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Influence of Growth Retardants on Dwarfism in Bougainvillea (*Bougainvillea spectabilis*)

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ABSTRACT: Bougainvillea (*Bougainvillea Spectabilis*) is a hardy, evergreen, shrubby vine that belongs to the Nyctanginaceae family. The architecture of the plants themselves is one of the most crucial aspects of landscaping. Bougainvillea require routine pruning by clipping shoots to lower plant height and sustain plant architecture because of their robust growth habits. To keep the plant's size consistent, PGR may be an alternative to frequent trimming. During the academic year 2020–21, a study was conducted at the ASPEE College of Horticulture and Forestry, NAU, Navsari, to determine how growth inhibitors affected the dwarfing and flowering of bougainvillaea (*Bougainvillea spectabilis*). Completely Randomized Design (CRD) was used to set up the experiment, with ten treatments using various dosages of paclobutrazol, cycocel, and daminozide. Three repetitions of the treatments were carried out. The growth retardants were applied as foliar spray at 30, 45, 60 and 75 days after planting of bougainvillea in pot. The results showed that the application of 3000 ppm daminozide followed by cycocel significantly reduced plant height, internode distance and improved plant spread in N-S and E-W direction, number of secondary branches, inflorescence length, number of bracts per inflorescence, bract length and width. While, early blossoming was noticed at 1500 ppm of cycocel, which was followed by daminozide. However, plants sprayed with 3000 ppm Daminozide received an excellent score for their visual appeal on a hedonic scale.

Keywords: *Bougainvillea spectabilis,* cycocel, daminozide, hedonic scale, paclobutrazol.

INTRODUCTION

The genus bougainvillea is a native of tropical and subtropical region of south America (Golby, 1970). Bougainvillea (*Bougainvillea Spectabilis*) is a hardy, evergreen, shrubby vine that belongs to the Nyctanginaceae family (Kobayashi *et al.,* 2007). They are grown all over the world for their beautiful colourful bracts. (Shilpi *et al*., 2016). Due to the high popularity and intense used in the tropical countries, they are called 'Glory of the Tropics' (Pal and Swarup 1974). Bougainvillea is most popular ornamental plant and used for landscaping in various ways. It is tolerant of pollution and draught and perfect for road dividers and landscaping in industrial areas.

Bougainvillea is an essential component of landscaping since it is a hardy attractive plant. The architecture of the plants themselves is one of the most crucial aspects of landscaping. Bougainvillea require routine pruning by clipping shoots to lower plant height and sustain plant architecture because of their robust growth habits. Some cultivars require pruning or shoot cutting to maintain their architectural integrity in order to be used in small pots, window sills, hanging baskets, or balconies, which raises the cost of maintenance. Therefore, finding a replacement for frequent pruning of bougainvillaea is essential to reduce labour costs while also restricting plant growth. Controlling plant size is one of the most important aspects in floricultural crops which can be achieved genetically, environmentally, culturally or chemically (Gopichand *et al.,* 2014; Kumar *et al*., 2015). To keep the plant's size consistent, PGR may be an alternative to frequent trimming. Growth retardants are synthetic compounds and used to retard shoot length of the plant without evoking phyto toxic effects (Jadhav *et al.,* 2015). Foliar spray and soil drench are common and effective application methods of growth retardant application in ornamental plants (Pobudkiewicz and Treder 2006). Most of the PGRs act by inhibiting the gibberellin biosynthesis (Rademacher, 2000). The effectiveness of growth regulators, such as paclobutrazol, daminozide, CCC, and dikedulac, has been found to be useful for controlling plant growth in bougainvillaea, despite the fact that the effectiveness varies depending on cultivar (Kobayashi *et al.,* 2007; Jain *et al.,* 2014; Jain *et al.,* 2016). Reduction of the longitudinal shoot growth of many ornamental plants is achieved through the use of plant growth retardants (Warner and Erwin 2003). Plant growth inhibitors can control plant behaviour to

produce aesthetic pot plants and to enhance the quality and look of plants during marketing (Latimer, 1991). However, species vary in responsiveness to plant growth retardants (Cathey, 1975) and optimum rates may vary with cultivar or growing conditions (Barrett and Bartuska 1982).

In order to cause dwarfing and boost flowering in bougainvillaea, the current study's goal was to do so.

MATERIALS AND METHODS

The current experiment was conducted in *Rabi* (September 2020 – April 2021) at the Floriculture Research Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India. Completely Randomised Design was used to set up the experiment, which had ten treatments totalling three repetitions and varied growth inhibitors at concentrations of 50 ppm Paclobutrazo (T_1), 75 ppm Paclobutrazol (T_2), 100 ppm paclobutrazol (T_3), 1000 ppm CCC (T_4), 1500 ppm CCC (T_5), 2000 ppm CCC (T_6), 2000 ppm Daminozide (T_7), 2500 ppm Daminozide (T_8), 3000 ppm Daminozide (T_9) and control (T_{10}). After the layout was prepared, the plastic pots with media made up of three parts soil, one part vermicompost, and two parts sand were set on the bricks. These pots have a top diameter of 30 cm, a bottom diameter of 22 cm, and a height of 25 cm. On September 24, 2020, red-coloured *Bougainvillea spectabilis* plants that were one year old were planted in containers. At 30, 45, 60, and 75 days after planting, foliar spray applications of freshly made growth retardant solutions were made. At 60- and 90-days following planting, vegetative parameters, including plant height and spread in N-S and E-W directions, were noted. During the blooming phase, it was possible to measure the number of secondary branches per plant, the distance between nodes, and flowering characteristics such inflorescence length, the number of bracts per inflorescence, bract length, bract width, and visual appearance as a pot plant. By using "Analysis of Variance" in accordance with the procedures outlined for Completely Randomized Design as described by Panse and Sukhatme (1985), the data collected for all vegetative and blooming characters were statistically analysed.

RESULTS AND DISCUSSION

A. Vegetative Parameters

Growth retardants had a considerable impact on the vegetative and blooming characteristics of plants, according to an analysis of the data in Tables 1-3.

It is evident from the data presented in Table 1 that the application of growth retardants significantly reduced plant height, internode distance and increase spread of plant and secondary branches. The shortest plant (24.80 cm and 28.40 cm) was noted in plants treated with 3000 ppm Daminozide (T_9) at 60 and 90 DAP, respectively. Whereas, tallest plants (31.12 cm and 37.14 cm) were obtained with T_{10} (control) at 60 and 90 DAP, respectively. Different doses of plant growth inhibitors drastically decreased bougainvillaea plant height. Additionally, synthetic plant growth retardants have been shown to reduce stem elongation, according to Warner and Erwin (2003). Furthermore, growth inhibitors usually cause cells to shrink when present in low concentrations, but when present in higher quantities, they cause shrinkage to grow by delaying cell division (Grossman, 1992). According to Cathey (1964), the reduction in plant height caused by daminozide and cycocel may be attributable to their inhibitory effects on cell division, apical meristematic cell elongation, and the manufacture of gibberellins. Daminozide's inhibition of 3ß-hydroxylation during the late stage (stage 3) of GA prevents the synthesis of GA_3 from sedentary precursors, which lowers plant height (Menhennet, 1980). Bose and Hore (1967) found the same thing with bougainvillaea, followed by Venkatesan *et al.* (2004) with crossandra, Anburani and Vijay (2008) with nerium, Lodeta *et al.* (2010) with poinsettia, and Kapadiya (2017) with Euphorbia milli.

The perusal of data in Table 1 had clearly indicated that the highest spread of plant in the North-South direction (38.77 cm, 42.90 cm) and in the East-West direction (39.40 cm, 44.61 cm) was recorded in plants treated with 3000 ppm Daminozide (T_9) at 60 and 90 DAP, respectively. While, the least spread in the North-South direction (25.67 cm and 27.05 cm) and East-West direction (28.23 cm and 31.21 cm) was noted with control treatment (T_{10}) at 60 and 90 DAP, respectively. A significant improvement in plant spread may be attributable to plant growth inhibitors, which are frequently employed to shorten plant shoots without causing phytotoxic effects. Daminozide and cycocel promote the formation of lateral vegetative buds by inhibiting apical dominance (Cathey and Stuart 1961), which simultaneously increases the number of branches and plant spread. CCC, an inhibitor of gibberellin biosynthesis, prevents the conversion of geranyl-geranyl pyrophosphate to copyallyl pyrophosphate. In order to promote plant spread, reduce plant height and encourage lateral vegetative growth. The results are consistent with past reports on bougainvillaea by Jain *et al.* (2014).

The data in Table 1 revealed that application of 3000 ppm Daminozide (T_9) resulted in maximum number of secondary branches per plant (7.18). Whereas, minimum number of secondary branches (3.03) was reported with control (T_{10}). Gent and McAvoy (2000) claim that plant growth inhibitors can increase the number of branches in ornamental plants. By suppressing apical dominance, plant growth inhibitors increase the number of branches by encouraging the formation of lateral vegetative buds. This may be because less endogenous auxin is produced, which encourages the growth of vegetative buds more (Cathey and Stuart 1961). The findings of the current study are consistent with those of Sen and Maharana (1971); Saikia and Talukdar (1997); Kapadiya (2017) in the case of *Euphorbia milli*.

The data in Table 1 revealed that plants sprayed with 3000 ppm Daminozide (T_9) resulted minimum internode distance (1.27 cm) which was statistically at par with application of 2500 ppm Daminozide (T_8) being 1.30 cm. Whereas, maximum internode distance (1.84 cm) was noted in control (T_{10}). Short internodes have been reported by Cathey (1964), and this

reduction in internodal length may be caused by growth inhibitors that reduce apical dominance totally by preventing cell proliferation and cell expansion of the apical meristem. Internodes are shortened and frequently thickened as a result of the inhibition of meristematic activity and cell elongation (Wirewille and Mitchell 1950). The results are consistent with earlier publications by Pinto *et al*. (2005) on zinnia and Venkatesan *et al.* (2004) on crossandra.

B. Flowering parameter

Early inflorescence initiation (53.98 days) was noted in the plants treated with 1500 ppm CCC (T_5) which was statistically at par with application of 2000 ppm CCC (T_6), 3000 ppm Daminozide (T_9) and 1000 ppm CCC (T_4) i.e., 54.03 days, 54.71 days 55.93 days, respectively as shown in Table 2. While, late inflorescence initiation (61.66 days) was observed in control (T_{10}). The use of cycocel and daminozide may have caused early flowering because these plants first accumulated enough food stores as a result of a decrease in plant height and an increase in the number of leaves and leaf area. Due to the inhibition of gibberellin by daminozide and the restriction of vegetative growth, this reserve food has been utilised for the reproductive phase (Ramesh *et al.*, 2001). Girwani *et al.* (1990) in African marigold, Singh (2004) in rose, Chopde *et al.* (2017) in jasmine and Kumar *et al.* (2019) in nerium all noted a significant influence of growth retardants on early flowering.

The longest inflorescence (26.05 cm) was obtained with foliar application of 3000 ppm Daminozide (T_9) which was statistically at par with application of 2500 ppm Daminozide (T_8), 2000 ppm Daminozide (T_7) and 1500 ppm CCC (T_5) being 25.48 cm, 25.43 cm and 24.00 cm, respectively as shown in Table 2. While, shortest inflorescence (18.27 cm) was reported with control treatment (T_{10}). The increase in the inflorescence length with application of daminozide might be due to increase in number of bracts which check off photosynthates to the flower as consequence of escalation of the sink.

The data in Table 2 revealed that plants sprayed with 3000 ppm Daminozide (T_9) resulted highest number of bracts per inflorescence (55.39) which was statistically at par with application of 2500 ppm Daminozide (T_8) being 54.85 and 1500 ppm CCC (T_5) being 53.59. Whereas, the least number of bracts per inflorescence (38.30) was observed in control (T_{10}). Daminozide and Cycocel may have increased the number of bracts per inflorescence due to the enormous number of axillary shoots that developed after the terminal growth stopped (Gowda and Jayanthi, 1991). After accumulating adequate food stores, plants treated with growth inhibitors produced more photosynthates. The number of bracts per spike increases due to the fast mobilisation of these photosynthates from leaves (source) to flowers (sink). Bose and Hore (1967) in bougainvillaea, Kher (1973) in chrysanthemum, Khandelwal *et al*. (2003) in African marigold, and Kapadiya (2017) in *Euphorbia milli* all reported substantial findings.

Table 1: Effect of plant growth retardants on vegetative characters of bougainvillea (*Bougainvillea spectabilis*).

Treatments	Plant height (cm)		Plant spread (cm)				Number of secondary branches per plant	Internode distance (cm)
			N-S		E-W			
	60 DAP	90 DAP	60 DAP	90 DAP	60 DAP	90 DAP		
T_1: Paclobutrazol 50 ppm	29.17	35.84	29.67	30.65	29.02	31.59	3.87	1.76
T_2: Paclobutrazol 75 ppm	28.17	35.07	30.02	32.21	29.29	32.09	4.19	1.75
T_3: Paclobutrazol 100 ppm	27.97	34.44	30.52	33.30	30.66	33.24	4.48	1.68
T_4: CCC 1000 ppm	27.66	33.70	33.18	36.07	33.72	36.49	4.87	1.56
T_5: CCC 1500 ppm	25.87	29.09	35.16	41.35	36.19	42.13	5.26	1.42
T_6: CCC 2000 ppm	26.78	29.99	37.91	42.23	37.72	42.50	4.99	1.44
T_7: Daminozide 2000 ppm	27.40	33.09	34.27	38.68	34.98	39.10	5.78	1.41
T_8: Daminozide 2500 ppm	26.09	31.29	36.74	41.85	37.35	42.29	6.84	1.30
T_9: Daminozide 3000 ppm	24.80	28.40	38.77	42.90	39.40	44.61	7.18	1.27
T_{10}: Control	31.12	37.14	25.67	27.05	28.23	31.21	3.03	1.84
S.Em.±	0.89	1.03	0.99	1.17	1.16	0.99	0.18	0.04
C.D. @ 5%	2.62	3.05	2.92	3.44	3.41	2.93	0.53	0.13
C.V. %	5.58	5.45	5.16	5.52	5.95	4.58	6.14	4.79

The perusal of data in Table 2 had clearly indicate that the maximum bract length and width (3.56 cm and 2.57 cm, respectively) were recorded in the plants sprayed with 3000 ppm Daminozide (T_9) which was statistically at par with application of 2500 ppm Daminozide (T_8) being 2.46 cm while, minimum bract length and width (3.01 cm and 2.20 cm, respectively) were found in control (T_{10}). The rise in biometric characteristics, such as the maximum number of lateral branches and increased vegetative development in terms of plant spread, may be the cause of the larger bracts and flowers in the plants treated with daminozide. According to Kashid *et al.* (2010), the use of daminozide resulted in a higher number of inflorescences per plant and bracts per inflorescence with larger diameter by promoting source sink relationships and photosynthate transfer toward sink. This is supported by research on bougainvillaea by Bose and Hore (1967), crossandra by Venkatesan *et al.* (2004), *Euphorbia milli* by Kapadiya (2017), and nerium by Kumar *et al.* (2019).

However, flowering duration was not affected due to the application of growth retardants.

The canopy development, branches, plant height, plant spread, inflorescence quality, and plant height and spread ratio all affect how ornamental a potted plant will look. Bougainvillea plants treated with 3000 ppm of Daminozide (T_9) scored extremely well (8.55), followed by 2500 ppm of Daminozide (T_8), which scored 8.49. While untreated plants received the lowest score (3.77) (T_{10}).

A dwarf plant with a healthy plant spread, more branches, the longest inflorescence, more bracts per inflorescence, and enhanced bract size improved the potted bougainvillaea plant's aesthetics. A greater variety of higher-quality flowers improves crop look and draws customers' attention (Kazaz *et al*., 2010).

Table 2: Effect of plant growth retardants on flowering characters of bougainvillea (*Bougainvillea spectabilis*).

Treatments	Initiation of inflorescence (days)	Inflorescence length (cm)	Number of bracts per inflorescence	Bract length (cm)	Bract width (cm)	Duration of flowering (days)
T_1: Paclobutrazol 50 ppm	60.04	20.75	40.12	3.03	2.24	128.56
T_2: Paclobutrazol 75 ppm	59.61	20.97	44.62	3.05	2.29	130.22
T_3: Paclobutrazol 100 ppm	58.72	21.46	46.49	3.11	2.31	131.00
T_4: CCC 1000 ppm	55.93	22.13	50.43	3.13	2.32	132.67
T_5: CCC 1500 ppm	53.98	24.00	53.59	3.27	2.37	125.28
T_6: CCC 2000 ppm	54.03	22.31	50.74	3.21	2.35	125.39
T_7: Daminozide 2000 ppm	58.50	25.43	51.93	3.18	2.39	133.67
T_8: Daminozide 2500 ppm	58.33	25.48	54.85	3.23	2.46	132.67
T_9: Daminozide 3000 ppm	54.71	26.05	55.39	3.56	2.57	137.17
T_{10}: Control	61.66	18.27	38.30	3.01	2.20	125.28
S.Em.±	1.46	0.78	1.16	0.09	0.06	4.83
C.D. @ 5%	4.31	2.29	3.43	0.27	0.17	NS
C.V. %	4.40	5.94	4.14	5.00	4.33	6.43

Table 3: Effect of plant growth retardants on visual appearance of plant as pot plant in *Bougainvillea spectabilis* (Based on hedonic scale 1-9).

Treatments	Visual appearance
T_1: Paclobutrazol 50 ppm	4.96
T_2: Paclobutrazol 75 ppm	5.39
T_3: Paclobutrazol 100 ppm	6.03
T_4: CCC 1000 ppm	7.11
T_5: CCC 1500 ppm	8.47
T_6: CCC 2000 ppm	8.20
T_7: Daminozide 2000 ppm	7.76
T_8: Daminozide 2500 ppm	8.49
T_9: Daminozide 3000 ppm	8.55
T_{10}: Control	3.77

CONCLUSION

Inferences about the foliar application can be drawn from the findings of the current experiment that foliar application of 3000 ppm Daminozide at 30, 45, 60, and 75 days after planting of bougainvillea in pot can be effectively used to retard plant height and improve the quality of flowers with better plant architecture in respect to plant canopy and inflorescence.

FUTURE SCOPE

Controlling plant size is one of the most important aspects in floricultural crops. Bougainvillea is one of the most important ornamental plants for landscaping in various ways. Bougainvillea require routine pruning by clipping shoots to lower plant height and sustain plant architecture because of their robust growth habits. Growth retardant is best alternative for pruning shrubs which make it dwarf, compact and produce more flowers which is beneficial for making best bonsai.

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Conflict of Interest. None.

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