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Effect of growth retardants on growth and flowering of bougainvillea (*Bougainvillea spectabilis*) cv. Shubra

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ABSTRACT

The present investigation to study the effect of growth regulators on growth and flowering of bougainvillea (*Bougainvillea spectabilis*) was carried out in the Division of Floriculture and Landscaping, IARI, New Delhi during 2012-13. The experiment was laid out in completely randomized block design with 11 treatments, 4 replications and 4 plants per replication. The bougainvilleas were planted in 10 inches pots in the month of July and were pruned back to a uniform height of 10+2 inches. The growth regulators, viz. maleic hydrazide, B-9 and paclobutrazol were applied in the form of foliar spray or drench and were compared with control (Distilled water) and the data were recorded for vegetative and flowering traits. Over a period of 14 weeks, it was observed that there was a significant reduction in plant height, plant spread, internode distance and shoot length with the application of maleic hydrazide followed by drenching with paclobutrazol. Maximum shoot diameter, maximum number of structural branches and maximum flower index was observed when plants were either sprayed or drenched with paclobutrazol.

Key words: B-9, Bougainvillea, Dwarfing, Growth index, Maleic hydrazide, Paclobutrazol

Bougainvillea (*Bougainvillea spectabilis*), a member of family *Nyctaginaceae* is a versatile, evergreen, beautiful plant suitable for tropical and subtropical areas as it provides colour almost throughout the year and requires very less water, therefore, greatly demanded by soft landscape architects for the development of landscapes in urban and peri urban areas. It is grown as shrub, climber, bush specimen, flowering hedge, ground cover, bonsai and pot plant bougainvillea requires full sunshine for blooming as shady situations favors vegetative growth. Shubra is a cultivar of bougainvillea having vigorous growth habit and excellent flowering with beautiful white bracts. This cultivar needs regular pruning (cutting of shoots to reduce plant height and to maintain plant architecture) by a trained person due to its vigorous growth habit. So using this white bracted cultivar for small pots, window sills, balconies or in hanging baskets will increase the maintenance cost due to pruning. Hence, there is a need to look for an alternative which can help in maintaining the plant size. PGRs could be alternatives to frequent pruning on bougainvillea to reduce labor costs as these plant growth retardants helps in retarding plant growth by reducing internodal distance and ultimately inducing dwarfing by reducing plant height. Growth retardants like daminozide, paclobutrazol, chlormequat and dikegulac have been reported effective in controlling plant height in bougainvillea although the effectiveness of growth retardant depends on cultivar (Kobayashi *et al.* 2007, Jain *et al*. 2014). Therefore, the present study was planned with an objective to induce dwarfing in bougainvillea cv. Shubra with the use of growth retardants.

MATERIALS AND METHODS

The present experiment was carried out at the Division of Floriculture and Landscaping at Indian Agricultural Research Institute, New Delhi during 2012-13. The plants of bougainvillea cv. Shubra were planted in 10 inch earthen pots containing potting media consisting of 1 part sand, 2 parts soil and 1 part FYM. The plants were cut back to a uniform height of 10+2 inches and were sprayed or drenched with different concentrations of growth regulators and were compared with control. Freshly prepared growth retardant solutions were either sprayed or drenched at 0, 2, 4, 6, 10 and 14 weeks. The growth retardants combinations used were 1 500 ppm MH-G_1, 2 500 ppm MH-G_2, 5 000 ppm B-9-G_3, 7 500 ppm B-9-G_4, 125 ppm Paclobutrazol-G_5, 250 ppm Paclobutrazol-G_6, 500 ppm Paclobutrazol-G_7, 20 ppm Paclobutrazol-G_8, 30 ppm Paclobutrazol-G_9, 40 ppm Paclobutrazol-G_{10} and Control -G_{11}. Based on previous studies, the plant growth retardants were applied either in the form of soil foliar spray or drench application and the quantity of solution used per pot was 125 ml and 200 ml, respectively. Maleic hydrazide is recommended as a foliar spray for the temporary growth inhibition of various trees,

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shrubs and grasses. Similarly, B-9 (daminozide) is also applied as a foliar spray because it is highly mobile in the plant and will rapidly move from the point of application to all parts of the plant, but if it is applied to the substrate, it breaks down rapidly, however, paclobutrazol can be applied both in the form of drench or foliar spray because it moves in the xylem and slows down vegetative growth by inhibiting gibberellin biosynthesis. The experiment was laid out in Completely Randomized Block Design with 11 treatments, four replications and four plants per replication. Observations were recorded at 0, 2, 6 , 10 and 14 weeks for the vegetative parameters like plant height, plant spread, internode distance, shoot length, shoot diameter, number of branches, while observations for qualitative traits like growth index (Average plant height+ plant spread/2), flower index (rating scale; 1.00=none, 2.00 = slight, 3.00= some, 4.00=moderate, 5.00=heavy), form index (rating scale 1.00=poor, 2.00= fair, 3.00= good, 4.00= excellent) and number of structural branches per plant (> 15 cm in length) and per cent disease incidence were also recorded at 14 weeks. The data were subjected to analysis by using CRD at 5% level of significance.

RESULTS AND DISCUSSION

Analysis of data in the Tables 1-4 showed that that there was significant effect of growth retardants on vegetative and floral traits. For all the traits the data was recorded after 0, 2, 4, 6, 10 and 14 weeks, since the trend of data was similar, therefore, for most of the traits the data is presented at initial stage, i.e. 0 week and final stage, i.e. after 14 weeks.

It is evident from the data presented in Table 1 that the application of growth retardants has significantly reduced the plant height. It was observed that minimum plant height (22.75 cm) was recorded in plants treated with 2 500 ppm maleic hydrazide (G_2) and it was statistically at par with G_1, however, maximum plant height (43.33 cm) was observed in plants sprayed with 5 000 ppm B-9 (G_3) and it was statistically at par G_4, G_5 and G_{11}). Data of duration shows that average maximum plant height (46.55cm) was observed after 14 weeks while minimum plant height (23.75 cm) was observed at 0 week (Fig 1). Interaction data of growth retardants and duration of application shows that application of maleic hydrazide at 2 500 ppm concentration restricted the plant height over a period of 14 weeks (G_2D_3) while minimum plant height (21.50 cm) was recorded in G_5D_1 and was at par with all the treatments at 0 week as well as with treatment combinations, viz. G_5D_2, G_8D_2, G_5D_2, G_6D_2, G_7D_2, G_8D_2, G_7D_3 and G_8D_3. Maximum plant height (69.50 cm) was observed after 14 weeks under control ($G_{11}D_3$) and was at par with G_5D_3 and G_3D_3. The dwarfing of plants may be attributed to the fact that maleic hydrazide act as a sprout inhibitor and therefore, inhibited cell division (Fig 1). However, paclobutrazol inhibited oxidation of ent-kaurene

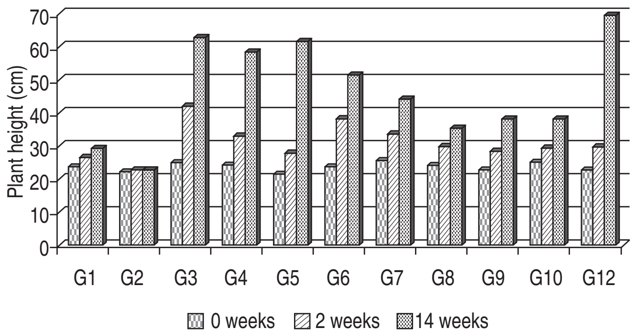

Fig 1 Effect of growth retardants on plant height during different durations

Table 1 Effect of plant growth retardants on plant height and percent increase in plant height of bougainvillea cv. Shubra.

Growth retardant (G)	Plant height (cm) Duration (D)				% increase in plant height Duration (D)		
	0 wk (D_1)	2 wk (D_2)	14 wk (D_3)	Mean	2 wk (D_2)	14 wk (D_3)	Mean
1500 ppm MH (Spray)- G_1	23.75	26.75	29.25	26.58	19.30(4.02)	29.30(5.33)	24.30(4.68)
2500 ppm MH (Spray)-G_2	22.25	23.00	23.00	22.75	10.80(3.29)	10.80(3.29)	10.80(3.29)
5000 ppm B-9 (Spray)-G_3	25.00	42.25	62.75	43.33	69.81(8.35)	148.20(11.95)	109.00(10.15)
7500 ppm B-9 (Spray) –G_4	24.25	33.00	58.50	38.58	36.64(5.96)	142.10(11.87)	89.37(8.92)
125 ppm Paclobutrazol (Spray)- G_5	21.50	27.75	61.75	37.00	27.77(4.26)	188.26(13.64)	108.02(8.95)
250 ppm Paclobutrazol (Spray)- G_6	23.75	38.50	51.50	37.92	63.80(7.90)	116.75 (10.59)	90.27(9.25)
500 ppm Paclobutrazol (Spray)- G_7	25.50	33.75	44.25	34.50	33.63(5.65)	76.52(8.65)	55.07(7.15)
20 ppm Paclobutrazol (drench)- G_8	24.25	30.00	35.25	29.83	24.21(4.84)	45.11(6.72)	34.66(5.78)
30 ppm Paclobutrazol (drench)- G_9	23.00	28.50	38.25	29.92	26.98(4.82)	67.69(8.15)	47.33(6.49)
40 ppm Paclobutrazol (drench)-G_{10}	25.00	29.25	38.00	30.75	20.72(4.30)	52.58(7.01)	36.65(5.65)
Control –G_{11}	23.00	29.75	69.50	40.75	30.52(4.90)	205.39(14.19)	117.95(9.54)
Mean	23.75	31.14	46.55		33.11(5.30)	98.42(9.22)	
CD (P=0.05)							
Growth retardants (G)				5.96			(2.17)
Duration(D)				3.11			(0.92)
G×D				10.32			(3.06)

into ent-kaurenoic acid ultimately inhibited gibberellins synthesis (Rademacher 2000). Earlier Kobayashi *et al.* (2007), Shao *et al.* (2006), Tang *et al.* (2006) and Jain *et al.* (2014), reported that chlormequat, ancymidol and paclobutrazol were effective in slowing bougainvillea growth. Moreover it was observed that the application of daminozide (B-9) resulted in taller plants in coleus and impatiens as compared to untreated/control Barett and Nell (1989), corroborating with our studies in bougainvillea.

Envisage of data in Table 1 reveals that that there was significant effect of growth retardant, duration and their interaction w.r.t. increase in per cent plant height over initial height (at 0 week). Minimum increase in plant height (10.80%) was observed in plants sprayed with 2 500 ppm maleic hydrazide (G_2) and it was statistically at par with G_1. Comparison of different paclobutrazol treatments reveals that drenching the pots with 20 ppm paclobutrazol (G8) resulted in minimum increase in plant height (34.66%) which was statistically at par with G_7, G_9 and G_{10}. Similar to our findings Mansuroglu *et al.* (2009) reported that the application of 500 mg/L paclobutrazol in consolida decreased plant height up to 215.3%. Similarly, Kobayashi *et al.* (2007) reported that paclobutrazol is effective in slowing bougainvillea growth. Effect of different durations of application of growth retardants shows that the minimum per cent increase in plant height (33.11%) was recorded after 2 weeks while maximum increase in plant height (98.42%) was observed over 14 weeks. However, interaction data shows that that minimum increase in plant height (10.80%) was observed after 2 weeks and 14 weeks in plants sprayed with 2 500 ppm maleic hydrazide (G_2D_1 and G_2D_3) and it was statistically at par with G_5D_2, G_7D_2, G_7D_3, G_8D_2, T_5D_2, T_6D_2, G_1D_2, G_1W_5, G_2W_5, G_4D_2 and $G_{11}D_2$.

It is clear from the Table 2 that the maximum plant spread (48.44 cm) was recorded in plants sprayed with distilled water (G_{11}) and was at par with G_5 and G_3, whereas, minimum plant spread (24.50cm) was recorded in plants sprayed with 2 500 ppm maleic hydrazide (G_2) and was statistically at par with T_6 and G_1. Comparison of different durations shows that minimum plant spread (25.46cm) was observed at 0 weeks (D_1) while maximum plant spread (46.60cm) was observed after 14 weeks (D_3). Interaction data shows that there was increase in plant spread in all the treatments over a duration of 14 weeks. After 14 weeks, minimum plant spread (24.13 cm) was recorded in plants sprayed with 2 500 ppm maleic hydrazide (G_2D_3) and was at par with G_5D_1 to $G_{11}D_1$, T6D3 and G_1D_3. The maximum plant spread (72.38 cm) was observed after 14 weeks when the plants were sprayed distilled water ($G_{11}D_3$). Minimum spread was observed in plants treated with 2 500 ppm maleic hydrazide, as maleic hydrazide has inhibitory effect on plant growth. Aldrich and Norcini (1996) reported similar findings in bougainvillea cv. Barbara Karst. However, application of paclobutrazol in bougainvillea in the form of drench resulted in more compact growth (Horowitz 1990, Jain *et al.* 2014).

Data presented in Table 2 indicates that only the durations of application significantly affected the number of branches while application of growth retardants and their interaction with different weeks was found to be non significant. The maximum numbers of branches (20.57) were observed after 14 weeks (D_3) however, minimum numbers of branches (7.05) were observed at 0 week (D_1).

Perusal of data presented in Table 3 indicates that application of growth retardants, application duration and the interaction of growth retardants with duration affected shoot length significantly. Maximum shoot length

Table 2 Effect of plant growth retardants on plant spread and number of branches of bougainvillea cv. Shubra

Growth retardant (G)	Plant spread (cm)			Number of branches		
	Duration (D)			Duration (D)		
	0 wk (D_1)	14 wk (D_2)	Mean	2 wk (D_2)	14 wk (D_3)	Mean
1500 ppm MH (Spray)- G_1	24.25	27.63	7.50	16.00	11.75	13.87
2500 ppm MH (Spray)-G_2	24.88	24.50	6.75	17.25	12.00	14.62
5000 ppm B-9 (Spray)-G_3	27.75	42.81	8.75	20.25	14.50	17.37
7500 ppm B-9 (Spray) –G_4	24.63	40.00	8.00	18.50	13.25	15.87
125 ppm Paclobutrazol (Spray)- G_5	26.00	60.13	43.06	6.25	18.75	12.50
250 ppm Paclobutrazol (Spray)- G_6	28.13	48.63	38.38	6.00	21.50	13.75
500 ppm Paclobutrazol (Spray)- G_7	25.25	40.50	32.88	6.50	23.00	14.75
20 ppm Paclobutrazol (drench)- G_8	24.25	44.25	34.25	9.25	27.25	18.25
30 ppm Paclobutrazol (drench)- G_9	26.50	46.38	36.44	7.00	23.75	15.38
40 ppm Paclobutrazol (drench)-G_{10}	23.88	27.94	5.50	25.50	15.50	20.50
Control –G_{11}	24.50	72.38	48.44	6.00	14.50	10.25
Mean	25.46	46.60		7.05	20.57	
CD 0.05 for						
Growth retardants (G)		8.28			NS	
Duration (D)		3.53			2.06	
G×D		11.72			NS	

Table 3 Effect of plant growth retardants on shoot length, shoot diameter and internode distance of bougainvillea cv. Shubra

Growth retardant (G)	Shoot length (cm)			Internode distance (cm)		
	Duration (D)			Duration (D)		
	0 wk (D_1)	14 wk (D_2)	Mean	0 wk (D_2)	14 wk (D_3)	Mean
1500 ppm MH (Spray)- G_1	15.83	20.71	18.27	1.47	2.05	1.76
2500 ppm MH (Spray)-G_2	17.89	19.77	18.83	1.39	1.71	1.55
5000 ppm B-9 (Spray)-G_3	20.50	60.63	40.56	1.23	2.71	1.97
7500 ppm B-9 (Spray) –G_4	16.75	46.83	31.79	1.82	2.23	2.02
125 ppm Paclobutrazol (Spray)- G_5	19.76	55.13	37.44	1.55	3.45	2.50
250 ppm Paclobutrazol (Spray)- G_6	20.18	42.88	31.53	1.81	4.64	3.22
500 ppm Paclobutrazol (Spray)- G_7	16.07	29.00	22.53	1.72	2.21	1.97
20 ppm Paclobutrazol (drench)- G_8	15.78	31.25	23.51	2.33	1.67	2.00
30 ppm Paclobutrazol (drench)- G_9	14.44	29.45	21.94	1.78	1.78	1.78
40 ppm Paclobutrazol (drench)-G_{10}	16.64	29.15	22.89	1.77	1.55	1.66
Control –G_{11}	16.08	51.83	33.95	2.65	1.89	2.27
Mean	17.26	37.87		1.77	2.35	
CD (P=0.05)						
Growth retardants (G)		8.80			0.87	
Duration (D)		3.75			0.37	
G×D		12.45			1.24	

(40.56 cm) was observed in plants sprayed with 5 000 ppm daminozide (G_3) and was at par with $G_{5,}$ $G_{4,}$ and G_{11}. The minimum shoot length (18.27 cm) was observed when the plants were sprayed with 1 500 ppm maleic hydrazide (G_1) and it was statistically at par with $G_{2,}$ G_7, $G_{8,}$ and G_9. Comparison of duration data shows that after 14 weeks maximum shoot length (37.87 cm) was observed. It was also observed that application of paclobutrazol in the form of soil drench and foliage spray greatly decreased the length of shoots, decreased the number of flowers per plant and increased the number of shoots per plant even at the lowest doses. Karaguzel (1999) also reported that the duration of growth suppression was greater when paclobutrazol was applied in the form of soil drench.

Data presented in Fig 2 shows that applications of growth retardants, duration and interaction was found to be non-significant with respect to shoot diameter.

Data presented in Table 3 shows that application of growth retardants, duration and their interaction have significantly affected the internode distance. The minimum internode distance (1.55cm) was observed in plants sprayed with 2 500 ppm maleic hydrazide (G_2) and was at par with all other treatments except G_5. Analysis of duration data shows that after 14 weeks maximum internode distance (2.35 cm) was observed in cv. Shubra. Interaction data shows that the plants drenched with 40 ppm paclobutrazol (G_{10}) showed minimum internode distance (1.55 cm) after 14 weeks ($G_{10}D_3$) and it was statistically at par with all the treatments except G_5D_3, G_6D_3 and $G_{11}D_1$. However, maximum internode distance (4.64 cm) was observed after 14 weeks when plants were sprayed with 250 ppm paclobutrazol (G_6D_3) and was statistically at par with G_5D_3. Application of the paclobutrazol inhibited the formation of gibberellins; which is responsible for cell elongation, since cell elongation was inhibited, thereby, internode length was reduced. According to Horowitz (1990) application of paclobutrazol in bougainvillea resulted in compact and shortened internodes. Similar, decreasing trends were recorded by Mansuroglu *et al.* (2009) in length and internode length of main inflorescences.

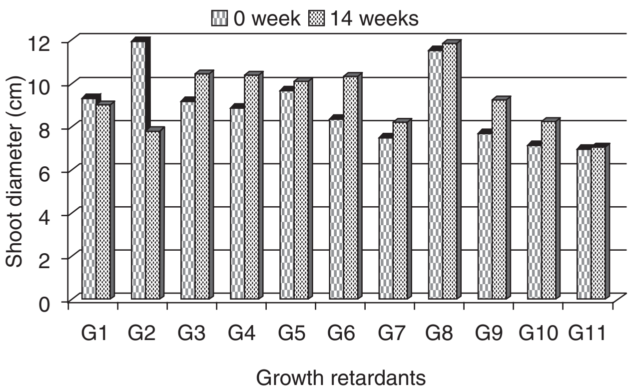

Fig 2 Effect of growth retardants on shoot diameter over 14 weeks duration

It is evident from the Table 4 that the growth retardants significantly affected the number of structural branches, growth index, flower index and form index. However, no significant difference was observed w.r.t. disease incidence. The maximum number of structural branches (9.50 cm) was observed in plants sprayed with 125 ppm paclobutrazol (G_5) and was at par with $G_{3,}$ G_4 and G_{11}. There were no structural branches in the plants sprayed with 1 500 ppm maleic hydrazide (G_1) and 2 500 ppm maleic hydrazide (G_2). The plants sprayed with 2 500 ppm maleic hydrazide (G_2) showed minimum growth index (23.56) and was statistically at par with G_{10} and G_1, whereas, maximum

Table 4 Effect of growth retardants on qualitative traits of bougainvillea cv. Shubra after14 weeks of treatment

Growth retardants	No. of structural branches	Growth index	Flower index	Form index	Disease incidence (%)
1500 ppm MH (Spray)- G_1	0.00	30.13	1.00	2.00	0.00(1.00)
2500 ppm MH (Spray)-G_2	0.00	23.56	1.00	2.00	6.25(2.03)
5000 ppm B-9 (Spray)-G_3	7.25	60.31	2.48	2.25	0.00(1.00)
7500 ppm B-9 (Spray) –G_4	7.00	56.94	1.93	2.50	6.25(2.03)
125 ppm Paclobutrazol (Spray)- G_5	9.50	60.94	2.84	2.25	0.00(1.00)
250 ppm Paclobutrazol (Spray)- G_6	6.50	50.06	3.00	1.75	0.00(1.00)
500 ppm Paclobutrazol (Spray)- G_7	5.00	42.38	2.74	1.50	6.25(2.03)
20 ppm Paclobutrazol (drench)- G_8	2.50	39.75	4.50	2.25	6.25(2.03)
30 ppm Paclobutrazol (drench)- G_9	5.00	42.31	3.24	1.75	0.00(1.00)
40 ppm Paclobutrazol (drench)-G_{10}	3.00	35.00	2.90	1.25	6.25(2.03)
Control –G_{11}	8.25	70.94	2.68	3.00	6.25(2.03)
CD (P = 0.05)	2.60	14.77	1.48	0.64	NS

growth index (70.94) was recorded under control (G_{11}) and was statistically at par with G_4 and G_5. The maximum flower index (4.50) was observed in plants drenched with 20 ppm paclobutrazol (G_8) and was statistically at par with G_7 while minimum flower index (1.00), i.e. no flowering was observed in plants sprayed with maleic hydrazide (G_1 and G_2) and it was statistically at par with G_3 and G_4. The growth of plants was almost inhibited by the application of maleic hydrazide, however, it was at par with the plants which were drenched with paclobutrazol, it means minimum growth was taking place in paclobutrazol treated plants, due to which plants were compact and were showing maximum flowering. Similar observations were recorded by Jain *et al.* (2014) in bougainvillea cv. Mahara and by Karaguzel (1999) in bougainvillea cv. Raspberry Ice, where application of paclobutrazol in the form of soil drench and foliage spray greatly decreased the plant growth and duration of growth suppression was greater when paclobutrazol was applied in the form of soil drench. Steffen *et al.* (1988) reported that the formation of gibberellic acid inhibits flower development in bougainvillea; because of diversion of essential photosynthetic assimilate away from the shoot apex, where the bloom forms (King *et al.* 2000). Since, growth retardants act by inhibiting gibberellins the application of PGRs reduces GA synthesis (Rademacher 2000), which would promote flowering on bougainvillea. Therefore, the increased flowering index for growth retardant treatment could be explained by more photosynthetic assimilates being used in reproductive growth from the shoot apex in treated plants as compared to control. As far as form index is concerned, maximum form index (3.00) was observed under control (G_{11}) and was at par with G_4, however, minimum form index (1.25) was recorded with 40 ppm paclobutrazol drench (G_{10}), and was at par with G_6, G_7 and G_9. Effect of growth retardants was found to be non significant with respect to per cent disease incidence, however no disease incidence was observed under treatments G_1, G_3, G_5, G_6, and G_9. Use of growth retardants like paclobutrazol, daminozide reduce the occurrence of diseases incidence because retardants, blocking gibberelic acid pathway. A secondary pathway leading off the GA pathway produces the building blocks used by fungi. Paclobutrazol act similarly as sterol biosynthesis inhibitor class of fungicides (SBIs). Paclobutrazol block that pathway, so the essential chemicals needed by fungi to grow aren't available and disease incidence is reduced (Whipker 2013).

In bougainvillea cv. Shubra, application of maleic hydrazide inhibited the plant growth, thereby showed minimum plant height, number of structural branches and no flowering, whereas application of paclobutrazol @ 20 ppm in the form of drench resulted in maximum reduction in plant height, shoot length, internode distance. However, drench application of paclobutrazol @ 30 ppm resulted in highest growth flower index as compared to other treatments. On the contrary, application of 5 000 ppm daminozide resulted in increased plant height, plant spread and number of branches and moderate flowering index. Therefore, drenching the plants with 20 ppm or 30 ppm paclobutrazol is effective for inducing the dwarfing and production of floriferous plants.

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