apr 25:1-8.
22. Kaberi Maharana, Srilakshmi B.D.V.V.N., N. Amrutha Pavani and Lilymoony Tripathy. Effect of Spacing, Pinching and Growth Retardants on Flowering of *Salvia* (*Salvia splendens L.*). *Biological Forum – An International Journal* 16(2): 134-139(2024)