INFLUENCE OF PACLOBUTRAZOL ON THE GROWTH AND FLOWERING OF *Bougainvillea glabra* 'SANDERIANA'

Osman KARAGUZEL Veli ORTACESME
University of Akdeniz, Faculty of Agriculture, Department of Landscape Architecture, Antalya, Turkiye

Abstract

In this study, effects of paclobutrazol on the growth and flowering of *Bougainvillea glabra* 'Sanderiana' under constant day/night (25/15°C) temperatures and natural photoperiods of two growing periods were investigated. For mid summer to late autumn and late autumn to early spring growing periods, 31 and 33 days after pruning, paclobutrazol at 0 (control), 5, 10, 20, 30 and 40 mg/plant were applied as soil drench and foliar spray on 14 July and 16 November, respectively. Slight shortening effects on the time to flowering were observed with 20 mg/plant dose in the soil drench, and 20 and 30 mg/plant doses in foliar spray treatments in only mid summer to late autumn period. Plants grown in late autumn to early spring period needed shorter time to flower with out any effect of treatments. Paclobutrazol reduced branch length with greater effect at increasing doses and soil drench treatments had stronger effect and longer suppressing duration on internodes and branch lengths. The branch numbers increased with foliar sprays, and decreased with soil drench treatments. 5 and 10 mg/plant paclobutrazol increased the flower numbers per plant in each growing period. Also flower numbers was higher in plants grown in late autumn to early spring period, although they had smaller canopy.

Keywords: *Bougainvillea glabra*, paclobutrazol, growth retardant, growth and flowering

Paclobutrazolun *Bougainvillea glabra* 'Sanderiana'nın Büyüme ve Çiçeklenmesi Üzerine Etkileri

Özet

Bu çalışmada paclobutrazolun sabit gündüz/gece sıcaklıkları (25/15°C) ve iki farklı yetiştirme döneminin doğal fotoperiyot koşullarında *Bougainvillea glabra* 'Sanderiana'nın büyüme ve çiçeklenme özelliklerine etkisi araştırılmıştır. Yaz ortası-geç sonbahar ve geç sonbahar-erken ilkbahar yetiştirme dönemleri için, budamalardan 31 ve 33 gün sonra, 14 Temmuz ve 16 Kasım tarihlerinde bitkilere 0 (kontrol), 5, 10, 20, 30 ve 40 mg/bitki dozunda paclobutrazol yapraktan ve topraktan olmak üzere iki farklı yöntemle uygulanmıştır. Paclobutrazol uygulamalarının çiçeklenmeye kadar geçen süre üzerine etkisi sadece yaz ortası-geç sonbahar yetiştirme döneminin doğal fotoperiyot koşullarında ortaya çıkmış ve toprak uygulamalarında 20 mg/bitki, yaprak uygulamalarında ise 20 ve 30 mg/bitki paclobutrazol dozları çiçeklenmeye kadar geçen süreleri sınırlı biçimde kısaltmış, buna karşın geç sonbahar-erken ilkbahar döneminde yetiştirilen bitkilerin uygulamalardan etkilenmeksizin çiçeklenmek için daha kısa sürelere ihtiyaç duydukları gözlenmiştir. Paclobutrazolun doz artışına paralel olarak artan bir etkiyle sürgün uzunluklarını kısalttığı ve toprak uygulamalarının boğum arası ve sürgün uzunlukları üzerinde daha uzun süreli ve güçlü bir kısaltıcı etkiye sahip olduğu saptanmıştır. Bitki başına sürgün sayıları yaprak uygulamalarıyla artmış, toprak uygulamaları ise sürgün sayılarının azalmasına neden olmuştur. 5 ve 10 mg/bitki dozlarındaki paclobutrazol uygulamalarının her iki yetiştirme döneminde de bitki başına çiçek sayılarını artırdığı, ayrıca daha küçük boyutlu olmalarına karşın geç sonbahar-erken ilkbahar döneminde yetiştirilen bitkilerin daha fazla çiçek oluşturduğu belirlenmiştir.

Anahtar Kelimeler: *Bougainvillea glabra*, Paclobutrazol, Büyüme Engelleyici, Büyüme ve Çiçeklenme.

1. Introduction

Bougainvillea glabra 'Sanderiana' with deep purple flowers offers a great potential as flowering pot plant. However, its growth habit is too large and flowering flashes in certain seasons as in the other bougainvillea species and cultivars. So, it is needed to control its excessive vegetative growth and also to stimulate year round flowering for pot culture.

Chemical growth retardants are widely used for manipulating the shape, size and form of floricultural crops (Davis and Andersen, 1989). Growth retardants, inhibitors of GA biosynthesis or action, stimulate flower formation in several woody plants. They are utilized commercially in order to produce compact, sturdy potted and bedding plants, to enhance the green color of the foliage, to strengthen flower stem, and to promote resistance of foliage to environmental stresses (Halevy, 1986).

Older growth retardants chlormequat

and daminozide (Davis and Andersen, 1989) have been used for growth control and flower induction in bougainvillea (Larson, 1985). Norcini et al. (1992) reported that the use of plant growth regulators to control growth and flowering of bougainvillea had met limited success, and responses of bougainvillea to growth retardants showed wide differences depending on the cultivars, compound and day length.

Dierking and Sanderson (1985) found that chlormequat and ancymidol caused 'Rasberry Ice' and San Diego Red' cultivars to flower two weeks earlier than untreated plants under short days, but they had no effect on reducing plant height or increasing shoot numbers. Also, dikegulac inhibited growth and increased branching of same cultivars under short days.

Short photoperiod and B-9 (diaminozide) at 400 ppm as foliar spray were found effective in flowering of *B. glabra* 'Sanderiana' plants raised from cuttings of 7-12 mm thickness and B-9 gave additive effect in increasing flower numbers (Awad et al., 1990).

Paclobutrazol, a triazole derivative, has a significant advantage over older compounds with wider activity even at lowest doses, applicability as foliar spray or soil drench, having no phytotoxic effect at high concentrations, and also stimulating branching and enhancing flowering in some woody ornamentals (Halevy, 1986; Davis et al., 1988; Davis and Andersen, 1989).

However, there are few studies on the effects of paclobutrazol on growth and flowering of bougainvillea species and cultivars. Karaguzel (1999) reported that paclobutrazol as soil drench or foliar spray strongly reduced branch length even at lowest doses and concentrations, slightly shortened the time from application to flowering under decreasing day lengths, and decreased flower number per plant in *B. spectabilis*.

The aim of this study was to determine the effect of paclobutrazol on growth and flowering of *B. glabra* 'Sanderiana' under the constant day/night (25/15°C) temperatures and natural photoperiods of mid summer to late autumn and late autumn to early spring growing periods.

2. Material and Methods

This study was performed in a computerized glasshouse under constant day/night (25/15°) temperatures and two separate experiments described below were conducted during the study.

2.1. Experiment 1

Rooted hardwood cuttings were transplanted in 3-liter (∅=18 cm, h=16,5 cm) pots on 12 May and placed in glasshouse under natural day lengths. On 13 June, 31 days after transplanting, plants having 3 main branches were selected and pruned to two buds and two leaves/branch. When new branches reached to 5-7 cm lengths, paclobutrazol at the doses of 0 (control), 5, 10, 20, 30 and 40 mg/plant was applied on plants as soil drench and foliar spray on 17 July. In the soil drench treatments, the amount of chemical calculated for each dose was drenched in the potting medium with 200 ml tapwater. In foliar spray treatments, 20 ml paclobutrazol solution per plant whose concentration was calculated for each dose was sprayed on plant, covering the top of pots with polyethylene to prevent drench of chemical into potting medium. Control plants were treated with the same amounts of water contained no chemical as soil drench and foliar spray.

2.2. Experiment 2

Rooted softwood cuttings were transplanted in 3-liter (∅=18 cm, h=16,5 cm) pots on 10 September and placed in glasshouse under natural day lengths. On 13 October, 33 days after transplanting, plants having 3 main branches were selected and pruned as in the experiment 1. On 2 November, when new branches reached to 5-7 cm length, the paclobutrazol at the doses of 0 (control), 5, 10, 20, 30 and 40 mg/plant were sprayed on plants as in the experiment 1.

In both experiments, potting medium

(pH=7.1) was composed 3 part of peat, 1 part of sand and 1 part of volcanic tuff by volume. Plants were hand-watered as needed and nutrient solution with 100 ppm N, 50 ppm P, 150 ppm K and complete mixture of microelements were applied 2 weeks intervals throughout the experimental period.

Experiments were set up a completely randomized design for each experiment with tree replications and 10 plants per replicate.

For each experiment, the time from application to flowering, branch length, branch and flower numbers per plant (counting three exact flowers and three colored bracts as one flower) were recorded. In addition, 30, 60, 90 and 120 days after treatments, internode lengths were measured in controls, and 10 mg/plant paclobutrazol was applied as soil drench and foliar spray, wrapping colored plastic taps on the upper points of measured parts to separate measured parts from each other, under natural photoperiods of mid summer to late autumn. Data were subjected to analysis of variance and means were separated using Duncan's multiple range test at 0,05 level.

3. Results

3.1. Experiment 1

Under natural photoperiod of mid summer to late autumn growing period, a slight shortening effect on the time from application to flowering occurred with paclobutrazol at 20 mg/plant in soil drench and 20 and 30 mg/plant in foliar spray treatments, compared to the control plants (Table 1). However, the doses 30 and 40 mg/plant significantly lengthened the time to flowering when applied as soil drench. There were no significant differences in the time from application to flowering between control and other doses regardless the application as soil drench or foliar spray.

Paclobutrazol applied as soil drench or foliar spray significantly reduced branch lengths with greater effect at increasing doses (Table 1). It was also found that reducing of branch length in soil drench treatments was higher than that of in foliar sprays.

Applying paclobutrazol as soil drench reduced branch numbers per plant, and the highest branch numbers were recorded in control plants (Table 1). With increasing

Table 1. Effects of paclobutrazol on the growth and flowering of *B. glabra* 'Sanderiana' under natural photoperiod of mid summer to late autumn growing period.

Treatment	Dose (mg/plant)	Time to flowering (day)	Branch length (cm)	Branches (no.)	Flowers (no.)
Soil drench					
	0	94 bc[z]	100.4 a	16.2 cde	55.6 d
	5	93 bcd	87.6 b	14.8 de	67.8 b
	10	90 cdef	70.8 d	14.3 de	73.2 a
	20	86 f	62.5 e	13.7 ef	43.5 e
	30	109 a	55.2 f	11.4 f	39.6 f
	40	112 a	43.0 g	8.6 g	24.3 g
Foliar spray					
	0	96 b	102.6 a	15.6 de	56.8 d
	5	94 bc	90.4 b	16.7 bcd	63.4 c
	10	92 bcde	78.8 c	18.4 abc	68.3 b
	20	88 ef	67.4 d	19.2 ab	54.5 d
	30	88 ef	60.3 e	19.6 a	53.8 d
	40	90cdef	54.1 f	19.0 ab	55.1 d
	Significance				
	Treatment:	*	*	**	*
	Dose:	***	***	N.S.	***
	Treatment x Dose:	***	*	***	***

[z]: Mean separation within columns by Duncan's multiple range test, at 0.05 level.
N.S., *, **, ***: Non- significant or significant at P< 0.05, 0.01 or 0.001, respectively.

doses, branch numbers per plant decreased and the highest dose (40 mg/plant) resulted in the lowest branch count. In contrast, application of paclobutrazol as foliar spray increased the branch numbers per plant compared to control plants. The first significant increase was observed in the lowest dose (5 mg/plant) and with higher doses, higher and constant branch numbers were recorded in foliar spray treatment regardless the increase in the doses (Table 1).

In the flower numbers per plant, increases were recorded in 5 and 10 mg/plant doses applied as soil drench or foliar spray compared to control plants. The highest flower number was counted in 10 mg/plant dose when applied as soil drench (Table 1). Applying higher doses of paclobutrazol (30 and 40 mg/plant) as soil drench resulted in a sharp and significant decrease in flower numbers, while there were no significance differences in flower numbers between same doses applied as foliar spray and also control plants.

Measurements of internode lengths on the 30, 60, 90 and 120 days after treatments showed slight decreases in the internode lengths in control plants grown under natural photoperiod of mid summer to late autumn growing period (Figure 1). Paclobutrazol (10 mg/plant) applied either as soil drench or foliar spray reduced internode lengths at the beginning, but reducing rates were slightly higher when application was made as soil drench. During 60, 90 and 120 days after treatments, higher reducing effects of soil drench applications continued a long time, so limited increases were measured in internode lengths until the end of 120 days growing period. Internode lengths in foliar spray treatments began to increase sharply 60 days after the application, and reached to about the same internode lengths of control plants at the end of 120 days growing period (Figure 1).

3.2. Experiment 2

Under natural photoperiod of late autumn to early spring growing period, applications of paclobutrazol at increasing doses as soil drench or foliar spray had no

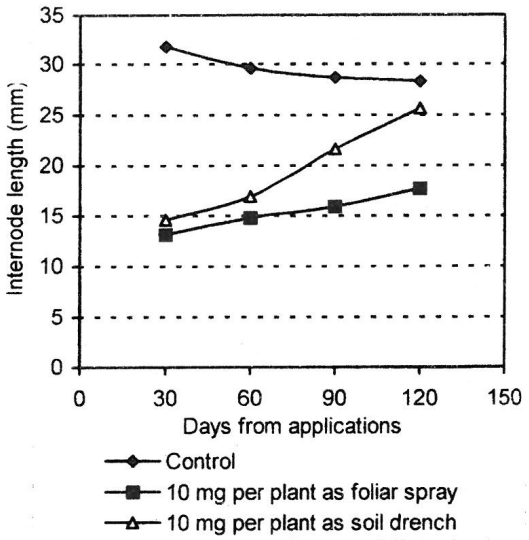

Figure 1. Effect of paclobutrazol (10 mg/plant as soil drench and foliage spray) on internode lengths of *B. glabra* 'Sandariana'.

effect on the time from application to flowering (Table 2). On the other hand, the times needed for flowering were shorter in all plants grown under natural photoperiods of late autumn to early spring growing period than the plants grown under natural photoperiod of mid summer to late autumn growing period (Table 1 and Table 2).

Paclobutrazol significantly reduced branch length with greater effect at increasing doses as in the experiment 1 (Table 2). However, reducing effect was higher in soil drench treatments than foliar sprays.

Effect of paclobutrazol on the branch numbers per plant was similar to the results that were obtained from the experiment 1. While soil drench applications had decreasing effect on the branch numbers per plant, foliar spray treatments increased the branch numbers compared with control (Table 2).

The highest flower numbers per plant was recorded at 5 and 10 mg/plant doses of paclobutrazol applied as soil drench or foliar spray, as in the experiment 1 (Table 2). Higher doses (20, 30 and 40 mg/plant) caused a considerable decrease in flower numbers, when applications were made as soil drench. Decreases in flower numbers were not sharp and considerable in the

Table 2. Effects of paclobutrazol on growth and flowering of *B. glabra* 'Sanderiana' under natural photoperiod of late autumn to early spring growing period.

Treatment	Dose (mg/plant)	Time to flowering (day)	Branch length (cm)	Branches (no.)	Flowers (no.)
Soil drench					
	0	48	33.4 a[z]	8.4 cd	66,7 cd
	5	48	25.4 bc	7.6 cde	70.6 bc
	10	48	16.3 e	6.9 de	74,2 ab
	20	48	12.7 f	6.5 de	54,2 g
	30	48	10.6 fg	6.2 e	46,7 h
	40	48	9.5 g	6.0 e	45,6 h
Foliar spray					
	0	48	34.2 a	8.2 cd	65,5 de
	5	48	27.8 b	9.5 bc	72,3 ab
	10	48	24.1 c	10.7 ab	76,4 a
	20	48	20.9 d	11.2 ab	65,8 de
	30	48	18.2 de	11.4 ab	61,7 ef
	40	48	16.7 e	11.7 a	58,9 f
	Significance				
	Treatment:	N.S.	*	**	**
	Dose:	N.S.	***	N.S.	***
	Treatment x Dose:	N.S.	**	***	***

[z]: Mean separation within columns by Duncan's multiple range test, at 0.05 level.
N.S., *, **, ***: Non-significant or significant at $P< 0.05$, 0.01 or 0.001, respectively.

application of higher doses as foliar spray (Table 2).

Results obtained from experiment 1 and experiment 2 showed that flower numbers per plant was higher in the plants grown under natural photoperiod of late autumn to early spring than those grown under natural photoperiod of mid summer to late autumn. Plants grown under natural photoperiod of late autumn to early spring had shorter branch lengths, lower branch number and finally smaller canopy (Table 1; Table 2).

4. Discussion and Conclusions

Results showed that there was a slight shortening effect of paclobutrazol at certain doses on the time to flowering under only natural photoperiod of mid summer to late autumn growing period. Also, plants grown in late autumn to early spring period flowered earlier. Karaguzel (1999) reported that paclobutrazol had a slight shortening effect on the time from application to flowering in *B. spectabilis* under decreasing day lengths. Dierking and Sanderson (1985) found that chlormequat and ancymidol caused 'Raspberry Ice' and 'San Diego Red' bougainvillea to flower 2 weeks earlier than untreated plants under short days. Criley (1977), however, reported that neither ancymidol and diaminozide nor chlormequat stimulated flowering of 'Carmencita' bougainvillea. On the other hand, short daylengths, high temperatures and light intensity under short photoperiod have been effective factors stimulating and enhancing the flowering of bougainvillea (Criley, 1977; Awad et al., 1990; Norcini et al., 1992).

Paclobutrazol significantly reduced branch length with greater effect at increasing doses and, soil drench treatments were found more effective than foliar sprays. Similar results were mentioned for *B. spectabilis* (Karaguzel, 1999). Strong retarding effect of paclobutrazol on growth and shoot elongation in several woody ornamentals was reported in previous papers (Larson, 1985; Halevy, 1986; Davis and Andersen, 1989; Joustra, 1989; Wilkinson and Richards, 1991; De Baedemaeker et al., 1994). Paclobutrazol, its half life in soil varies considerably but usually between 3 and 12 months, is relatively immobile in soil, and can be easily uptaken via roots (Davis et al., 1989). This may partly be

explained why soil drench of paclobutrazol was more effective in retarding growth compared to foliar spray treatments.

Paclobutrazol increased the number of branches per plant when application was made as foliar spray, while soil drench treatments decreased branch numbers. Acropetally translocation of paclobutrazol can be seen one of the reasons of this opposition. However, there are several studies that found different results. Davis et al. (1988) reported that triazoles had little effect on the shoot numbers per plant in some species but in others shoot number was reduced substantially. Paclobutrazol as soil drench inhibited lateral shoot production in *Plectranthus australis* (Wang and Blessington, 1990) and increased lateral shoot numbers in *Gardenia jasminoides* (De Baerdemaeker et al., 1994). It was also reported that paclobutrazol as soil drench or foliar spray increased the branch numbers in *B. spectabilis* (Karaguzel, 1999).

The doses of paclobutrazol at 5 and 10 mg/plant increased the number of flowers per plant under natural photoperiods of two different growing periods. Previous studies mentioned some opposite results. Wilkinson and Richards (1988) mentioned that paclobutrazol promoted flowering in a broad range of species. His findings showed that paclobutrazol increased the number of flowers in *Camellia x Williamsii* 'Debbie', but decreased in 'Waterlily'. Andrasek (1989) found that paclobutrazol enhanced flowering in *Hibiscus rosa-sinensis*. Karaguzel (1999) stated that paclobutrazol decreased flower number per plant in *B. spectabilis* even in the plants treated with the lowest dose. In the light of previous results, it can be concluded that effects of paclobutrazol on the number of flowers depend largely on the species and cultivars.

In conclusion, the results indicated that a single application of paclobutrazol at 5 and 10 mg/plant doses as soil drench or foliar spray was suitable for controlling excessive vegetative growth and enhancing flowering of *B. glabra* 'Sanderiana'. It was also found that there was no big chance to shorten the time to flowering in this cultivar under either natural photoperiods of mid summer to late autumn or late autumn to early spring growing periods.

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