

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

Abstract:

The present investigation 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 include first factor spacing with two levels i.e., S₁ (20 x 25 cm) and S₂ (25 x 25 cm), second factor pinching with two levels i.e., P₀ (no pinching) and P₁ (pinching) and third factor application of growth retardants with three levels i.e., G₀ (control), G₁ (CCC @500ppm) and G₂ (MH @100ppm). The results indicated that the important flowering characters were significantly influenced by pinching and application of growth retardants than spacing tried under this investigation. The treatment combination S₂P₁G₁ i.e., T₁₁ was found to be superior and revealed significant results. 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, number of branches, number of leaves and flowering characters like number of flower spikes per plant, length of flower spike, and length of florets.

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. For proper growth salvia requires a sunny area with a loamy and well drained soil rich in organic matter. This genus belongs to the family "Lamiaceae" which is well known for having many aromatic and medicinal plants, Clebsch and Barner (2003). It is thought that, *S. splendens* contains the substances “salviarin” and “splendidin” which are chemically similar to “salvinorin”, also a “neoclerodane diterpene” which are said to be sedating and relaxing. *Salvia splendens* L. is a popular bedding plant used primarily to add a splash of brilliant colour to gardens. It can be planted by sowing seeds from August to the beginning of October and blooms in the winter until spring and it can carry its spikes to 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,

Commented [A1]: The reference cited in the text must be available in the list of references and vice versa.

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. Plant growth retardants application 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). With the aim of developing attractive pot plants by manipulation of growth and enhancing flowering through cultural tactics or chemically, the present investigation was carried out to find the effect of spacing, pinching and growth retardants on growth and flowering behaviour of *Salvia*.

2. Materials and methods

The experiment 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.

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

Commented [A2]: Please check...all of the reference cited in the text must be available in list of references and vice versa.

In the present investigation two levels of spacing viz., S₁ (20cm x 25cm), S₂ (25cm x 25cm), 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. Growth parameters like plant height, number of branches per plant, number of leaves per plant and Flowering parameters like, number of flower spikes per plant, length of flower spikes, number of florets per spike were recorded. All the data concerning various growth parameters, flowering components were analyzed statistically. The analysis of variance table was prepared. The treatment effects were tested by 'F' test at 5 % level of significance. The critical difference at 5 % level was calculated for comparing treatment means.

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 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).

Number of branches

From the perusal of data presented in table 2, the treatments levels of spacing didn't show significant difference. However, the treatments S₁ (13.32) and S₂ (13.45) were recorded similar number of branches plant⁻¹. The treatment pinching exhibited significant difference where the maximum number of branches plant⁻¹ were recorded for plants where pinching was done i.e., P₁ (15.58) whereas the minimum number of branches plant⁻¹ were recorded in treatment where pinching was not done i.e., P₀ (11.19). The treatments of growth retardants exhibited significant difference and they were statistically significant where the maximum number of branches plant⁻¹ were recorded for treatment CCC G₁ (14.50) followed by MH G₂ (12.90) over control G₀ (12.77).

The interaction between spacing and pinching revealed statistically significant results. The minimum number of branches plant⁻¹ were recorded for treatment S₁P₀ (10.86) and the maximum number of branches plant⁻¹ were recorded for treatment S₁P₁ (15.78) which remained statistically at par with S₂P₁ (15.38). The S x G interaction revealed significant results where the minimum number of branches plant⁻¹ were recorded for S₁G₀ (12.46) and the maximum number of branches per plant were recorded for treatment S₂G₁ (14.81). The P x G interaction was found to be significant. The minimum number of branches per plant were recorded for treatment P₀G₀ (10.61) whereas the maximum number of branches plant⁻¹ were recorded for treatment P₁G₁ (17.26). The interaction S x P x G also yielded significant results where the minimum number of branches plant⁻¹ were recorded for treatment S₁P₀G₀ (10.13) and the maximum number of branches plant⁻¹ were recorded for treatment S₂P₁G₁ (17.76).

Number of leaves

From the perusal of data presented in table 3, the treatments levels of spacing did not exhibited significant difference. However, the treatments S₁ (53.63) recorded maximum number of leaves plant⁻¹ and S₂ (52.95) recorded minimum number of leaves plant⁻¹. The treatment pinching exhibited significant difference where the maximum number of leaves plant⁻¹ were recorded for plants where pinching was done i.e., P₁ (59.47) whereas the minimum number of leaves plant⁻¹ were recorded in treatment where pinching was not done i.e., P₀ (47.10). The treatments of growth retardants also exhibited significant difference and they were statistically significant where the maximum number of leaves plant⁻¹ were recorded for treatment CCC G₁ (55.87) over control G₀ (52.05).

The interaction between spacing and pinching showed non-significant. However, the minimum number of leaves plant⁻¹ were recorded for treatment S₁P₀ (46.92) and the maximum number of leaves plant⁻¹ were recorded for treatment S₁P₁ (60.33). The S x G interaction revealed significant results where the minimum number of leaves plant⁻¹ were recorded for S₂G₁ (49.33) and the maximum number of leaves per plant were recorded for treatment S₁G₁ (56.02). The P x G interaction was also found to be significant where the minimum number of leaves per plant were recorded for treatment P₀G₂ (45.75) whereas the maximum number of leaves plant⁻¹ were recorded for treatment P₁G₁ (63.03). The interaction S x P x G was also found to be significant where the minimum number of leaves plant⁻¹ were recorded for

treatment S₁P₀G₂ (45.20) and the maximum number of leaves plant⁻¹ were recorded for treatment S₂P₁G₁ (63.16).

Flowering characters:

Number of flower spikes per plant:

From the perusal of data presented in table 4, significant difference was observed among the different levels of spacing. The treatment S₂ (8.45) recorded more number of flower spikes per plant than S₁ (7.33) which were not at statistically par with each other. Pinching also revealed significant results where pinched plants P₁ (8.66) produced more number of flower spikes per plant than plants which were not pinched P₀ (7.12). The treatments of growth retardants also exhibited significant results where the treatment CCC G₁ (8.72) produced more number of flower spikes over 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.

Length of flower spikes:

From the perusal of data presented in table 5, there was no significant difference among the different levels of spacing. Significant difference was observed among pinching levels where P₁ (18.36 cm) recorded maximum spike length than P₀ (17.05cm). However, the treatments of growth retardants are also significantly different from each other where the treatment CCC G₁ (19.79cm) maximum spike length over MH G₂ (16.01cm) and control G₀ (17.30cm). The interactions between S x P, S x G and P x G and S x P x G were found to be non-significant.

Number of florets per spike:

From the perusal of data presented in table 6, significant difference was observed among the different levels of spacing. The treatment S₂ (66.48) recorded more number of florets per spike than S₁ (60.33). Pinching also revealed significant results where pinched plants P₁ (68.48) produced more number of florets per spike than plants which were not pinched P₀ (58.33). The treatments of growth retardants are also significantly different from each other where the treatment CCC G₁ (68.33) produced more number of flower spikes over control G₀ (58.80).

The interaction between S x P was found to be non-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.

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

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. Effect of spacing, pinching and growth retardants and their interaction on number of branches per plant in *Salvia splendens* L.

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	
	Pinching (P ₁)	14.80	16.76	15.80	15.78	

	Mean	12.46	14.18	13.33		13.32
25 cm x 25 cm (S ₂)	No pinching (P ₀)	11.10	11.86	11.60	11.52	
	Pinching (P ₁)	15.06	17.76	13.33	15.38	
	Mean	13.08	14.81	12.46		13.45
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. Effect of spacing, pinching and growth retardants and their interaction on number of leaves per plant in *Salvia splendens* L.

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	
	Pinching (P ₁)	55.23	62.90	62.86	60.33	
	Mean	50.28	56.02	54.58		53.63
25 cm x 25 cm (S ₂)	No pinching (P ₀)	48.40	48.26	45.20	47.28	
	Pinching (P ₁)	59.23	63.16	53.46	58.62	
	Mean	53.81	55.71	49.33		52.95
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. Effect of spacing, pinching and growth retardants and their interaction on number of flower spikes per plant in *Salvia splendens* L.

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	8.66
	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. Effect of spacing, pinching and growth retardants and their interaction on length of the flower spikes in *Salvia splendens* L.

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	18.36
	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. Effect of spacing, pinching and growth retardants and their interaction on number of florets per spike in *Salvia splendens* L.

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

Commented [A3]: Please add a scale to Figure 1.1 to allow us to compare the actual size!.

Commented [A4]: Please add a scale to Figure 1.1 to allow us to compare the actual size!.

Discuss the results obtained and compare them with previous literature, including the best treatment from the application of spacing, pinching, and the use of growth retardants.

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Justified

The S2P1G1 treatment emerged as the most effective combination for promoting plant height, number of branches number of leaves and flowering characters like number of flower spikes per plant, length of flower spike, and length of florets. By conducting further research, you can gain a deeper understanding of the S2P1G1 fertilizer combination's effects and determine its suitability for widespread recommendation to farmers.

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Conclusion:

Based on the results obtained spacing did not show significant effect for most of the parameters. However, pinching and application of growth retardants particularly cycocel produced pronounced effect on flowering behavior of salvia plants. Pinching helped increased flower production. Likewise, 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 S2P1 G1 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:

Effect of different levels of pinching in salvia should be further standardized. Effect of different level of various growth retardants can also be studied.

References:

- Akshay, A. T., Megha, H. D., Dhanshri, P. L., Aniket, K. L. B. and Aishwarya, R. I. (2020). Effect of pinching and nitrogen on flowering and flower quality of annual chrysanthemum, *International Journal of Chemical Studies*, 8(6), 2799-2803.
- 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.
- 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.
- 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.
- Jagdale, A. R., Khobragade, Y. R., Panchbhai, D. M., Ghormade, G. N. and Bhaskarwar, A. C. (2017). Growth and flowering of annual Chrysanthemum influenced by cycocel and paclobutrazol. *Journal of Soil and Crops*, 27(1), 143-146.
- 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.
- 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.
- 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.
- 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.
- Taksande, S., Raut, V. U. and Nagre, P. K. (2017). Effect of pinching and cycocel on flowering and flower quality of annual chrysanthemum. *Journal of Soils and Crops*, 27(1), 75-79.