Pak. J. Bot., 41(5): 2323-2332, 2009.

EFFECT OF PACLOBUTRAZOL ON FLOWERING, LEAF AND FLOWER COLOUR OF *CONSOLIDA ORIENTALIS*

SIBEL MANSUROGLU, OSMAN KARAGUZEL*, VELI ORTACESME AND M. SELCUK SAYAN

Department of Landscape Architecture, Faculty of Agriculture, Akdeniz University, 07070 Antalya, Turkey.

Abstract

Effect of paclobutrazol on flowering characteristics, leaf and flower colour of *Consolida orientalis* (Gay) Schröd., native to South Anatolia (Turkey) was investigated. Seeds were directly sown into soil under unheated greenhouse and natural photoperiod conditions on 17 January and paclobutrazol at concentrations of 0 (control), 125, 250 and 500 mg·L^{-1} was applied to plants as foliar spray, when 5% of plants had elongated first internodes. Paclobutrazol had no significant effect on the time from sowing to flowering. Plant height, length and internode length of main and secondary inflorescences, pedicel length and the number of secondary inflorescence significantly reduced with increasing concentrations of paclobutrazol. Flower number on main inflorescence at concentration of 250 mg·L^{-1}, and stem diameter and flower number on secondary inflorescence at concentration of 500 mg·L^{-1} increased compared with control treatment. Paclobutrazol decreased lightness (L*) and colour saturation (chroma) values of leaves and lightness (L*) of flowers. Plants treated with paclobutrazol had darker green leaves and deeper violet flowers than that of control plants.

Introduction

Turkey is one of the unique countries in the world in terms of plant genetic resources and diversity (Tan, 1998). The rich plant genetic resources have provided raw materials such as primitive land races, wild crop relatives and plant species as new sources to improve agricultural production worldwide. Flora of Turkey is also rich for Ranunculaceae family, particularly the species of genus *Delphinium* L., and *Consolida* (DC.) S.F. Gray (Davis, 1965) that some of them have real potential to be used as raw breeding material or new floricultural crops.

Consolida orientalis (Gay) Schröd. is medium to tall, stickily-hairy annual with simple or branched stems 20-74 cm in length and laciniae numerous and linear-setaceous leaves (Davis, 1965; Blamey & Grey-Wilson, 1998). Flowers are purplish-violet, 18-26 mm, borne in a fairly dense raceme; flower stalks shorter than the lower dissected bracts; spur 10-12 mm long (Blamey & Grey-Wilson, 1998; Burnie, 2000). It is one of *Consolida* species used in cut flower trade as dried and fresh cut flower crops and in bedding plant designs (Armitage, 1995; Brickell & Zuk, 1997; Armitage, 2001). In landscape surveys of Cevizli district (Antalya, South Anatolia, Turkey), a native population of *C. orientalis* was observed with higher plant height, longer main and secondary inflorescences, and higher flower numbers in comparison to samples of *C. orientalis* described previously from Anatolia (Karaguzel *et al*., 2006). Responses of this population to culture conditions including sowing time, growing conditions and photoperiod treatments were investigated (Karaguzel *et al*., 2007; Karaguzel *et al*., 2009). Results of this studies indicated that this native population has a tendency to bending in greenhouse growing and plant height is slightly higher for using in bedding plant design. Breeding the plant for more useful form ought to be the primary goal of a long-term study and previous studies state that a plant growth retardant could be effective for obtaining sturdy plant and reducing plant height in several species without decreasing flowering quality (Larson, 1985; Davis *et al*., 1988; Karaguzel & Ortacesme 2002).

*Corresponding author E-mail: okaraguzel@akdeniz.edu.tr

Paclobutrazol, an inhibitor of gibberellin biosynthesis or action, can significantly retard plant growth and accelerate flowering at certain doses in several woody, perennial and annual plants, such as *Bouwardia humboldtii* Hum., and *Bougainvillea glabra* Choisy (Wilkinson & Richards, 1987; Karaguzel & Ortacesme, 2002), a local variety of *Pelargonium zonale* L. and *Pelargonium x hortorum* L.H. Bailey (Cox, 1991; Nasr, 1995), and *Cosmos bipinnatus* Cav. and *Zinnia elegans* Jacq. (Mohd *et al*., 1988; Chen *et al*., 1993). It is also utilized in order to produce compact, sturdy potted and bedding plants, to enhance the green colour of the foliage, to strengthen flower stem and to promote resistance of foliage to environmental stresses (Halevy, 1986). Although growth reduction effect of paclobutrazol is common, growth reduction percentage, flowering, leaf area and chlorophyll content, flower shape and colour responses of plants to this chemical can vary depending on the dose or concentration, method, site of application, species and cultivar and also growing season (Barrett & Bartuska, 1982; Menhennett, 1984; Heursel & Witt, 1985; Davis *et al*., 1988; Qrunfleh & Suwwan, 1988; Ripka & Szanto, 1988; Davis & Andersen, 1989; Keever & Cox, 1989; Lee & Lee, 1990; Nasr, 1995; Karaguzel, 1999; Banon *et al*., 2002). With respect to the needs of ornamental plant industry, there is limited scientific information on the responses of Ranunculaceae members to paclobutrazol in general and on the response of *C. orientalis* in particular, except a study on *Anemone blanda* Schott & Kotschy which stated that soil drench application of paclobutrazol reduced excessive stem elongation in the warm greenhouse conditions (van Leeuwen & Dop, 1990).

The objective of this study was to investigate the effect of paclobutrazol on flowering characteristics, leaf and flower colour of *C. orientalis* native to South Anatolia under unheated plastic greenhouse and natural photoperiod conditions.

Material and Methods

Plant material: In this study, plants propagated from seeds collected from a native population of *C. orientalis* in Cevizli (altitude 1200 m) district of Antalya province (South Anatolia, Turkey) were used as plant material. Seeds were harvested in July 2001, and non-standard seeds were discarded in the laboratory. The selected seed lots were dusted with captan and stored at room temperature under conditions of relative humidity until sowing dates.

Experimental site and procedures: Experiment was carried out in an unheated plastic greenhouse at the Research and Application Station of the Faculty of Agriculture, Akdeniz University, Antalya, Turkey (36º 53' N, 30º 42' E), between January and May 2002.

Greenhouse soil was a loam having a pH of 7.6, and consisted of 16.4% of $CaCO_3$, 1.6% of organic matter, and 50.2 and 81.7 $mg \cdot kg^{-1}$ of available phosphorus (P) and potassium (K), respectively. The soil was solarized for two months during June and July 2002, and dug 20 cm in depth two weeks before sowing. Then, 12 plots measuring 1.2*0.6 m^{-2} were prepared with 0.5 m distances and they were assigned to four paclobutrazol concentrations with three replicates within completely randomized experimental design (Gomez & Gomez, 1984). Five days before sowing date, the dose of composed fertilizer (15:15:15; N:P:K) at 30 $g \cdot m^{-2}$ was applied to experimental plots and mixed with the soil to a depth of 20 cm on 17 January 2002. Three sowing lines 1.5-2 cm in depth were prepared in each experimental plot with a distance of 20 cm, and 2 g seeds per 100 cm sowing line were sown considering the results of previous germination tests and suggestions for culture lines of *C. orientalis* (Armitage, 1995). On 24 February 2002, seedlings were reduced to ~7.5 cm distances between plants on sowing lines and provided a planting density of 45 plants per square meter, when seedlings reached to 5-7.5 cm height. Plants were watered by hand as needed and grown without applying any additional fertilizer or pesticide during growing period. When 5% of the plants had elongated first internodes, paclobutrazol at concentrations of 0 (control), 125, 250 and 500 mg·L^{-1} was applied to plants as a foliar spray with minimal runoff on 28 March 2002. The concentrations were obtained by diluting a concentrated suspension of paclobutrazol and control plants were sprayed with an equal amount of tap water.

Data collection: Air temperatures and photosynthetically active radiation (PAR, in 400-700 nm) were recorded in the greenhouse during experimental period. Plant heights were measured from 4 April to 2 May at one-week intervals. Days to flower (first 2-5 basal flowers opened on the main inflorescences of 50% of plants) were estimated relative to sowing date. Plant height at flowering (height from soil to top of plant) and stem diameter (10 cm above the soil) were measured on the dates when 90% of flowers on the main inflorescences were opened. At the same growth stage, measurements on length (length from connecting point with stem to the top of inflorescence), diameter (5 cm above the connecting point of inflorescence with stem) and internode length (mean of first tree internode lengths) were made and flower numbers were counted in the main inflorescences. For determining the flower characteristics, pedicel length, corolla diameter and corolla length (including spur) were also measured at the same growth stage. When all flowers of the first three secondary inflorescences opened, secondary inflorescence numbers were counted and data was also gathered on secondary inflorescence length and internode length, diameter and flower number as described for main inflorescences. For the colour measurements, leaf and flower samples were taken in the middle part of stems and main inflorescences when all flowers on the main inflorescences opened. In the measurements, CIELAB L*, a* and b* coordinates were used. Colour coordinates in leaves and corollas were measured with a calibrated Minolta CR-200 colorimeter at mid point of the leaves and corollas. Chroma (colour saturation) was calculated as $(a^{*2}+b^{*2})^{1/2}$ and the hue angle was calculated as (arctan b*/a* in degree).

Data analysis: Data on the changes in the plant heights were plotted with standard error (SE) using Microsoft Excel software. The remaining data relating to the characteristics considered in this study were analyzed by ANOVA using SPSS 9.0 for Windows and means were compared using Duncan's multiple range tests at a significance level of 5%.

Results and Discussion

Plant growth and main inflorescence characteristics: Monthly average greenhouse temperatures and daily total photosynthetically active radiation (PAR, in 400-700 nm) measured in greenhouse in January, February, March and May were 16.8°C and 6.18 mol·m^{-2}·d^{-1}, 18.8°C and 9.09 mol·m^{-2}·d^{-1}, 19.7°C and 10.76 mol·m^{-2}·d^{-1} and 20.5°C and 12.74 mol·m^{-2}·d^{-1}, respectively. Data show that the inhibitory effect of paclobutrazol on plant height could be seen seven days after treatments (in measurement on 4 April) with slight differences between concentrations (Fig. 1). Two weeks after treatments, significant differences were observed in plant height, and plants treated with paclobutrazol continued to grow with shorter plant heights throughout the experimental period compared to control plants with significant differences between concentration at 125 mg·L^{-1} and concentrations at 250 and 500 mg·L^{-1} (Fig. 1).

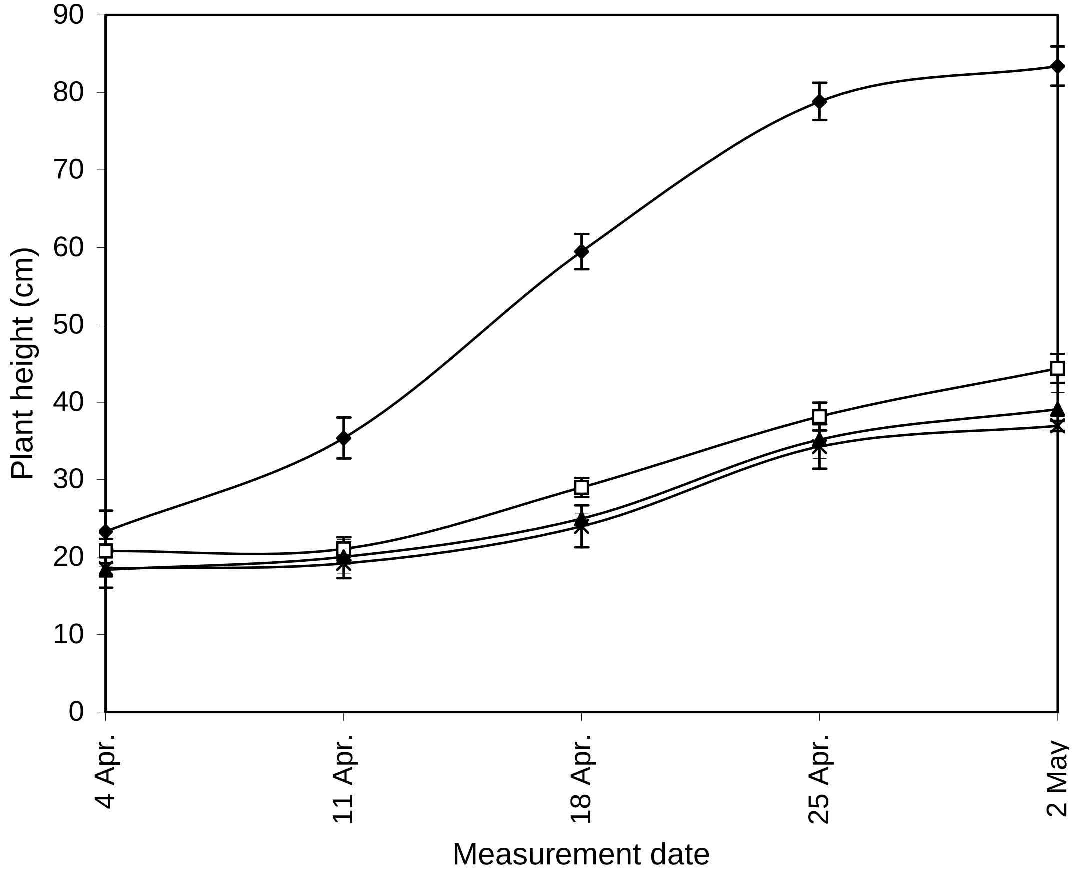

Fig. 1. Effects of paclobutrazol on plant height in *C. orientalis* [Control (◆), 125 mg·L^{-1} (□), 250 mg·L^{-1} (▲), 500 mg·L^{-1} (×)]. Vertical bars represent standard error ($_{SE}$) when larger than the symbols.

The ANOVA results showed no significant effect (*P*=0.952) induced by paclobutrazol treatment on days to flower and plants treated with different paclobutrazol concentrations flowered within 90.7or 91.3 days after sowing (Table 1). Previous studies reveal that the days to flower responses of plant species and cultivars to paclobutrazol are quite different. Paclobutrazol did not affect days to flowering in *Episcia cupreata* (Hook.) Hanst. 'Pink Panther', *P. x hortorum* 'Tours Truly' and *Angelonia angustifolia* Benth. (Stamps & Henny, 1986; Tayama & Carver, 1990; Miller & Armitage, 2002). Ecker *et al*., (1992) found that while the time to flowering in *Matthiola incana* (L.) R. Br. 'Lavender' increased with increasing paclobutrazol concentrations; flowering time of 'Midget-Red' was not affected. In contrast, paclobutrazol reduced the time to flowering in *P. zonale* and promoted early flowering in *Z. elegans* (Chen *et al.*, 1993; Nasr, 1995).

Foliar sprays of paclobutrazol significantly affected plant height (*p*<0.001), main inflorescence length *(p*<0.001) and internode length of main inflorescence *(P*=0.014). Data on these characteristics indicated that paclobutrazol led to a linear reduction in the height or the length of measured plant attributes, with a greater effect being observed at increasing concentrations (Table 1). While the mean highest plant height was recorded 85.7 cm for control plants, mean plant height in the plants treated with 500 mg·L^{-1} paclobutrazol decreased to 39.8 cm with a reduction rate of 215.3%. Similar decreasing trends were recorded in length and internode length of main inflorescences with the reduction rates of 214.8% and 184.6%, respectively (Table 1). These reduction rates can be interpreted to indicate *C. orientalis* is more sensitive to spray application of paclobutrazol than some of other plant species such as *Camellia* X *williamsii* W.W. Sn., *Lupinus varius* L., and *B. glabra* (Wilkinson & Richards, 1988; Karaguzel & Ortacesme, 2002; Karaguzel *et al*., 2004).

Results indicated that paclobutrazol treatments had slight but significant effect (*P*=0.039) on plant stem diameter, but had no effect (*P*=0.429) on main inflorescence diameter (Table 1). In the plant stem diameter values, significant difference was only recorded at concentration of 500 mg·L^{-1} in which plant stem diameter significantly increased compared to other concentrations including control treatment. However, paclobutrazol treatments had no significant effect on main inflorescence diameter. In *L. varius*, it was found that paclobutrazol applied either foliar spray or soil drench resulted in increases in both stem and main inflorescence diameters (Karaguzel *et al*., 2004).

Flower numbers of the main inflorescence were significantly affected by paclobutrazol treatment (*P*=0.030) (Table 1). With an increase in the concentration of paclobutrazol, flower numbers increased. However, the highest flower numbers were obtained with the second concentration (250 mg·L^{-1}). Previous studies indicate that the effects of paclobutrazol on flower number could vary due to plant species, dose and method of application. It was stated that spray treatments increased, while drench treatments reduced the total number of open flowers in *C.* X *williamsii* (Wilkinson & Richards, 1988). Matsoukis *et al*., (2001) found that the number of flowers per plant increased to a maximum as drenched paclobutrazol concentration increased to 80 mg·L^{-1}, but higher concentrations resulted in a decrease in the number of flowers per plant in a subspecies of *Lantana camara* L. Results are quite similar to findings of previous studies that spray application of paclobutrazol at 250 mg·L^{-1} concentration increased the number of flowers compared to control treatments in *B. glabra* and *L. varius* (Karaguzel & Ortacesme, 2002; Karaguzel *et al*., 2004).

Secondary inflorescence characteristics: Secondary inflorescence growth and characteristics are also important in determining ornamental value for these kinds of plants species. The ANOVA results indicated that paclobutrazol treatments had significant effect (*P*=0.019) on the number of secondary inflorescences per plant (Table 2). The number of secondary inflorescences linearly decreased with increasing concentrations of paclobutrazol. While the highest number of secondary inflorescencewas counted in control plants with 9.1 inflorescences/plant, this value decreased to 7.1 inflorescences/plant in the plants treated with paclobutrazol at 500 mg·L^{-1} (Table 2). Previous studies state that branch and shoot or secondary inflorescence responses of plants to paclobutrazol could also vary depending on species or cultivar, dose or concentration and application method. Davis *et al*., (1988) reported that triazoles had little effect on shoot number per plant in some plants species, but in others shoot number was substantially reduced. Paclobutrazol applied as a soil drench inhibited lateral shoot production in *Plectranthus australis* R. Br. (Wang & Blessington, 1990) and increased lateral shoot numbers in *Gardenia jasminoides* Ellis (De Baerdemaeker *et al*., 1994). Application of paclobutrazol either as media drench or foliar spray resulted in an increase in the number of lateral shoots per plant in *Bougainvillea spectabilis* Willd. (Karaguzel, 1999), but spray treatments increased and media drenches reduced lateral shoot production in *B. glabra* ‘Sanderiana’ (Karaguzel & Ortacesme, 2002).

As in the main inflorescences, spray treatment of paclobutrazol at different concentrations resulted in significant and linear decreases in lengths and internode lengths of secondary inflorescences (Table 2). The secondary inflorescences were 32.1 cm long on average in control plants. In the plants treated with 500 mg·L^{-1} paclobutrazol, this value decreased to 21.5 cm with a reduction rate of 149.3%, and similar decreasing trend was recorded in internode length with a reduction rate of 175.0%. In contrast, number of flowers on secondary inflorescences increased with increasing paclobutrazol concentrations and the highest flower numbers (21.4 flowers/inflorescence) were counted in plants treated with 500 mg·L^{-1} paclobutrazol (Table 2). However, paclobutrazol treatment had no significant effect (*P*=0.673) on secondary inflorescence diameter as being recorded for main inflorescences. Reduction rates in length and internode length of secondary inflorescences were lower than that of main inflorescences. Concentration, in which the highest flower numbers were counted, was also higher in secondary inflorescences. These differing responses are possibly due to the consumption of paclobutrazol absorbed via leaves first mainly for reducing plant height and length of main inflorescence in the relatively short time and less amount of paclobutrazol remained to reduce inflorescence length and increase flower number in secondary inflorescences. Therefore higher concentration of paclobutrazol was needed to reduce length and increase flower number in secondary inflorescences.

Flower characteristics: Data on flower characteristics showed that paclobutrazol treatments significantly affected pedicel lengths (Table 3). As in the height and length related characteristics considered in this study, pedicel lengths were linearly decreased with increasing concentrations of paclobutrazol. While mean pedicel length in control plants was 1.7 cm, this value decreased to 1.2 cm in the plants treated with 500 mg·L^{-1} paclobutrazol with a reduction rate of 141.7%. However, paclobutrazol treatments did not result in significant differences in corolla diameters and lengths (including spurs) (Table 3). Results from previous studies indicate that paclobutrazol reduced length of peduncles in *Callistephus chinensis* (L.) Nees, *Calendula officinalis* L., *Portulaca grandiflora* Hook.and *G. jamesonii* (Qrunfleh & Suwwan, 1988; Lee & Lee, 1990), and the length of pedicel in *Hibiscus rosa-sinensis* L., (Wang & Gregg, 1991). Flower size responses of plants to paclobutrazol can vary depending on species and cultivars. Qrunfleh & Suwwan (1988) reported that paclobutrazol reduced flower diameters in *P. grandiflora*, but flower sizes in *C. chinensis* and *C. officinalis* were not affected. Also, it is stated that paclobutrazol treatments resulted in significant decreases in flower diameter in cultivars of *Rhododendron simsii* Planch., and *Rhododendron obtusum* (Lindl.) Planch. (Heursel & Witt, 1985; Keever *et al.*, 1990), and had no significant effect on flower size in *H. rosa-sinensis* (Wang & Gregg, 1991).

Leaf and flower colours: Data on leaf colorimetric values indicated that paclobutrazol treatment significantly affected L*(lightness) and chroma (colour saturation) values of leaves, but it had no significant effect (*P*=0.125) on hue angle (Table 4). At all paclobutrazol concentrations, L* values of leaves significantly decreased compared with control treatment without significant differences between concentrations at 125, 250 and 500 mg·L^{-1} (Table 4). At the same time, paclobutrazol treatments at 125 and 250 mg·L^{-1} significantly decreased chroma values of leaves related to control plants, but there was no significant difference in chroma values measured in control plants and plants treated with paclobutrazol at 500 mg·L^{-1} (Table 4). As a result, it can be concluded that paclobutrazol produced darker foliage in *C. orientalis*. In general, similar results are mentioned by Halevy (1986) and Davis *et al*., (1988). It is also reported that paclobutrazol intensified leaf colour in Azalea, *Fuchsia* L. and Poinsettia (Witt, 1986), darkened the foliage in different cultivars of *R. simsii* (Heursel & Witt 1985), increased chlorophyll content in *G. jamesonii* (Lee & Lee, 1990), and produce a darker foliage in *Dianthus caryophyllus* L. 'Mondriaan' (Banon *et al*., 2002).

Table 1. Effect of paclobutrazol on growth and main inflorescence characteristics of *C. orientalis*.

Concentration ($mg·L^{-1}$)	Plant			Main inflorescence			
	Time to flowering (day)	Plant height (cm)	Stem diameter (mm)	Length (cm)	Diameter (mm)	Internode length (cm)	Flowers (no.)
Control	91.3	85.7 a	4.6 b	73.9 a	2.9	2.4 a	25.4 b
125	90.7	48.4 b	4.5 b	44.1 b	2.5	1.5 ab	25.7 b
250	91.3	42.3 bc	4.5 b	38.4 bc	2.7	1.6 ab	29.0 a
500	90.7	39.8 c	5.5 a	34.4 c	2.6	1.3 b	25.8 b
Probability > *F*							
Concentration	0.952	<0.001	0.039	<0.001	0.429	0.014	0.030

Mean separation within columns by Duncan's multiple range test, $p \leq 0.05$ level.

Table 2. Effect of paclobutrazol on secondary inflorescence characteristics of *C. orientalis*.

Concentration ($mg·L^{-1}$)	Secondary inflorescences (no.)	Length (cm)	Diameter (mm)	Internodes length (cm)	Flowers (no.)
Control	9.1 a	32.1 a	1.6	2.1 a	14.9 b
125	7.7 ab	23.9 b	1.5	1.5 ab	15.5 ab
250	6.8 b	22.3 b	1.7	1.2 b	18.8 ab
500	7.1 b	21.5 b	1.9	1.2 b	21.4 a
Probability > F					
Concentration	0.019	0.003	0.673	0.012	0.040

Mean separation within columns by Duncan's multiple range test, $p \leq 0.05$ level.

Table 3. Effect of paclobutrazol on some flower characteristics of *C. orientalis*.

Concentration ($mg·L^{-1}$)	Pedicel length (cm)	Corolla	
		Diameter (cm)	Length (including spur) (cm)
Control	1.7 a	2.1	2.1
125	1.6 ab	2.1	2.0
250	1.4 bc	2.1	2.0
500	1.2 c	2.2	1.9
Probability > *F*			
Concentration	0.003	0.715	0.078

Mean separation within columns by Duncan's multiple range test, $p \leq 0.05$ level.

Table 4. Effect of paclobutrazol on leaf and flower colorimetric values in *C. orientalis*.

Concentration ($mg·L^{-1}$)	Leaf			Flower		
	L*	Chroma	Hue (°)	L*	Chroma	Hue (°)
Control	38.04 a	23.49 a	147.38	40.72 a	35.44	302.93
125	33.56 b	16.41 b	146.79	37.67 ab	34.78	302.37
250	33.35 b	16.64 b	147.67	36.80 ab	34.94	301.20
500	33.93 b	18.18 ab	146.57	35.43 b	34.27	301.40
Probability > *F*						
Concentration	<0.001	<0.001	0.125	0.018	0.853	0.189

L* = Lightness, Chroma = Saturation $(a^{*2}+b^{*2})^{1/2}$, Hue (°) = Arctan (b*/a*).
Mean separation within columns by Duncan's multiple range test, $p \leq 0.05$ level.

Paclobutrazol had significant effect (P=0.018) on only L* (lightness) values of flowers and there were no significant differences in chroma and hue angle values of flowers caused by paclobutrazol treatments (Table 4). L* values of flowers linearly decreased with increasing concentration of paclobutrazol, but chroma values and hue angles (in degree) were constant with slight and non significant differences at all concentrations (Table 4). However, paclobutrazol treatments resulted in deeper violet flowers with lower L* values than that of control plants. Previous studies showed that flower colour responses of plants to paclobutrazol can also vary with plant species and growing season. Paclobutrazol can intensify flower colour in Azalea, *Fuchsia* and Poinsettia without reducing the size of flowers (Witt, 1986), but did not affect blossom colour of some *R. simsii* cultivars (Heursel & Witt, 1985). Banon *et al*., (2002) found that paclobutrazol significantly affected flower colour of *D. caryophyllus* 'Mondriaan' in winter cycle of cultivation, whereas there were no significant differences caused by paclobutrazol treatments in flower colorimetric values of flowers in spring cultivation.

Taking the results of this study as a whole, it is evident that *C. orientalis* is growth, flowering and leaf and flower colour sensitive to spray application of paclobutrazol. This chemical can easily be used to produce sturdy plants with reduced excessive plant growth, increased flower numbers and darkened leaf and flower colours in *C. orientalis*.

Acknowledgement

This study was supported by the Administration Unit of Scientific Research Projects of Akdeniz University (Project No. 21.01.0104.09).

References

Armitage, A.M. 1995. *Specialty cut flowers.* Timber Press, Portland, Oregon.

Armitage, A.M. 2001. *Armitage's manual of annuals, biennials, and half-hardy perennials*. Timber Press, Portland, Oregon.

Banon, S.A., E.A. Gonzalez, J.A. Cano, J.A. Franco and Fernandez. 2002. Growth, development and color response of potted *Dianthus caryophyllus* cv. Mondriaan to paclobutrazol treatment. *Scientia Horticulturae*, 94: 371-177.

Barrett, J.E. and C.A. Bartuska. 1982. PP333 effects on stem elongation dependent on site of application. *HortScience*, 17: 737-738.

Blamey, M. and C. Grey-Wilson. 1998. *Mediterranean Wild Flowers*. HarperCollins, London.

Brickell, C. and J.D. Zuk. 1997. *A-Z Encyclopedia of Garden Plants-The American Horticultural Society*. DK Publishing Inc., New York.

Burnie, D. 2000. *Wild flowers of the Mediterranean*. Dorling Kindersley, London.

Chen, C.L., G.J. Keever and C.F. Deneke. 1993. Growth and flowering of triazole-treated Zinnia (*Zinnia elegans*) and Marigold (*Tagetes erecta*). *Plant Growth Regulat. Soc. of Amer.-Qrtly.*, 21: 169-179.

Cox, D.A. 1991. Gibberellic acid reverses effects of excess paclobutrazol on Geranium. *HortScience*, 26(1): 39-40.

Davis, P.H. 1965. Ranunculaceae. In: *Flora of Turkey and The East Aegean Islands*. (Ed.): P.H. Davis. Vol 1, Edinburgh University, Edinburgh, United Kingdom, pp. 94-134.

Davis, T.D., G.L. Steffens and N. Sankha. 1988. Triazole plant growth regulators. *In*: *Horticultural Reviews*. (Ed.): J. Janick. Vol. 10, pp. 63-105.

Davis, T.D. and A.S. Andersen. 1989. Growth retardants as aids in adapting new floricultural crops to pot culture. *Acta Horticulturae*, 252: 77-85.

De Baerdemaeker, C.I., J.M. van Huylenbroeck and P.C. Debergh. 1994. Influence of paclobutrazol and photoperiod on growth and flowering of *Gardenia jasminoides* Ellis cultivar 'Wetchii'. *Scientia Horticulturae,* 58: 315-324.

Ecker, R., A. Barzilay, L. Afgin and A.A. Watad. 1992. Growth and flowering responses of *Methiola incana* L. R. Br. to paclobutrazol. *HortScience*, 27: 1330.

Gomez, K.A. and A.A. Gomez. 1984. *Statistical Procedures for Agricultural Research*. Second Edition, John Wiley & Sons, New York.

Halevy, A.H. 1986. Recent advances in the use of growth substances in ornamental horticulture. *Plant Growth Substances 1985*, Heidelberg, Berlin, West Germany, pp. 391-398.

Heursel, J. and H.H. Witt. 1985. Bonzi-a new growth regulator for evergreen azaleas. *Deutscher Gartenbau*, 39(37): 1742-1746.

Karaguzel, O. 1999. The effects of paclobutrazole on growth and flowering of *Bougainvillea spectabilis* WİLLD. *Turkish Journal of Agriculture and Forestry*, 23 (Supplement 2): 527-532.

Karaguzel, O. and V. Ortacesme. 2002. Influence of paclobutrazol on the growth and flowering of *Bougainvillea glabra* 'Sanderiana'. *Ziraat Fakultesi Dergisi, Akdeniz Universitesi*, 15(1): 79-84.

Karaguzel, O., I. Baktir, S. Cakmakci and V. Ortacesme. 2004. Growth and flowering responses of *Lupinus varius* L. to paclobutrazol. *HortScience*, 39(7): 1659-1663.

Karaguzel, O., S. Mansuroglu, M.S. Sayan and E. Yildirim. 2006. Relations between different native ecological conditions and growth and flowering characteristics of *Consolida orientalis* Populations. *Ziraat Fakultesi Dergisi, Akdeniz Universitesi*, 19(2): 235-244.

Karaguzel, O. S. Mansuroglu, M.S. Sayan and S.G. Tascioglu. 2007. Effects of growing conditions and sowing time on the growth and flowering characteristics of native *Consolida orientalis* Population. *Ziraat Fakultesi Dergisi, Akdeniz Universitesi*, 19(2): 235-244.

Karaguzel, O. S. Mansuroglu, M.S. Sayan, E. Yildirim and A. Benliay. 2009. Effects of photoperiod and sowing times interaction on growth and flowering of *Consolida orientalis* native to South Anatolia. *Acta Horticulturae*, 807: 681-686.

Keever, G.J. and D.A. Cox. 1989. Growth inhibition in Marigold following drench and foliar-applied paclobutrazol. *HortScience* 24: 390.

Keever, G.J., W.J. Foster and J.C. Stephenson. 1990. Paclobutrazol inhibits growth of woody landscape plants. *Journal of Environmental Horticulture*, 8(1): 41-47.

Larson, R.A. 1985. Growth regulators in floriculture. *In*: Janick J. (Ed.), *Hortcultural Reviews* Vol. 7, pp. 400-481.

Lee, P.O. and J.S. Lee. 1990. Effects of ancymidol and paclobutrazol on growth and flowering of potted gerbera. *Journal of the Korean Society for Horticultural Science*, 31(3): 300-304.

Matsoukis, A.S., A. Sereli-Chronopoulou, I.D. Dimopoulus and A. Kamoutsis. 2001. Responses of *Lantana camara* subsp. *camara* to paclobutrazol and shading. *Canadian Journal of Plant Science*, 81(4): 761-764.

Menhennett, R. 1984. Comparison of a new triazole retardant paclobutrazol (PP 333) with ancymidol, chlorphonium chloride, daminozide and piproctanyl bromide on stem extension and inflorescence development in *Chrysanthemum morifolium* Ramat. *Scientia Horticulturae*, 24(3-4): 349-358.

Miller, A. and A.M. Armitage. 2002. Temperature, irradiance, photoperiod and growth retardants influence greenhouse production of *Angelonia angustifolia* Benth. Angel Mist Series. *HortScience*, 37: 319-321.

Mohd, A., S. Gauri, A.K. Muthoo, M. Ahmad and G. Shanker. 1988. Effect of paclobutrazol on growth and flowering of Cosmos (*Cosmos bipinnatus*). *Punjab Horticultural Journal*, 28: 105-108.

Nasr, M.N. 1995. Effects of methods of application and concentrations of paclobutrazol on *Pelargonium zonale* (L) as a pot plant. *Alaxandria Journal of Agricultural Research*, 40(3): 261-279.

Qrunfleh, M.M. and M.A. Suwwan. 1988. Response of three summer annuals to paclobutrazol application. *Advances in Horticultural Science*, 2(1): 15-18.

Ripka, G. and B. Szanto. 1988. Studies on the effect of a new growth regulator on greenhouse ornamentals. *Novenyvedelem*, 24(9): 415-418.

Stamps, R.H. and R.J. Henny. 1986. Paclobutrazol and night interruption lighting affect Episcia growth and flowering. *HortScience*, 21: 1005-1006.

Tan, A. 1998. Current status of plant genetic resources conservation in Turkey. *In*: Zincirci N., Z. Kaya, Y. Anikster, W.T. Adams (Eds.). *The Proceedings of International symposium on In Situ Conservation of Plant Genetic Diversity*, Central Research Institute for Field Crops, Ankara.

Tayama, H.K. and S.A. Carver. 1990. Zonal geranium growth and flowering responses to six growth regulators. *HortScience*, 25: 82-83.

van Leeuwen, P.J. and A.J. Dop. 1990. Effects of storage, cooling and greenhouse conditions on *Anemone blanda*, *Fritillaria meleagris* and *Oxalis adenophylla* for use as pot plant. *Acta Horticulturae*, 266: 101-107.

Wang, Y.T. and T.M. Blessington. 1990. Growth of four tropical foliage species treated with paclobutrazol and uniconazole. *HortScience*, 25(2): 202-204.

Wang, Y.T. and L.L. Gregg. 1991. Modification of hibiscus growth by treating unrooted cuttings and potted plants with uniconazole or paclobutrazol. *Journal of Plant Growth Regulation*, 10(1): 47-51.

Wilkinson, R.J. and D. Richards. 1987. Effects of paclobutrazol on growth and flowering of *Bouvardia humboldtii*. *HortScience*, 22: 444-445.

Wilkinson, R.J. and D. Richards. 1988. Influence of paclobutrazol on the growth and flowering of *Camellia x Williamsii*. *HortScience*, 23(2): 359-360.

Witt, H.H. 1986. Bonzi promises economy. *Deutscher Gartenbau*, 40(6): 239-243.

(Received for publication 3 November 2003)