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Effect of Spacing, Pinching and Growth Retardants on Flowering of Salvia (*Salvia splendens* L.)

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ABSTRACT: A field experiment was carried in a Factorial Randomized Block Design (FRBD) with three replications, comprising of 12 treatment combinations. The results indicated that the important growth characters were significantly influenced by pinching and application of growth retardants than spacing tried under this investigation. The treatment combination $S_2P_1G_1$ i.e., T_{11} was found to be superior and recorded more number of flower spikes per plant (11.13) at 75 DAT, maximum length of spike (21.48 cm), maximum florets per spike (82.40), maximum length of florets (1.90cm) and maximum flowering duration (97.06 days). The treatment combination $S_2P_1G_1$ i.e., T_{11} (25 cm × 25 cm spacing + pinching + CCC@500ppm) was found to be superior for flowering characters in salvia.

Keywords: Pinching, spacing, growth regulators, MH, cycocel, spike, flowering.

INTRODUCTION

Salvia splendens L. comes in a variety of hues, including white, salmon, pink, purple, lavender, burgundy, and orange, however the scarlet varieties are highly popular. *Salvia splendens* L. attains a height of 18" to 30". This genus belongs to the family "Lamiaceae". *Salvia splendens* L. is a popular bedding plant used primarily to add a splash of brilliant colour to gardens. It blooms in the winter until spring and it can carry its spikes to the next summer.

Growth retardants also have influence on the flowering behavior of plants and may result in early flowering or developing more number of flowers per plant, increasing the colour intensity of leaves and bracts (Banon *et al.*, 2001), and also enhances the ability of the plant to tolerate various stress encountered during handling and shipping (Mackay and Sankhla 2006).

Spacing influences the compactness of the plants therefore effects the growth and flowering whereas pinching induces more number of lateral branches and results in increasednumber of flowers.

Besides, the cultural practices followed in bedding plant salvia, use of growth retardants is recommended to get quality crop with high yield by reducing the height and increasing the compactness.

Thus, present study is to study the effect of spacing, pinching and growth retardants on flowering and longevity of spikes on the salvia plants.

MATERIALS AND METHODS

The experiment was conducted in the garden of Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar from December 2021 to April 2022. One month old seedlings of salvia were used as planting material and transplanted into main field as per the treatment. The seedlings were procured from near by nursery in Bhubaneswar.

Design of experiment: The experimental design followed was Factorial Randomized Block Design (FRBD) with three replications, comprising of 12 treatment combinations which include first factor spacing with two levels i.e., S_1 (20 cm × 25 cm) and S_2 (25 cm × 25 cm), second factor pinching with two levels i.e., P_0 (no pinching) and P_1 (pinching) and third factor application of growth retardants with three levels i.e., G_0 (control), G_1(CCC @500ppm) and G_2(MH @100ppm).

Preparation of experimental plot: The land was brought to fine tilth and the experimental plots were laid out with a dimension of 1m × 1m, a path of 30 cm width between two plots was created for formation of bunds and carrying out cultural operations.

Four weeks old healthy, uniform and well rooted seedlings were transplanted in the experimental unit according to the spacing *viz.*, of 20 cm × 25 cm and 25 cm × 25 cm, within the row and in between the plants respectively was followed according to treatment combinations. Pinching was done 25 days after

transplanting i.e., immediately after flower bud initiation.

The roots of the seedlings were thoroughly washed with clean water and immersed in the solutions of the growth retardants cycocel and maleic hydrazide and kept for 2 hours for proper absorption.

Observations recorded: In each treatment, five plants were selected at random and labelled in order to record the observations on floral parameters using a non-destructive process at 15 days interval, starting from 30 DAT i.e., at 30, 45, 60, 75 days after transplanting.

Number of days taken to visible flower bud initiation (days): The number of days taken from the date of transplanting to the date of appearance of first flower bud was counted and considered as number of days taken to emergence of first flower bud.

Number of flower spikes per plant: Total number of spikes per plant was counted and recorded.

Length of spikes (cm): Spikes length was measured with the help of centimetre scale.

Duration of flowering (days): This was recorded by counting the number of days from initial day of flowering to 100% of the plants in a plot which showed flowering.

Statistical analysis: Statistical significance was tested with F value at 5% level of probability.

Treatment combinations:

Sr. No.	Treatments	TreatmentSymbols	Details of treatment
1.	T_1	$S_1P_0G_0$	Spacing of 20cm × 25 cm + no pinching + control
2.	T_2	$S_1P_0G_1$	20cm × 25cm+ no pinching + CCC@500ppm
3.	T_3	$S_1P_0G_2$	20cm × 25cm + no pinching +MH @100ppm
4.	T_4	$S_1P_1G_0$	20cm x 25cm + pinching + control
5.	T_5	$S_1P_1G_1$	20 cm × 25 cm + pinching +CCC@500ppm
6.	T_6	$S_1P_1G_2$	20cm × 25cm + pinching+ MH @100ppm
7.	T_7	$S_2P_0G_0$	25cm × 25 cm + no pinching + control
8.	T_8	$S_2P_0G_1$	25cm × 25 cm+ no pinching + CCC@500ppm
9.	T_9	$S_2P_0G_2$	25cm × 25 cm+ no pinching + MH @100ppm
10.	T_{10}	$S_2P_1G_0$	25cm × 25 cm+ pinching + control
11.	T_{11}	$S_2P_1G_1$	25cm × 25 cm+ pinching + CCC@500ppm
12.	T_{12}	$S_2P_1G_2$	25cm × 25 cm+ pinching+ MH @100ppm

RESULTS

Number of days taken to visible flower bud initiation (days): From the perusal of data in Table 1, the treatments levels of spacing did not exhibited significant difference. Significant differences were found among the treatments of pinching with regard to number of days taken to visible flower bud initiation. The pinched plants, P_1 (27.32) had taken more number of days to initiate flower bud over the plants which were not pinched P_0 (22.45). Application of growth retardants at different levels showed significant influence on number of days taken to visible flower bud initiation. The treatment MH G_2 had taken more number of days to initiate flowering as compared to CCC G_1 (23.70) over the control G_0 (22.55). The interactions between S × P, S × G, P × G, S × P × G was found non-significant and were statistically similar.

Table 1: Effect of spacing, pinching and growth retardants and their interaction onnumber of days taken to visible flower bud initiation (days) in *Salvia splendens* L.

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control(G0)	CCC 500ppm (G1)	MH 100ppm (G2)		
20 cm × 25 cm(S_1)	No pinching (P_0)	19.30	20.43	28.50	**22.74**	
	Pinching (P_1)	24.53	27.66	30.93	**27.71**	
	Mean	**21.91**	**24.05**	**29.71**		**25.22**
25 cm × 25 cm(S_2)	No pinching (P_0)	22.63	20.40	23.46	**22.16**	
	Pinching (P_1)	23.73	26.33	31.90	**27.32**	
	Mean	**23.18**	**23.36**	**27.68**		**24.74**
Pinching(P)	No pinching (P_0)	20.96	20.41	25.98		**22.45**
	Pinching (P_1)	24.13	27.00	31.41		**27.32**
	Grand Mean	**22.55**	**23.70**	**28.70**		

Effects	SE(m)±	CD at 5%
Spacing (S)	0.653	NS
Pinching (P)	0.653	1.915
Growth retardants (G)	0.800	2.346
Interactions		
Spacing × Pinching (S × P)	0.923	NS
Spacing × Growth retardants (S × G)	1.131	NS
Pinching × Growth retardants (P × G)	1.131	NS
Spacing × Pinching × Growth retardants (S × P × G)	1.599	NS

Number of flower spikes per plant at 60 DAT: From the perusal of data presented in Table 2, significant difference was observed among the different levels of spacing. The treatment S_2 (7.03) recorded more number of flower spikes per plant than S_1 (5.73). Pinching also revealed significant results where pinched plants P_1 (7.08) produced more number of flower spikes per plant than plants which were not pinched P_0 (5.68). The treatments of growth retardants did not exhibit any significant results. However, the interactions between S × P, S × G, P × G, S × P × G was also found to be non-significant.

Number of flower spikes per plant at 75 DAT: From data presented in Table 3, significant difference was observed among the different levels of spacing. The treatment S_2 (8.45) recorded more number of flower spikes per plant than S_1 (7.33) which were not at statistically par with each other. Pinching also revealed significant results where pinched plants P_1 (8.66) produced more number of flower spikes per plant than plants which were not pinched P_0 (7.12). The treatments of growth retardants also exhibited significant results where the treatment CCC G_1 (8.72) produced more number of flower spikes over control G_0 (7.25).

However, the interactions between S × P and S × P × G was found to be non-significant. But the interactions between S × G and P × G were statistically significant where more number of flower spikes were produced in treatment S_2G_1 (9.80), P_1G_1 (10.05) respectively and least number of flower spikes per plant were produced in treatment S_1G_0 (6.06), P_0G_0 (6.70) respectively.

Number of flower spikes per plant at 90 DAT: Data presented in Table 4, significant difference was observed among the different levels of spacing. The treatment S_2 (5.91) recorded almost same number of flower spikes per plant as S_1 (5.36). Pinching also revealed significant results where pinched plants P_1 (6.12) produced more number of flower spikes per plant than plants which were not pinched P_0 (5.14).

The treatments of growth retardants are also significantly different from each other where the treatment CCC G_1 (6.00) produced more number of flower spikes over control G_0 (5.22). However, the interactions between S × P, S × G, P × G, S × P × G were found to be non-significant.

Length of the spike (cm): From the data presented in Table 5, there was no significant difference among the different levels of spacing. Significant difference was observed among pinching levels where P_1 (18.36 cm) recorded maximum spike length than P_0 (17.05cm). However, the treatments of growth retardants are also significantly different from each other where the treatment CCC G_1 (19.79cm) maximum spike length over MH G_2 (16.01cm) and control G_0 (17.30cm). The interactions between S × P, S × G and P × G and S × P × G were found to be non-significant.

Flowering duration (days): From the perusal of data presented in Table 6, there is no significant difference among the different levels of spacing. Pinching revealed significant results where the treatment P_1 (86.91) has recorded increased flowering duration which was at par with P_0 (85.25).

However, the treatments of growth retardants are also significantly different from each other where the treatment CCC G_1 (92.24) recorded increased flowering duration as compared to MH G_2 (84.97) and control G_0 (81.03).

The interactions between S × P and S × P × G were found to be non-significant and did not differ statistically from each other. However, the interaction between S × G and P × G was found to be significant and the treatment S_0G_0 (80.76), P_0G_0 (80.80) recorded minimum duration of flowering respectively whereas S_2G_1 (94.66), P_1G_1 (94.68) recorded maximum duration of flowering respectively.

Table 2: Effect of spacing, pinching and growth retardants and their interaction onnumber of flower spikes per plant at 60 DAT 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 × 25 cm(S_1)	No pinching (P_0)	5.26	5.63	3.93	**4.94**	
	Pinching (P_1)	6.66	6.73	6.20	**6.53**	
	Mean	**5.96**	**6.18**	**5.06**		**5.73**
25 cm × 25 cm(S_2)	No pinching (P_0)	5.83	6.93	6.53	**6.43**	
	Pinching (P_1)	7.60	7.93	7.40	**7.64**	
	Mean	**6.71**	**7.43**	**6.96**		**7.03**
Pinching(P)	No pinching (P_0)	5.55	6.28	5.23		**5.68**
	Pinching (P_1)	7.13	7.33	6.80		**7.08**
	Grand Mean	**6.34**	**6.80**	**6.01**		

Effects	SE(m)±	CD at 5%
Spacing (S)	0.245	0.718
Pinching (P)	0.245	0.718
Growth retardants (G)	0.300	NS
Interactions		
Spacing × Pinching (S × P)	0.346	NS
Spacing × Growth retardants (S × G)	0.424	NS
Pinching × Growth retardants (P × G)	0.424	NS
Spacing × Pinching × Growth retardants (S × P × G)	0.599	NS

Table 3: Effect of spacing, pinching and growth retardants and their interaction on number of flower spikes per plant at 75 DAT in *Salvia splendens* L.

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control(G0)	CCC 500ppm (G1)	MH 100ppm (G2)		
20 cm × 25 cm(S_1)	No pinching (P_0)	6.06	6.33	7.13	**6.51**	
	Pinching (P_1)	7.53	8.96	8.00	**8.16**	
	Mean	**6.80**	**7.65**	**7.56**		**7.33**
25 cm × 25 cm(S_2)	No pinching (P_0)	7.33	8.46	7.40	**7.73**	
	Pinching (P_1)	8.06	11.13	8.30	**9.16**	
	Mean	**7.70**	**9.80**	**7.85**		**8.45**
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 × Pinching (S × P)				0.145	NS	
Spacing × Growth retardants (S × G)				0.177	0.519	
Pinching × Growth retardants (P × G)				0.177	0.519	
Spacing × Pinching × Growth retardants (S × P × G)				0.250	NS	

Table 4: Effect of spacing, pinching and growth retardants and their interaction on number of flower spikes per plant at 90 DAT in *Salvia splendens* L.

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control(G0)	CCC 500ppm (G1)	MH 100ppm (G2)		
20 cm × 25 cm(S_1)	No pinching (P_0)	4.73	5.13	5.26	**5.04**	
	Pinching (P_1)	5.03	5.96	6.03	**5.67**	
	Mean	**4.88**	**5.55**	**5.65**		**5.36**
25 cm × 25 cm(S_2)	No pinching (P_0)	4.80	5.73	5.20	**5.24**	
	Pinching (P_1)	6.33	7.16	6.23	**6.57**	
	Mean	**5.56**	**6.45**	**5.71**		**5.91**
Pinching(P)	No pinching (P_0)	4.76	5.43	5.23		**5.14**
	Pinching (P_1)	5.68	6.56	6.13		**6.12**
	Grand Mean	**5.22**	**6.00**	**5.68**		
Effects				**SE(m)±**	**CD at 5%**	
Spacing (S)					0.493	
Pinching (P)					0.493	
Growth retardants (G)					0.603	
Interactions						
Spacing x Pinching (S × P)					NS	
Spacing × Growth retardants (S × G)					NS	
Pinching × Growth retardants (P × G)					NS	
Spacing x Pinching × Growth retardants (S × P × G)					NS	

Table 5: Effect of spacing, pinching and growth retardants and their interaction onlength of the spike (cm) in *Salvia splendens* L.

Spacing (S)	Pinching (P)	Growth retardants (G)			Mean	Grand mean
		Control(G0)	CCC 500ppm (G1)	MH 100ppm (G2)		
20 cm × 25 cm(S_1)	No pinching (P_0)	14.90	19.13	15.07	**16.36**	
	Pinching (P_1)	17.63	19.11	17.04	**17.93**	
	Mean	**16.26**	**19.12**	**16.05**		**17.14**
25 cm × 25 cm(S_2)	No pinching (P_0)	17.86	19.46	15.86	**17.73**	
	Pinching (P_1)	18.83	21.48	16.06	**18.79**	
	Mean	**18.35**	**20.47**	**15.96**		**18.26**
	No pinching (P_0)	16.38	19.30	15.46		**17.05**

Pinching(P)	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 × Pinching (S × P)				0.565	NS	
Spacing × Growth retardants (S × G)				0.692	NS	
Pinching × Growth retardants (P × G)				0.692	NS	
Spacing × Pinching × Growth retardants (S × P × G)				0.979	NS	

Table 6: Effect of spacing, pinching and growth retardants and their interaction on flowering duration in *Salvia splendens* L.

Spacing (S)	**Pinching (P)**	**Growth retardants (G)**			**Mean**	**Grand mean**
		Control(G0)	**CCC 500ppm (G1)**	**MH 100ppm (G2)**		
20 cm × 25 cm(S_1)	No pinching (P_0)	80.06	87.33	88.00	**85.13**	
	Pinching (P_1)	81.46	92.30	85.93	**86.56**	
	Mean	**80.76**	**89.81**	**86.96**		**85.85**
25 cm × 25 cm(S_2)	No pinching (P_0)	81.53	92.26	82.33	**85.37**	
	Pinching (P_1)	81.06	97.06	83.63	**87.25**	
	Mean	**81.30**	**94.66**	**82.98**		**86.31**
Pinching(P)	No pinching (P_0)	80.80	89.80	85.16		**85.25**
	Pinching (P_1)	81.26	94.68	84.78		**86.91**
	Grand Mean	**81.03**	**92.24**	**84.97**		
Effects				**SE(m)±**	**CD at 5%**	
Spacing (S)				0.419	NS	
Pinching (P)				0.419	1.230	
Growth retardants (G)				0.514	1.507	
Interactions						
Spacing × Pinching (S × P)				0.839	NS	
Spacing × Growth retardants (S × G)				1.027	2.131	
Pinching × Growth retardants (P × G)				1.027	2.131	
Spacing × Pinching × Growth retardants (S × P × G)				1.453	NS	

DISCUSSION

The floral parameter days to visible flower bud initiation was recorded and it was found to be non-significant for spacing but revealed significant results for pinching and application of growth retardants. The plants which were pinched P_1 (27.32) had taken more days to bud initiation than non-pinched plants i.e., P_0 (22.45 days). Pinching took more days to bud initiation which might be due to breaking of apical dominance leading to prolonged vegetative growth and resulted in delayed onset of reproductive phase. These results were in accordance with the findings of Akshay *et al.* (2020) in chrysanthemum and Ashvini *et al.* (2020) in china aster. Among growth retardants early flower bud initiation was observed in control G_0 (22.55) which was at par with CCC i.e., G_1 (23.70).

Delayed bud initiation was recorded in MH i.e., G_2 (28.70 days). This delay in appearance of first flower bud might also due to action of growth retardant which by virtue suppress the activities of GA, which is a growth regulator effective in bud initiation. The current results were also supported by findings of Taksande *et al.* (2017) in chrysanthemum and Chikte *et al.* (2017) in marigold.

The flowering parameter number of spikes per plant was recorded at 60, 75 and 90 DAT. The factor spacing and pinching was found to be significant at all the three intervals. The application of growth retardants was found to be non-significant initially but later revealed significant results. It was evident from the data that maximum flower spikes were recorded at 75 DAT and were significantly different. It was clear that wider spacing S_2 (8.45), pinched treatment P_1 (8.66) and application of growth retardant CCC recorded more number of flower spikes per plant i.e., G_1 (8.72). The interactions were found be non-significant at all the intervals except for S × G and P × G at 75 DAT. This increase in number of flower spikes due to pinching might be because of restriction of terminal growth, resulting in production of more lateral branches which might have led to lateral bud initiation from where flowers originate thereby producing more number of flower spikes per plant as reported by Subhendu *et al.* (2021) in chrysanthemum and Singh *et al.* (2019) in marigold. Likewise, the increase in flowers per plant by application of growth retardants might be correlated with the vegetative growth characters like number of branches and number of leaves where the treatment exhibited significant effect. As a result of this the plant had a comparatively higher level of organic reserves conducive for better floral development and thereby

increased the number of flower spikes per plant. These findings were corroborated with the results of Sasikumar *et al.* (2015) in marigold and Jagdale *et al.* (2017) in chrysanthemum.

The character length of the spike was recorded. Significant differences were noticed for pinching and application of growth retardants. The factor spacing and the interactions between the factors were found to be non-significant. Maximum length of spike was recorded for S_2 (18.26cm) and G_1 (19.79cm) and the lowest in MH i.e., G_2 (16.01cm) over control i.e., G_0 (17.30cm). This increase in spike length might be due to better availability of carbohydrates and other nutrients for floral development.

The parameter flowering duration was found to be significant for pinching and growth retardants but no significant difference was observed for spacing. The interactions were also found to be non-significant except for S × G and P × G. The maximum flowering duration was recorded for P_1 (86.91 days) and G_1 (92.24 days) for pinching and application of growth retardants respectively. This might be due to delayed flower bud initiation which might have made the treated plants more sturdy and fresh for longer duration and this might have assisted the supply of flower inducing hormones for longer period and might have increased the duration of flowering as reported by Singh *et al.* (2019) in marigold and Ashvini *et al.* (2020) in china aster.

CONCLUSIONS

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 S_2P_1 G_1 i.e., T_{11} of spacing 25 cm × 25 cm + pinching + CCC@500 ppm was found to be best for most of the flowering parameters including number of flower spikes per plant (7.16), length of the spike (21.48), number of florets per spike (82.40) and delayed flowering duration (97.06 days) 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.

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