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PLANT HEIGHT CONTROL OF *HYACINTHUS ORIENTALIS* BY GIBBERELLIN INHIBITORS

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ABSTRACT

In this study, effect of gibberellin inhibtors as preplant bulb soaks on plant height of *Hyacinthus orientalis* cv. 'Jan Bos' grown in pots were investigated. Bulbs of hyacints were soaked in flurprimidol at 0, 10, 20 ppm and paclobutrazol at 0, 100, 200 ppm before planting. Effect of gibberellin inhibitors on the flowering time, flower diameter and length, leaf length, plant height, flower life, chlorophyll content of leaves were determined. In addition, after hyacints grown in pots in the greenhouse arrived at the sales stage to determine the changes that occur in the plant height, plants were taken to the laboratory where temperature was held constant at 20 °C. The shortest plant height was obtained from the 200 ppm paclobutrazol and 20 ppm flurprimidol treatment as given bulb soaks. In this treatments, plant heihgt was 7.33 and 8.61 cm and were 49% , 41% shorter than untreated control. The lower dose of 10 ppm flurprimidol and 100 ppm paclobutrazol were also effective on height control with 9.11 and 9.71 cm plant height, respectively. Gibberellin inhibitors also shortened leaf lenght. Flurprimidol and paclobutrazol treatments resulted in higher chlorophyll content per unit area in the leaves than untreated controls. The highest chlorophyll contetnt was obtained from the plants treated 200 ppm paclobutrazol with 83.36 CCI (Chlorophyll content index), while the control was 50.56 CCI. The effects of treatments on plant height were maintained in lab conditions (home-office). The shortest plant height was obtained from 200 paclobutrazol treatment with 9.75 cm, while the control was 21.5 cm during post production period.

Keywords: *Flurprimidol, Paclobutrazol, Bulb Soak, Hyacinthus, Plant Height.*

INTRODUCTION

Hyacinthus orientalis from the Hyacinthaceae family is perennial plant (Samuitiene et al., 2007; Addai, 2010). It is a horticulturally important plant and native of the West and Central Asia (Addai, 2010). *H. orientalis* is a spring flowering bulb, they have a strong sweet fragrance (Gender, 1994). They are also commonly used in parks, gardens and refuges as ornamental plants. In addition, *Hyancinthus* is also used as potted plant in the indoor. But the fact that their excessive elongation after production at consumer conditions with low light makes

it difficult to use as indoor plants (Çelikel et al., 2016). Elongation causes also downward curvature of the flower stem with heavy inflorescence. Therefore, plant height control is important for maintaining compactness and aesthetically pleasing appearance, as well as preventing damage during transportation and marketing due to stem elongation (Çelikel et al., 2016). We may control plant height either by physical methods with environmental factors (light, temperature, etc.), or by chemical methods with growth regulators mostly gibberellin inhibitors (Demir and Çelikel, 2013; Çelikel et al., 2016). These inhibitors are paclobutrazol, flurprimidol, ancymidol, uniconazole, chlormequat chloride and daminozide (Currey and Lopez, 2017).

Flurprimidol as bulb soaks at 20 mg L^{-1} controlled the plant height of 'Pink Pearl' hyacinth cultivar cultivars at anthesis and postharvest evaluation (Krug et al., 2006a). Flurprimidol ≥ 10 mg L^{-1} controlled plant height of 'Delft Blue' hyacinth cultivar during postharvest evaluation (Krug et al., 2006a). Uniconazole at 30 mg L^{-1} controlled height of 'Delft Blue' during the postharvest evaluation and plants treated with uniconazole were 8% shorter than untreated control (Krug et al., 2006a). 'Jan Bos' hyacinth cultivar treated with ≥ 10 mg L^{-1} flurprimidol were 4% shorter than untreated control during greenhouse forcing (Krug et al., 2006a). Miller (2010a), reported that growth regulators such as ancymidol, paclobutrazol, flurprimidol act to reduce gibberellin levels in the plant thereby causing shorter plants. Pre-plant flurprimidol dips show excellent control for hyacinth growth regulation (Miller, 2010a). Paclobutrazol or uniconazole pre-plant dips were effective in controlling height of prepared 'Anna Marie' hyacinths (Miller, 2002). Plant height of 'Carlton' narcissus cultivar was controlled by flurprimidol and paclobutrazol as soil drench at 3 mg/pot concentration (Miller, 2010b). Flurprimidol bulb soaks controlled plant height of narcissus during both greenhouse and postproduction evaluation (Krug et al., 2006b).

Effects of flurprimidol and paclobutrazol were investigated on plant height of *Hyacinthus orientalis cv.* 'Jan Bos' and other *Hyacinthus* cultivars before but other parameters (leaf length, flower diameter and length, chlorophyll content of leaves) except plant height were not studied on *H. orientalis cv.* 'Jan Bos'. In addition there is no previous study on plant height control of *H. orientalis* cultivars in Turkey. Therefore, we investigated the effects of these chemical treatments as preplant bulb soaks on plant height and other properties of *Hyacinthus orientalis* cv. 'Jan Bos' grown in pots.

MATERIAL AND METHOD

Hyacinthus orientalis cv. 'Jan Bos' bulbs with circumference of 12 cm from Asya Lale (Konya, Turkey) were used in this study. Bulbs were soaked into flurprimidol (FP,Sigma-Aldrich) solutions of 0, 10, 20 ppm or paclobutrazol (PBZ, 25% Cultar; Syngenta) of 0, 100, 200 ppm for 30 min before planting. Ethanol (2%) was used as a solvent of flurprimidol. Therefore a control for the solvent was included in these experiments. Bulbs were allowed to air dry and were planted into a 15 cm diameter plastic pots (1.6 volume) containing soil, peat and perlite (1:1:1) as one

bulb per pot on the day of treatment (11th October 2013). Plants grown in a polyethylene covered greenhouse were irrigated as needed with tap water.

Postproduction evaluation: When hyacinths reached to the sale stage (50% open flower in a stem with buds), four replicate plants randomly selected from each treatment were taken to the laboratory. Postproduction life and quality of pot plants were evaluated in this laboratory at 20 °C illuminated with Cool White Fluorescent light of 1000 lux at bench level, under a diurnal cycle of 12 h day, 12 h night as standard conditions (Çelikel and Karaçalı, 1991; Çelikel, 1993).

Flowering time and flower life: Flowering time was determined as number of days from planting time to opening of the 50% flower in stem. Flower life was calculated as the number of days from the opening of the 50 % flower to the wilting of the more than 50% flower in stem.

Chlorophyll content: Chlorophyll content of leaves was measure by chlorophyll meter (Apogee). It was determined as Chlorophyll content index (CCI).

Plant height and Leaf length: The plant height (from the pot rim to the uppermost of the inflorescence) and leaf length (the longest leaf) were started to measure respectively 103 days (22nd January 2014) and 117 (5th February 2014) after planting. Measurements were made weekly.

Flower diameter and length: the flower diameter and length was measured by a caliper at anthesis time.

Data Analysis: Data were tested by one way analysis of variance (ANOVA) using a completely randomized design. The study was conducted with 10 replications except 4 replications for postproduction evaluation. The obtained data were analyzed statistically by using the SPSS package program. The mean and standard error ($\overline{X} \pm S\overline{x}$) values were determined. Differences between means were separated by Duncan's multiple range test ($P \leq 0.01$).

RESULTS AND DISCUSSION

Flowering time, flower life and chlorophyll content; Plant growth regulators delayed the flowering time of hyacinths. The delay of flowering time was found significant ($P \leq 0.01$). The latest flowering was obtained from 200 ppm PBZ with 128 days, while control and ethanol were 118 and 119 days, respectively (Table 1). The gibberellin inhibitors delayed flowering time about 3-9 days. A delay was observed in some *Iris* cultivars in the visible appearance buds in plants treated with paclobutrazol (Francescangeli, 2009). The application of paclobutrazol delayed the appearance of the flower color in *Petunia* (Francescangeli and Zagabria, 2009). Flurprimidol application caused flowering delay of *Ornithogalum saundersiae* (Salachana and Zawadzińska, 2013). Flowering time of 'Mona Lisa' lily cultivar was slightly delayed with flurprimidol treatment (Pobudkiewicz and Treder, 2006). Flurprimidol has been reported as a highly effective retardant on a number of flowering ornamentals (Barrett 1983; Criley, 1997).

In our study gibberellin inhibitors did not affect the flower life of hyacinths except 200 ppm PBZ treatment (Table 1). The flower life of 'Jan Bos' changed in 15-22 days. There was no difference among the applications except higher dose (200

ppm) of PBZ in flower life of hyacinths (Table 2). The higher doses of PBZ shortened the flower life 5 days, while the lower dose of PBZ and FP treatments didn't affect the flower life. In addition the higher doses of these plant growth regulators also reduced significantly the plant height. Blázquez et al., (1998) reported that the gibberellin class of plant hormones has been implicated in the control of flowering in several species. It was reported that exogenous GA_2 promote the switch from vegetative growth to flowering in a variety of plants by Wilson et al., 1992. Therefore the gibberellin inhibitors used in this study, effected flowering. Treatments affected the duration of the cycle.

There was significant difference ($P \leq 0.01$) in chlorophyll content of leaves in hyacinths (Table 1). PBZ and FP treatments caused an increase in chlorophyll content of leaves (Table 1). The highest chlorophyll content was obtained from 200 ppm PBZ treatments with 83.36 CCI, while control plants were 50.56 CCI (Table 1). In addition the lower doses (100 ppm) of paclobutrazol and flurprimidol aplications also increased the chlorophyll content of hyacinths (Table 1). Chlorophyll content of hyacinths treated with 100 ppm paclobutrazol, 10 and 20 ppm flurprimidol were 64.74, 60.19 and 66.00 CCI, respectively. Paclobutrazol and uniconazole increased foliar chlorophyll content and leaf thickness in soybean (Barnes et al., 1989). The use of flurprimidol resulted plants with an increased relative chlorophyll content of *Ornithogalum saundersiae* (Salachna and Zawadzińska, 2013). It was reported that total chlorophyll content of leaves increased by 15 and 16% in tomato treated with paclobutrazol (Berova and Zlatev, 2000). Triazoles (Paclobutrazol, uniconazole) have generally increased chlorophyll content of treated plants, although exceptions have been reported (Wieland and Wample 1985; Barnes et al., 1989). In our study also gibberellin inhibitors of paclobutrazol and flurprimidol increased the chlororphyll content of leaves in hyacinths. Therefore leaves were dark green than control plants.

Table 1. The effects of flurprimidol (FP) and paclobutrazol (PBZ) on flowering time flower life and chlorophyll content of *Hyacinthus orientalis* cv. 'Jan Bos'

Mean ± Standard Error ($\overline{X} \pm S\overline{x}$)

Treatments	Flowering time	Flower life (days)	Chlorophyll content (CCI)
Control	117.86 ± 0.94 c	19.00 ± 0.87 a	50.56 ± 4.80 c
Ethanol (%2)	118.88 ± 1.30 c	20.37 ± 1.03 a	50.67 ± 2.41 c
10 ppm FP	121.33 ± 1.01 bc	20.11 ± 0.96 a	60.19 ± 2.87 bc
20 ppm FP	121.22 ± 1.33 bc	20.56 ± 1.18 a	66.00 ± 4.26 b
100 ppm PBZ	123.83 ± 0.91 b	19.00 ± 0.97 a	64.74 ± 6.32 b
200 ppm PBZ	127.67 ± 1.31 a	14.56 ± 0.53 b	83.36 ± 4.98 a
Significance	0.000	0.000	0.000

* Different letters in the same columns indicate differences among treatments according to Duncan multiple range test (1%).

Plant height, leaf length, flower diameter and length; In our study the gibberellin inhibitors applications decreased the plant height, leaf length, flower diameter and length (Table 2). The shortest plant height (7.33, 8.61, 9.11, 9.71 cm) was obtained from 200 ppm PBZ, 20 ppm FP, 10 ppm FP and 100 ppm PBZ treatments, respectively, whereas the control plants (14.5 cm) were the longest ones (Table 2, Figure 1). There was no difference between ethanol and control plants (Table 2). Plants applied gibberellin inhibitors were 49% (200 ppm PBZ), 41% (20 ppm FP), 37% (10 ppm FP) and 33% (100 ppm PBZ) shorter than control (Figure 3, 4). It was reported that flurprimidol was effective growth retardant in reducing stem extension of 'Mona Lisa' lily cultivar without adverse side-effects (Pobudkiewicz and Treder, 2006). Paclobutrazol substrate drenches control plant height of 'Tete a Tete' narcissus cultivar during greenhouse forcing (Krug et al., 2006b). Soil drenches of uniconazole retarded shoot and petiole elongation of *Brassaia actinophylla* (Wang et al., 1990). In another study flurprimidol, paclobutrazol and uniconazole suppressed height of *Impatiens hawker* cultivars (Currey et al., 2016). *Hyacinths* treated with plant growth regulators in this study were shorter than control plants during post production evaluation (Figure 2). The height differences between control and treated plants were maintained in the post-production period (Figure 2). 'Tete a Tete' narcissus treated with 0.69 mg / pot flurprimidol were 15% shorter than control at the end of the post production evaluation (Krug et al., 2006b). We found that FP and PBZ effectively controlled the plant height not only during production in greenhouse but also after production and there was no significant difference between low and high doses of chemicals (Figure 2). Our results clearly indicated that the effect of plant growth regulators on plant height (Figure 2), leaf length, flower diameter and length continued in the laboratory (home-office) conditions during the post-production period. The leaf area and plant size of kalanchoe was decreased by gibberellin inhibitors of paclobutrazol and uniconazole treatments (Hwang et al., 2008). Similarly we found that FP was effective for height control of hyacinths in our study.

The shortest leaf length was obtained from 200 ppm PBZ, 20 ppm FP and 100 ppm PBZ application with 5.33, 5.94 and 6.07 cm, respectively. The longest leaf length is 7.8 and 7.7 cm in ethanol application and untreated control (Table 2). There was a significant ($P \leq 0.01$) difference among application for leaf length (Table 2). It was reported that Topflor (flurprimidol) treatment shortened leaf length of hyacinths cultivars (Miller 2010a). Uniconazole foliar spray caused to reduction in leaf length and width of *Fuchsia x hybrida* (Kim, 1995). In our study the gibberellin inhibitors decreased leaf length, flower diameter and length (Table 2). There was significant difference ($P \leq 0.01$) in flower diameter and length of 'Jan Bos' hyacinths (Table 2). The smallest flower diameters were 54.99, 55.04, 55.93 and 55.96 mm from 200 ppm PBZ, 20 ppm FP, 10 ppm FP and 100 ppm PBZ, respectively. Flower diameter of control and ethanol were 58.51 and 58.81 mm. The shortest flower length was obtained from 200 PBZ and 20 ppm FP with 5.81 and 6.63 cm, respectively, while control and ethanol was 9.65 and 9.12 cm, respectively. The tepal size, leaf size and pedicel length of plants applied

flurprimidol were smaller than the control plants in 'Mona Lisa' lily cultivar (Pobudkiewicz and Treder, 2006). Flurprimidol application caused a reduction the inflorescence and flower diameter of *Ornithogalum saundersiae* (Salachana and Zawadzińska, 2013). The use of flurprimidol resulted with the shorter leaves in *Ornithogalum saundersiae* (Salachana and Zawadzińska, 2013) and *Zantedeschia aethiopica* (Gonzalez et al., 1999). Similarly in our study gibberellin inhibitors of FP and PBZ caused a reduction in flower diameter and length, were effective to shorten leaf length of hyacinth both during greenhouse and post-production period.

Table 2. The effects of flurprimidol (FP) and paclobutrazol (PBZ) on plant height, leaf length flower diameter and length of *Hyacinthus orientalis* cv. 'Jan Bos'

Mean ± Standard Error ($\overline{X} \pm S\overline{x}$)

Treatments	Plant height (cm)	Leaf length (cm)	Flower diameter (mm)	Flower length (cm)
Control	14.50 ± 2.05 a	7.69 ± 0.67 a	58.51 ± 1.76 a	9.65 ± 1.31 a
Ethanol (%2)	13.25 ± 0.80 a	7.83 ± 0.46 a	58.81 ± 2.31 a	9.12 ± 0.59 a
10 ppm FP	9.11 ± 0.35 c	6.33 ± 0.28 bc	55.93 ± 0.48 b	7.38 ± 0.31 b
20 ppm FP	8.61 ± 0.40 c	5.94 ± 0.21 c	55.04 ± 2.55 b	6.63 ± 0.21 bc
100 ppm PBZ	9.71 ± 1.15 c	6.07 ± 0.95 c	55.96 ± 0.26 b	7.50 ± 0.45 b
200 ppm PBZ	7.33 ± 0.69 c	5.33 ± 0.26 c	54.99 ± 1.31 b	5.81 ± 0.46 c
Significance	0.000	0.003	0.000	0.000

* Different letters in the same columns indicate differences among treatments according to Duncan multiple range test (1%).

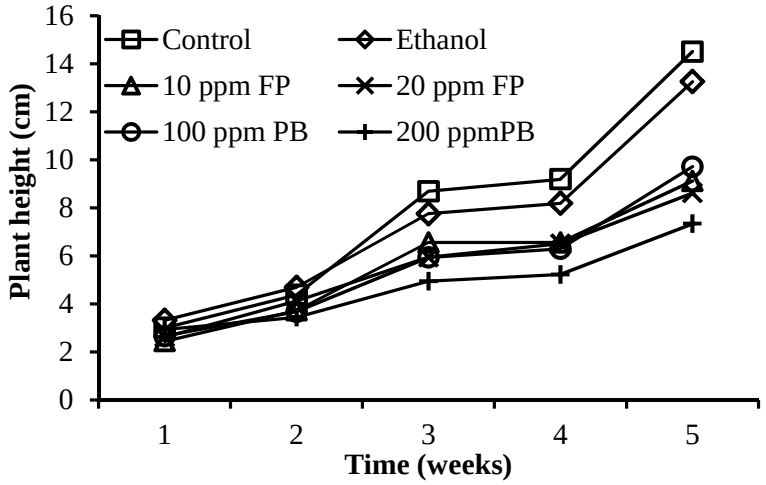

Figure 1. Effect of flurprimidol (FP) and paclobutrazol (PB) treatments on plant height of *Hyacinthus orientalis* cv. 'Jan Bos' during greenhouse production period The plant height was started to measure 103 days after planting (1. week)

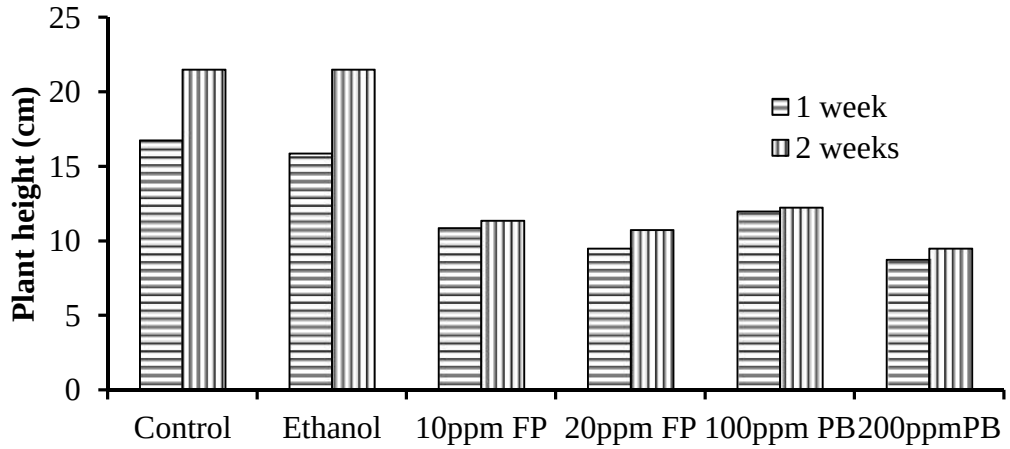

Figure 2. Effect of flurprimidol (FP) and paclobutrazol (PB) treatments on plant height of *Hyacinthus orientalis* cv. 'Jan Bos' during post production period in lab conditions. Plant height was started to measure 138 days after planting (1 week; 26 February 2014) in lab.

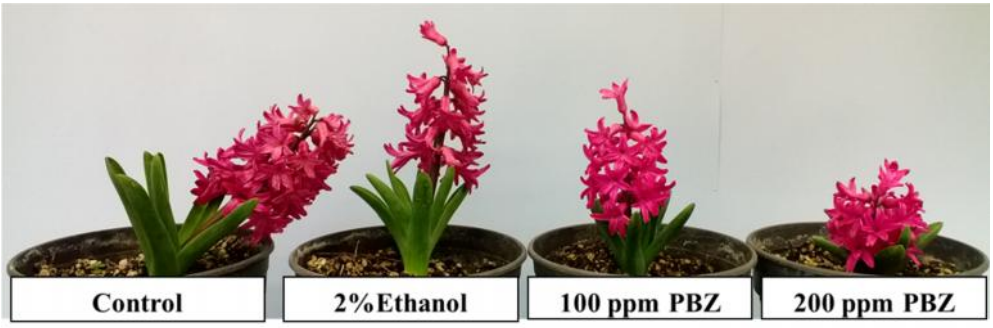

Figure 3. The effects of paclobutrazol (PBZ) bulb soak on *H. orientalis* cv. 'Jan Bos'

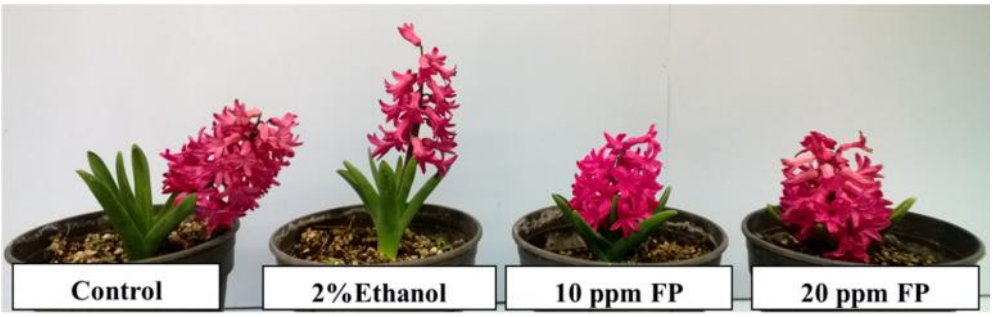

Figure 4. The effects of flurprimidoll (FP) bulb soak on *H. orientalis* cv. 'Jan Bos'

CONCLUSIONS

In conclusion gibberellin inhibitors controlled the plant height in hyacinths both during greenhouse and postproduction period. Paclobutrazol and flurprimidol decreased the leaf length, flower diameter and length and increased chlorophyll content of leaves. We found that there was no difference in flower life among the applications except higher dose (200 ppm) of PBZ. As a conclusion, we suggest 10 ppm flurprimiol or 100 ppm paclobutrazol, treatment as preplant bulb soak in order to provide plant height control and maintain post production quality of *H. orientalis* cv. 'Jan Bos' grown in pots.

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