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 include first factor spacing with two levels i.e., S_1 (20 x 25 cm) and S_2 (25 x 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).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 $S_2P_1G_1$ i.e., T_{11} 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 $S_2P_1G_1$ i.e., T_{11} 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,

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	$S_1P_0G_0$	20cm x 25 cm + no pinching + control
2.	T_2	$S_1P_0G_1$	20cm x25cm+ no pinching + CCC@500ppm
3.	T_3	$S_1P_0G_2$	20cm x 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 x 25 cm + pinching +CCC@500ppm
6.	T_6	$S_1P_1G_2$	20cm x 25cm + pinching+ MH @100ppm
7.	T_7	$S_2P_1G_0$	25cm x 25 cm + no pinching + control
8.	T_8	$S_2P_1G_1$	25cm x 25 cm+ no pinching + CCC@500ppm
9.	T_9	$S_2P_1G_2$	25cm x 25 cm+ no pinching + MH @100ppm
10.	T_{10}	$S_2P_1G_0$	25cm x 25 cm+ pinching + control
11.	T_{11}	$S_2P_1G_1$	25cm x 25 cm+ pinching + CCC@500ppm
12.	T_{12}	$S_2P_1G_2$	25cm x 25 cm+ pinching+ MH @100ppm

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 S_1 (18.61cm) and S_2 (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., P_1 (17.93cm) whereas the highest plant height was observed in treatment where pinching was not done i.e., P_0 (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 G_0 (21.35cm), followed by MH G_2 (18.16cm) and the lowest plant height was recorded for treatment CCC G_1 (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 S_1 (13.32) and S_2 (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., P_1 (15.58) whereas the minimum number of branches plant^{-1} 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 plant^{-1} 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 plant^{-1} were recorded for treatment S_1P_0 (10.86) and the maximum number of branches plant^{-1} were recorded for treatment S_1P_1 (15.78) which remained statistically at par with S_2P_1 (15.38). The S x 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 x 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 plant^{-1} were recorded for treatment P_1G_1 (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 $S_1P_0G_0$ (10.13) and the maximum number of branches plant^{-1} were recorded for treatment $S_2P_1G_1$ (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 S_1 (53.63) recorded maximum number of leaves plant^{-1}and S_2 (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., P_1 (59.47) whereas the minimum number of leaves plant^{-1} 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 plant^{-1} 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 plant^{-1} were recorded for treatment S_1P_0 (46.92) and the maximum number of leaves plant^{-1} were recorded for treatment S_1P_1 (60.33). The S x G interaction revealed significant results where the minimum number of leaves plant^{-1} 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 x 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 plant^{-1} 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 plant^{-1} were recorded for

treatment $S_1P_0G_2$ (45.20) and the maximum number of leaves plant^{-1} were recorded for treatment $S_2P_1G_1$ (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 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 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 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.

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 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 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 S_2 (66.48) recorded more number of florets per spike than S_1 (60.33). Pinching also revealed significant results where pinched plants P_1 (68.48) produced more number of florets per spike than plants which were not pinched P_0 (58.33). The treatments of growth retardants are also significantly different from each other where the treatment CCC G_1 (68.33) produced more number of flower spikes over control G_0 (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 S_2G_1 (74.53), P_1G_1 (77.93), $S_2P_1G_1$ (82.40) recorded maximum number of florets per spike respectively and the minimum number of florets per spike were recorded in S_1G_0 (55.06), P_0G_0 (52.26), $S_1P_0G_0$ (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**		**18.61**
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**		**18.68**
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**	
	Pinching (P_1)	7.53	8.96	8.00	**8.16**	
	Mean	**6.80**	**7.65**	**7.56**		**7.33**
25 cm x 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 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**	
	Pinching (P_1)	17.63	19.11	17.04	**17.93**	
	Mean	**16.26**	**19.12**	**16.05**		**17.14**
25 cm x 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**
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. 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**	
	Pinching (P_1)	64.53	73.46	59.20	**65.73**	
	Mean	**55.06**	**62.13**	**63.80**		**60.33**
25 cm x 25 cm (S_2)	No pinching (P_0)	58.93	66.66	59.60	**61.73**	
	Pinching (P_1)	66.13	82.40	65.20	**71.24**	
	Mean	**62.53**	**74.53**	**62.40**		**66.48**
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:

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.

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