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Induction of dwarfing in bougainvillea cv Mahara by use of growth regulators

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ABSTRACT

Bougainvillea (*Bougainvillea spectabilis*) is a very popular evergreen landscape plant in tropical and subtropical areas. Because of the vigorous growth habit, bougainvillea needs a lot of labor-intensive pruning when being used as a potted plant. PGRs could be alternatives to frequent pruning on bougainvillea to reduce labor costs. But, little research has been carried out on the use of plant growth retardants (PGRs) for controlling the growth and flowering. The present investigations were carried out to study the effect of growth regulators mainly; paclobutrazol, daminozide and maleic hydrazide on bougainvillea cv Mahara to induce dwarfing. The experiment was laid out in completely Randomized Block Design with 11 treatments and four replications. The rooted cuttings of bougainvillea were planted on 7 July 2012 in earthen pot (10" diameter) containing potting media consisting of sand: soil: FYM in a ratio of 1:2:1. The plants were pruned to a uniform height of 10±2 inches on 3rd September 2012. The growth regulators were applied in the form of foliar spray or drench and data was recorded for vegetative and flowering traits. After 14 weeks, it was observed that there was a significant reduction in plant height and plant spread when paclobutrazol was applied in the form of spray or drench. However, application of maleic hydrazide inhibited the plant growth, on the contrary increased plant height and plant spread over control (Distilled water spray) was observed with 5000 ppm Daminozide (B-9) application. Drench application of paclobutrazol @30 ppm resulted in highest flower index as compared to other treatments.

Key words: Daminozide, Dwarfing, Flower index, Growth index, Internode distance, Maleic hydrazide, Paclobutrazol

Bougainvilleas (*Bougainvillea spectabilis*) are very versatile plants and they provide colour to the gardens when the flowering of winter season annuals ceases and the blooming of summer annuals or other ornamental plants is yet to arrive. The plants can be grown as climbers by training them on walls of a house or any building, decoration of houses, institute, hotels, temples, schools, colleges, hospitals, parks, farm gardens, open spaces and on arches or pergola or on a tree. Bougainvilleas are in great demand by soft landscape architects, for development of home gardens, factory gardens, municipal gardens, multinational companies, indoor and outdoor landscape, slopes of river bank, sides of railway track, railway station, airport surroundings, and historical monuments. They can be grown as shrubs in the garden along a boundary wall or in front of ugly spot, as bush specimen in a corner of the lawn, developed into a compact thorny impenetrable flowering hedge, as ground cover on slopes and mounds in the garden. They look very attractive when developed and trained as a standard. Its use as an attractive pot plant is universally known. It belongs to family Nyctaginaceae and is a very important plant for landscape purpose as it requires minimum maintenance. Bougainvillea requires full sunshine for blooming as shady situations favors vegetative growth. Mahara is a very prominent cultivar of bougainvillea having vigorous growth habit and excellent flowering with beautiful magenta. In order to use this variety for small pots, window sills, balconies or in hanging baskets but due to vigorous growth habit of this cultivar, there will be need of regular pruning (cutting of shoots to reduce plant height and to maintain plant architecture) by a trained person, which will increase the maintenance cost .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).

Therefore, the present studies were conducted on bougainvillea cv Mahara, because Mahara is a vigorous, recurrent and profuse flowering, double bracted cultivar

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which requires lots of pruning if grown as potted plant or in hanging baskets. Therefore, the present study was planned with an objective to induce dwarfing in bougainvillea cv Mahara 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 rooted cuttings of bougainvillea were planted in earthen pots of 10 inch diameter during the month of July. The potting media was containing 1 part sand, 2 parts soil and 1 part FYM. On 3 September 2012, the plants were cut back to a uniform height of 10±2 inches. On 9 September the plants were sprayed with different concentrations of growth regulators, based on the past studies. Freshly prepared growth retardant solutions were sprayed at 0, 2, 4, 6, 10 and 14 weeks. The concentrations of growth retardants was used, viz 125 ppm paclobutrazol spray (T_1), 250 ppm paclobutrazol spray (T_2), 500 ppm paclobutrazol spray (T_3), 20 ppm paclobutrazol drench (T_4), 30 ppm paclobutrazol drench (T_5), 40 ppm paclobutrazol drench (T_6), 1500 ppm maleic hydrazide spray (T_7), 2500 ppm maleic hydrazide spray (T_8), 5000 ppm daminozide (B-9) spray (T_9), 7500 ppm daminozide spray (B-9) (T_{10}), double distilled water spray (T_{11}). The quantity of growth regulator solution used was 125 ml in case of foliar spray and 200 ml in case of drench.

Based on previous studies, the plant growth retardants were applied either in the form of soil drench or foliar spray application. Since, paclobutrazol is a xylem plant growth regulator can be applied both in the drench or foliar spray form as it slows down vegetative growth by inhibiting gibberellin biosynthesis. Daminozide is also applied as a foliar spray because it's rapidly broken down when applied to the substrate. It is highly mobile in the plant and will rapidly move from the point of application to all parts of the plant. Similarly, maleic hydrazide is recommended as a foliar spray for the temporary growth inhibition of various trees, shrubs and grasses. The experiment was laid out in Completely Randomized Block Design with 11 treatments and four replications. Observations for plant height, plant spread, internode distance, shoot length, shoot diameter, number of branches were recorded at 0, 2, 6 , 10 and 14 weeks. 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 percent disease incidence were also recorded. The data were subjected to analysis by using CRD at 5% level of significance.

RESULTS AND DISCUSSION

Analysis of data in the Tables 1-5 showed that that there was significant effect of growth retardants on vegetative and floral traits.

It is evident from the data presented in Table 1 indicates that application of growth retardants have significantly reduced the plant height. Minimum plant height (24.75 cm) was recorded in plants treated with 2500 ppm maleic hydrazide (T8) and it was statistically at par with T_5 and T_6. The maximum plant height (62.75 cm) was observed in plants sprayed with 5000 ppm Daminozide (T_9) and it was statistically at par with T_4 and T_{11}. Interaction data shows that application of maleic hydrazide at 2500 ppm concentration arrested the plant height. However, application of 40 ppm paclobutrazol in the form of drench (T_6) showed maximum reduction in plant height in 0-14 week duration. Since, maleic hydrazide is a sprout inhibitor and herbicide, therefore, acts by inhibiting cell division in plants. However, paclobutrazol is a compound having N-containing heterocycle, which block cytochrome P450-dependent mono-oxygenases, thereby, inhibiting oxidation of ent-kaurene into ent-kaurenoic acid ultimately inhibit gibberellins synthesis (Rademacher 2000). It was reported that chlormequat, ancymidol and paclobutrazol were reported effective in slowing bougainvillea growth (Kobayashi *et al.* 2007, Shao *et al.* 2006, Tang *et al.* 2006). Application of 500 mg/L paclobutrazol decreased plant height of Consolida up to 215.3% (Mansuroglu *et al*. 2009). On the contrary, it was observed that the application of daminozide in the form of spray (5000 ppm) resulted in maximum (83.75 cm) plant height after 14 weeks (T_9W_5) and it was at par with control. Similarly, Barett and Nell (1989) observed that the application of daminozide in coleus and impatiens resulted in taller plants as compared to untreated/control.

Comparison of per cent plant height increase over initial height (at 0 week) reveals that there was significant effect of treatment with growth retardant, weeks and their interaction (Table 1). Comparison of growth retardants indicates that minimum increase in plant height (9.27%) was observed in plants sprayed with 2500 ppm maleic hydrazide (T_8) and it was statistically at par with 30 and 40 ppm paclobutrazol drench application (T_5 and T_6). Since maleic hydrazide and paclobutrazol prevent gibberllin synthesis, therefore minimum increase or maximum percent reduction in plant height was observed with both the chemicals. Similarly, Kobayashi *et al.* (2007) reported that paclobutrazol is effective in slowing bougainvillea growth. When the effect of different weeks was studied, it was observed that minimum percent increase in plant height (39.66%) was recorded after 2 weeks, and was significantly superior over all the treatments while maximum increase (136.44%) was observed over 14 weeks period and was at par with 6 and 10 weeks. However, maximum increase in plant height (223.19%) was recorded under control and was at par with T_9 and T_{10}. Interaction data shows that that minimum increase in plant height (5.38%) was observed after 2 weeks in plants sprayed with 2500 ppm maleic hydrazide (T_8W_2) and it was statistically at par with T_1W_2, T_2W_2, T_3W_2, T_5W_2, T_6W_2, T_9W_2, $T_{10}W_2$, $T_{11}W_2$, T_3W_3, T_6W_3, T_7W_3, T_8W_3, T_9W_3, T_5W_4, T_6W_4, T_7W_4, T_8W_4, T_5W_5, T_6W_5, T_7W_5 and T_8W_5.

Table 1 Effect of plant growth regulators on plant height and percent increase in plant height of bougainvillea cv Mahara

Treatment	Plant height (cm)						Percent increase in plant height				
	0 wk (W_1)	2 wk (W_2)	6 wk (W_3)	10wk (W_4)	14 wk (W_5)	Mean	2 wk (W_2)	6 wk (W_3)	10 wk (W_4)	14 wk (W_5)	Mean
T_1 125 ppm Paclobutrazol	22.00	23.50	42.25	46.50	47.25	36.30	14.45	92.57	112.16	115.60	83.69
T_2 250 ppm Paclobutrazol	23.00	34.00	51.25	56.50	57.25	44.40	53.19	129.33	154.94	158.15	123.90
T_3 500 ppm Paclobutrazol	24.25	32.75	42.00	47.00	48.00	38.80	33.19	69.55	89.80	94.00	71.63
T_4 20 ppm Paclobutrazol (Drench)	21.50	42.25	67.00	76.75	78.00	57.10	100.25	215.02	259.51	265.12	209.97
T_5 30 ppm Paclobutrazol (Drench)	22.25	24.25	28.50	31.25	31.75	27.60	17.29	30.25	42.67	44.87	33.77
T_6 40 ppm Paclobutrazol (Drench)	21.50	23.75	26.50	27.75	28.25	25.55	12.66	22.33	28.14	30.26	23.35
T_7 1500 ppm Maleic Hydrazide	22.00	34.50	37.00	37.00	37.00	33.50	55.25	66.52	66.51	66.52	63.70
T_8 2500 ppm Maleic Hydrazide	23.00	24.25	25.50	25.50	25.50	24.75	5.38	10.57	10.57	10.57	9.27
T_9 5000 ppm Daminozide (B-9)	23.50	42.00	81.75	82.75	83.75	62.75	80.14	246.91	251.19	255.46	208.42
T_{10} 7500 ppm Daminozide (B-9)	23.75	30.25	62.00	63.50	64.50	48.80	29.54	158.41	164.93	169.05	130.48
T_{11} Distilled Water (control)	20.50	27.25	76.50	78.00	79.00	56.25	34.98	280.14	286.35	291.27	223.19
Mean	22.48	30.80	49.11	52.05	52.75		39.66	120.14	133.34	136.44	
CD (P=0.05)											
Treatments (T)	7.99						42.38				
Weeks (W)	5.39						25.55				
(T×W)	17.87						84.75				

It is clear from the Table 2 that the maximum plant spread (46.75 cm) was recorded in plants sprayed with 5000 ppm daminozide (T_9) and was at par with T_2 and T_{11}, whereas minimum plant spread (24.80 cm) was recorded in plants sprayed with 2500 ppm maleic hydrazide (T_7) and was statistically at par with T_6 (40 ppm paclobutrazol drench application). Interaction data indicates that there was increase in plant spread in all the treatments over a duration of 14 weeks. After 14 weeks, minimum plant spread (25.75 cm) was recorded in plants sprayed with 2500 ppm maleic hydrazide (T_8W_5) and it was statistically at par with T_5W_5, T_6W_5 and T_7W_5. The maximum plant spread (61.88 cm) was observed after 14 weeks (W_5) and was at par with W_3 and W_4. When the plants were sprayed with 5000 ppm daminozide (T_9W_5) and it was statistically at par with (T_4W_5). It is evident from the data that minimum growth was observed in plants treated with maleic hydrazide, as maleic hydrazide has inhibitory effect on plant growth. Similar were the findings of Aldrich and Norcini (1996) in bougainvillea cv Barbara Karst. Application of paclobutrazol in bougainvillea in the form of drench resulted in more compact growth (Horowitz 1990). Application of growth retardants significantly affected the number of branches while effect of weeks and interaction between treatment and weeks was found to be non-significant (Table 2). The maximum number of branches (14.65) was observed in plants sprayed with 7500 ppm daminozide and it was statistically at par with all the treatments except T_5, T_8 and T_9; while minimum number of branches (5.75) were recorded in plants sprayed with 2500 ppm maleic hydrazide (T_8).

The data presented in Table 3 indicates that application of growth retardants affected shoot length and shoot diameter significantly. Maximum shoot length (49.95 cm) was observed under control and it was at par with T_9. The minimum shoot length (17.59 cm) was observed when the plants were drenched with 40 ppm paclobutrazol (T_4) and was at par with T_5, T_7 and T_8. The week data shows that maximum shot length (34.92 cm) was recorded after 14 weeks (W_5) sprayed with 1500 ppm maleic hydrazide (T_7W_5) and it was statistically at par with T_5, T_7 and T_8. Interaction data shows that minimum shoot length (19.15 cm) was observed after 14 weeks in plants drenched with 40 ppm paclobutrazol (T_6W_5) and it was statistically at par with T_2W_5, T_3W_5, T_5W_5, T_6W_5 and T_8W_5. Maximum shoot length (63.83 cm) was recorded under control ($T_{11}W_5$) and was statistically at par with (T_9W_5). It was observed that maximum average shoot diameter (10.10 cm) was observed in plants drenched with 20 ppm paclobutrazol (T_4) and was statistically at par with T_{10}, however minimum average shoot diameter (5.49 cm) was recorded in plants sprayed with 500 ppm paclobutrazol and was at par with T_2. The effect of weeks and interaction between growth retardants

Table 2 Effect of plant growth regulators on plant spread and number of branches of bougainvillea cv Mahara

Treatment	Plant spread (cm)						Number of branches					
	0 wk (W_1)	2 wk (W_2)	6 wk (W_3)	10 wk (W_4)	14 wk (W_5)	Mean	0 wk (W_1)	2 wk (W_2)	6 wk (W_3)	10 wk (W_4)	14 wk (W_5)	Mean
T_1 125 ppm paclobutrazol	26.38	30.75	42.25	49.25	50.13	39.75	2.25	11.25	16.50	16.50	16.50	12.60
T_2 250 ppm paclobutrazol	21.50	26.50	33.50	38.88	39.88	32.05	5.25	13.00	15.50	15.50	15.50	12.95
T_3 500 ppm paclobutrazol	23.38	25.88	34.38	38.00	39.00	32.13	4.00	11.75	17.75	17.75	17.75	13.80
T_4 20 ppm paclobutrazol (Drench)	25.88	30.63	48.25	53.50	54.25	42.50	3.75	15.00	17.75	17.75	17.75	14.40
T_5 30 ppm paclobutrazol (Drench)	27.13	29.00	30.50	32.00	32.33	30.19	4.25	11.25	13.50	13.50	13.75	11.25
T_6 40 ppm paclobutrazol (Drench)	24.88	25.50	29.75	30.63	30.88	28.33	1.50	15.75	18.00	18.00	18.00	14.25
T_7 1500 ppm maleic hydrazide	24.75	30.25	34.75	34.75	34.75	31.85	2.75	13.75	17.75	17.75	17.75	13.95
T_8 2500 ppm maleic hydrazide	23.63	23.13	25.75	25.75	25.75	24.80	3.50	5.75	6.50	6.50	6.50	5.75
T_9 5000 ppm daminozide (B-9)	22.50	28.38	60.00	61.00	61.88	46.75	2.25	12.25	14.75	14.75	14.75	11.75
T_{10} 7500 ppm daminozide (B-9)	22.75	24.75	48.63	50.13	50.88	39.43	3.25	16.00	18.00	18.00	18.00	14.65
T_{11} Distilled water (control)	22.88	26.63	58.83	59.83	60.67	45.76	2.50	14.00	16.25	16.25	16.25	13.05
Mean	24.15	27.40	40.60	43.06	43.67		3.21	12.71	15.66	15.66	15.68	
CD (P=0.05)												
Treatments (T)	4.61						2.88					
Weeks (W)	3.11						1.94					
(T×W)	10.31						NS					

Table 3 Effect of plant growth regulators on shoot length and shoot diameter of bougainvillea cv Mahara

Treatment	Shoot length (cm)						Shoot diameter (cm)					
	0 wk (W_1)	2 wk (W_2)	6 wk (W_3)	10 wk (W_4)	14 wk (W_5)	Mean	0 wk (W_1)	2 wk (W_2)	6 wk (W_3)	10 wk (W_4)	14 wk (W_5)	Mean
T_1 125 ppm paclobutrazol	14.70	25.08	30.23	32.31	32.83	27.03	5.92	6.51	7.50	7.64	7.69	7.05
T_2 250 ppm paclobutrazol	12.22	28.74	27.42	29.76	31.64	25.95	5.65	6.60	6.85	7.32	7.52	6.79
T_3 500 ppm paclobutrazol	13.22	23.70	24.33	28.04	29.02	23.66	5.23	5.20	5.36	5.81	5.86	5.49
T_4 20 ppm paclobutrazol (Drench)	17.13	30.85	39.33	43.19	43.63	34.83	9.29	9.24	9.59	11.17	11.24	10.10
T_5 30 ppm paclobutrazol (Drench)	17.35	22.44	23.91	25.15	25.36	22.84	6.74	6.98	7.45	7.02	7.07	7.05
T_6 40 ppm paclobutrazol (Drench)	14.45	17.34	17.56	19.19	19.42	17.59	6.46	7.32	7.23	7.20	7.26	7.09
T_7 1500 ppm maleic hydrazide	14.62	19.31	19.15	19.15	19.15	18.27	7.66	7.73	7.77	7.88	7.93	7.79
T_8 2500 ppm maleic hydrazide	15.12	20.00	20.26	17.06	20.27	18.54	8.07	8.65	8.80	8.42	8.46	8.48
T_9 5000 ppm daminozide (B-9)	15.13	41.63	54.13	55.25	56.09	44.44	8.47	8.55	6.76	8.78	8.82	8.27
T_{10} 7500 ppm daminozide (B-9)	15.02	30.35	40.88	42.34	42.86	34.29	9.17	8.46	8.58	9.23	9.29	8.94
T_{11} Distilled water (control)	17.59	43.05	62.10	63.20	63.83	49.95	7.38	7.71	6.98	8.23	8.31	7.72
Mean	15.14	27.50	32.66	34.06	34.92		7.28	7.54	7.53	8.06	8.13	
CD (P=0.05)												
Treatments (T)	5.68						1.38					
Weeks (W)	3.83						NS					
(T×W)	12.70						NS					

and weeks were found to be non-significant. 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 and concentrations. It was found that the duration of growth suppression was greater when paclobutrazol was applied in the form of soil drench (Karaguzel 1999).

Data presented in Table 4 shows that application of growth retardants have significantly affected the internode distance. The minimum internode distance (0.88 cm) was observed in plants drenched with 40 ppm paclobutrazol (T_6) and was significantly superior over all other treatments while maximum internode distance (2.83 cm) was observed under control (T_{11}) and was statistically at par with T_9. Interaction data shows that the plants drenched with 40 ppm paclobutrazol showed minimum internode distance (0.62 cm) after 14 weeks (T_6W_5) and it was statistically at

Table 4 Effect of plant growth regulators on internode distance and stem diameter of bougainvillea cv Mahara

Treatment	Internode distance (cm)						Stem diameter (cm)					
	0 wk (W_1)	2 wk (W_2)	6 wk (W_3)	10 wk (W_4)	14 wk (W_5)	Mean	0 wk (W_1)	2 wk (W_2)	6 wk (W_3)	10 wk (W_4)	14 wk (W_5)	Mean
T_1 125 ppm paclobutrazol	1.99	1.99	1.46	1.38	1.47	1.65	14.90	13.24	11.95	10.10	10.15	12.06
T_2 250 ppm paclobutrazol	1.66	1.84	1.44	1.24	1.27	1.49	12.46	12.82	13.04	15.02	15.05	13.68
T_3 500 ppm paclobutrazol	1.89	2.30	1.03	1.28	1.35	1.57	10.72	10.17	9.77	8.06	8.17	9.38
T_4 20 ppm paclobutrazol (Drench)	2.30	1.46	0.87	1.08	1.06	1.35	15.98	14.90	15.21	16.60	16.64	15.86
T_5 30 ppm paclobutrazol (Drench)	2.37	1.29	0.89	0.94	1.05	1.31	9.65	10.97	9.67	9.91	9.97	10.03
T_6 40 ppm paclobutrazol (Drench)	1.60	1.11	0.54	0.56	0.62	0.88	13.24	10.95	10.96	14.12	14.19	12.69
T_7 1500 ppm maleic hydrazide	1.28	1.76	1.91	1.91	2.01	1.77	18.00	15.74	16.33	15.57	15.59	16.24
T_8 2500 ppm maleic hydrazide	1.75	1.92	2.26	2.45	2.46	2.16	14.15	14.12	13.91	15.74	15.81	14.75
T_9 5000 ppm daminozide (B-9)	1.25	2.55	2.89	2.99	3.09	2.55	12.66	12.38	13.42	15.03	15.07	13.71
T_{10} 7500 ppm daminozide (B-9)	1.40	1.93	2.29	2.23	2.41	2.05	14.29	15.85	16.10	15.54	15.57	15.47
T_{11} Distilled water (control)	2.13	2.91	2.97	3.03	3.09	2.83	12.78	11.88	10.92	14.40	14.45	12.89
Mean	1.78	1.91	1.68	1.73	1.81		13.53	13.00	12.84	13.64	13.70	
CD (P=0.05)												
Treatments (T)	0.34						2.57					
Weeks (W)	NS						NS					
(T×W)	0.75						NS					

par with T_1W_5, T_2W_5, T_3W_5, T_4W_5 and T_5W_5. The possible reason of reduced internode distance may be attributed to the fact the application of the paclobutrazol inhibited the formation of gibberellins; which are responsible for the 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 in length and internode length of main inflorescences with the reduction rates of 214.8% and 184.6%, respectively (Mansuroglu *et al.* 2009).

It is evident from the Table 5 that growth retardants significantly affected the number of structural branches, growth index and flower index. However, no significant difference was observed w.r.t. form index and disease incidence. The maximum number of structural branches (9.00 cm) was observed in plants sprayed with 5000 ppm daminozide T_9 and was statistically at par with T_{10}. However the plants sprayed with 2500 ppm maleic hydrazide (T_8) did not show any structural branches and it was statistically at par with T_6 and T_7.The plants sprayed with 2500 ppm maleic hydrazide (T_8) showed minimum growth index (25.62) and was statistically at par with T_5, T_6 and T_7, whereas maximum growth index (72.81) was recorded in plants sprayed with 5000 ppm daminozide (T_8) and was statistically at par with T_4 and $T_{11.}$ The maximum flowering index (4.50) was observed in plants drenched with 30 ppm paclobutrazol (T_5) and was statistically at par with T_1, T_2, T_3, T_4 and T_6 while minimum flowering index (1.00), i e no flowering was observed in plants sprayed with maleic hydrazide (T_7 and T_8) and it was statistically at par with $T_{10.}$ The growth of plants was almost inhibited by the application

Table 5 Effect of growth retardants on qualitative traits of bougainvillea cv Mahara after 14 weeks of treatment

Treatment	Growth regulators	Number of structural branches	Growth index	Flower index	Form index	% disease incidence
T_1	125 ppm paclobutrazol	5.50(2.53)	48.68	4.00	1.75	0.00(1.00)
T_2	250 ppm paclobutrazol	5.00(2.42)	48.53	3.00	2.25	0.00(1.00)
T_3	500 ppm paclobutrazol	3.25(2.04)	43.50	3.50	2.50	0.00(1.00)
T_4	20 ppm paclobutrazol (Drench)	4.50(2.34)	66.15	3.75	2.00	0.00(1.00)
T_5	30 ppm paclobutrazol (Drench)	3.25(2.04)	32.03	4.50	2.00	6.25(2.03)
T_6	40 ppm paclobutrazol (Drench)	2.75(1.91)	29.56	3.50	2.25	0.00(1.00)
T_7	1500 ppm maleic hydrazide	0.50(1.21)	35.87	1.00	2.25	0.00(1.00)
T_8	2500 ppm maleic hydrazide	0.00(1.00)	25.62	1.00	2.25	0.00(1.00)
T_9	5000 ppm daminozide (B-9)	9.00(3.12)	72.81	2.50	2.50	0.00(1.00)
T_{10}	7500 ppm daminozide (B-9)	8.50(3.06)	57.68	2.25	2.50	0.00(1.00)
T_{11}	Distilled water (control)	5.25(2.37)	69.83	2.75	2.50	6.25(2.03)
	CD (P=0.05)	3.23(0.65)	16.41	1.38	NS	NS

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 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. Formation of gibberellic acid inhibits flower development on bougainvillea (Steffen *et al.* 1988), and it is caused by a diversion of essential photosynthetic assimilate away from the shoot apex, where the bloom forms (King *et al.* 2000). Since, growth retardants act by inhibiting GA, the application of PGR reduces GA synthesis (Rademacher 2000), which would promote flowering on bougainvillea. Therefore, the increased flowering index for PGR treatment could be explained by more photosynthetic assimilates being used in reproductive growth from the shoot apex in treated plants compared to control. The values of form index varied from 1.75 to 2.50, however, the effect of treatments was found to be non-significant. Similarly, effect of growth retardants was also found to be non-significant with respect to percent disease incidence (Table 5), however 6.25% disease incidence was observed under T_5 and control. Use of growth retardants like paclobutrazol, daminozide reduce the occurrence of diseases incidence because retardants, block GA 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).

CONCLUSIONS

The present findings reveals that in bougainvillea cv Mahara, application of maleic hydrazide inhibited the plant growth, thereby showed minimum plant height, number of structural branches and no flowering, whereas application of paclobutrazol @ 40 ppm in the form of drench resulted in maximum reduction in plant height, plant spread, shoot length, internode distance and maximum growth and flowering index, and the comparable results were obtained with 30 ppm paclobutrazol drench. However, drench application of paclobutrazol @30 ppm resulted in highest flower index as compared to other treatments. On the contrary, application of 5000 ppm daminozide (B-9) resulted in increased plant height and plant spread and number of branches and moderate flowering index (Distilled water spray). Therefore, 30 ppm and 40 ppm paclobutrazol drench is effective in the induction of dwarfing and production of floriferous plants.

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