

A STUDY ON PLANT HEIGHT CONTROL OF *IRIS* FLOWERS

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ABSTRACT

We investigated the effect of paclobutrazol as preplant bulb soaks on plant height of *Iris x hollandica* cv. 'Frans Hals' and 'Blue Magic' cultivars which were grown in pots. Bulbs of iris were soaked into gibberellin inhibitor paclobutrazol solution at 0, 15, 30 ppm before planting. Effect of paclobutrazol on the flowering time, flower diameter and length, leaf length, plant height, flower life, and chlorophyll content of leaves were determined. The shortest plant height was obtained from the 'Blue Magic' cultivar treated with 30 ppm paclobutrazol which gave plants with 11.3 cm, 68% shorter than untreated control. 'Frans Hals' cultivar treated with 30 ppm paclobutrazol was 20.9 cm and 50% shorter than control. In 'Blue Magic' and 'Frans Hals' cultivars the lower dose of 15 ppm paclobutrazol were also effective on height control with 11.8 and 21.5 cm plant height, respectively. This gibberellin inhibitor also shortened the leaf length of iris cultivars. Paclobutrazol treatments resulted in higher chlorophyll content per unit area in the leaves. The highest chlorophyll content (57.00 CCI) was obtained from the 'Blue Magic' iris treated with 30 ppm paclobutrazol, while the control plants had 32.70 CCI chlorophyll in their leaves. Chlorophyll content of 'Frans Hals' treated with 30 ppm paclobutrazol were 52.87 CCI, while control plants of this cultivar were 28.80 CCI. Plants applied with paclobutrazol resulted with smaller flower diameter compared to the control plants of both cultivars. The smallest flower diameter was obtained from 30 ppm paclobutrazol treatment with 38.83 mm in 'Blue Magic' iris while the control of this cultivar was 99.63 mm. The flower diameter of 'Frans Hals' cultivar treated with 30 ppm paclobutrazol was 109.1 mm, while the control one was 112 mm.

Keywords: *Paclobutrazol, bulb soak, Iris x hollandica, plant height.*

INTRODUCTION

Iris x hollandica from the Iridaceae family is perennial plant and known as 'Dutch Iris'. *Iris x hollandica* crossed two varieties of *Iris xiphium* (var. *praecox* from Spain and var. *lusitanica* from France) with *Iris tingitana* from North Africa (Hekstra and Boertjes 1968; Okubo and Sochacki; 2012). The majority of the Irises are the rhizomatous species. However the bulbous species are the most important commercially. Most of the bulbous cultivars are Dutch irises and they are bulbous

irises (Okubo and Sochacki, 2012). Irises are horticulturally important plants and have been used for centuries both as ornamental plants and a source of making perfumes (Köhlein, 1987; Fancescangeli, 2009). Bulbous iris species are produced commercially in greenhouses as cut flowers and potted plants (Le Nard, 1983; Fancescangeli, 2009). When cut flower species are produced in pots a problem of these cultivars of great commercial interest is that the stalk is longer. It is important that maintain a harmonious relationship with the container and plant growth (Krug, 2004; Fancescangeli, 2009). In addition elongation can continue after production at consumer conditions with low light. These reasons make it difficult to use as indoor plants (Çelikel et al., 2016). 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).

A concentration of 20 mg L⁻¹ paclobutrazol was found sufficient to achieve harmonious plants with the containers in ‘Casablanca’ and ‘Professor Blaauw’ *Iris x hollandica* cultivars and these plants were shorter 41 to 44% compared to the control plants (Fancescangeli, 2009). It was reported that growth regulators such as ancymidol, paclobutrazol, flurprimidol act to reduce gibberellin levels in the plant thereby causing shorter plants (Miller, 2010a). Paclobutrazol or uniconazole preplant dips were effective in controlling height of ‘Anna Marie’ hyacinths (Miller, 2002). Plant height of ‘Carlton’ narcissus cultivar was controlled by flurprimidol and paclobutrazol (Miller, 2010b). Paclobutrazol preplant bulb soaks significantly controlled ‘Tete a Tete’ narcissus plant height during greenhouse forcing at concentration 150 ppm. Flurprimidol as bulb soaks at 20 mg L⁻¹ controlled the plant height of ‘Pink Pearl’ hyacinth cultivar cultivars (Krug et al., 2006a).

Effects of paclobutrazol were not investigated on plant height of *Iris x hollandica* cv. ‘Frans Hals’ and *Iris x hollandica* cv. ‘Blue Magic’ cultivars before. Therefore, we investigated the effects of paclobutrazol as preplant bulb soaks on plant height and other properties of *Iris x hollandica* cv. ‘Frans Hals’ and *Iris x hollandica* cv. ‘Blue Magic’ grown in pots.

MATERIAL AND METHOD

Iris x hollandica cv. ‘Frans Hals’ and *Iris x hollandica* cv. ‘Blue Magic’ bulbs with circumference of 8-10 cm from Asya Lale (Konya, Turkey) were used in this study. Bulbs were soaked into paclobutrazol (PBZ, 25% Cultar; Syngenta) of 0, 15, 30 ppm for 30 min before planting. 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 (3 November 2016). Plants grown in a polyethylene covered greenhouse were irrigated as hydroponic drip irrigation system.

Flowering time and flower life: Flowering time was determined as number of days from planting time to opening of the flower (when petal color is visible). Flower life was calculated as the number of days from the opening of the flower to the wilting of the flower.

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 172 days (24 April) and 37 days (20 December) after planting, when they were started to emerge. Measurements were made weekly.

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

Flower diameter: The flower diameter was measured by a caliper at anthesis time.

Data Analysis: Data were tested by two way analysis of variance (ANOVA). The study was conducted with 10 replications. The obtained data were analyzed statistically by using the SPSS package program. The mean and standard error ($\bar{X} \pm \Delta\bar{x}$) values were determined. Differences between means were separated by Duncan's multiple range test ($P = 0.01$).

RESULTS AND DISCUSSION

Flowering time and flower life: PBZ delayed the flowering time of irises. There was significant ($P = 0.01$) difference among the application. The latest flowering was obtained from 15 and 30 ppm PBZ with 184 days in 'Frans Hals' cultivar, while control 182 days. PBZ also delayed flowering in 'Blue Magic' cultivar. Flowering was accrued 179 and 180 days after planting in 'Blue Magic' iris treated with 15 and 30 ppm PBZ, while control was 176 days. A delay was observed in some *Iris* cultivars in the visible appearance buds in plants treated with PBZ (Francescangeli, 2009). The application of PBZ delayed the appearance of the flower color in *Petunia* (Francescangeli and Zagabria, 2009). Flurprimidol application caused flowering delay of *Ornithogalum saundersiae* (Salachana and Zawadzi ska, 2013). 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 of paclobutrazol used in this study, effected flowering. Treatments affected the duration of the cycle. Flowering time was not affected by lower rates of flurprimidol, but it was slightly delayed when flurprimidol was applied at higher doses in 'Mona Lisa' lily cultivar (Pobudkiewicz and Treder, 2006). In our study gibberellin inhibitors of paclobutrazol didn't affect the flower life of iris cultivars. There was no difference among the applications in flower life of irises. However, there was difference ($P = 0.01$) in flower life between cultivars (Table 1).

Table 1. The effects of paclobutrazol (PBZ) on flowering time and flower life of *Iris x hollandica* cv. 'Frans Hals' and *Iris x hollandica* cv. 'Blue Magic'Mean \pm Standard Error ($\bar{X} \pm S\bar{x}$)

Cultivar	Treatments	Flowering time (days)	Flower life (days)
<i>Iris x hollandica</i> cv. 'Frans Hals'	Control	182.4 \pm 0.33 b	10.1 \pm 0.46 a
	15 ppm PBZ	184.1 \pm 0.46 a	10.1 \pm 0.60 a
	30 ppm PBZ	184.3 \pm 0.58 a	10.0 \pm 0.30 a
<i>Iris x hollandica</i> cv. 'Blue Magic'	Control	176.4 \pm 0.48 d	7.9 \pm 0.58 b
	15 ppm PBZ	179.3 \pm 0.75 c	7.5 \pm 0.29 b
	30 ppm PBZ	179.5 \pm 0.22 c	7.3 \pm 0.21 b
Significance		0.000	0.000
Means of cultivars	'Frans Hals'	183.6 \pm 0.71	10.07 \pm 0.89
	'Blue Magic'	178.4 \pm 0.47	7.57 \pm 0.43
Significance		0.782	0.000

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

In our study the PBZ applications decreased the plant height and leaf length (Table 2). There was significant ($P = 0.01$) difference among treatments for plant height (Table 2). The shortest plant height (11.3 and 11.8 cm) was obtained from 15 and 30 ppm paclobutrazol treatments, respectively, in 'Blue Magic' cultivar whereas the control plants were 35.6 cm (Table 2). 'Frans Hals' treated with 15 and 30 ppm paclobutrazol were 20.9 and 21.5 cm, while the control 41.5 cm, the longest one. 'Blue Magic' irises applied with gibberellin inhibitors of paclobutrazol were 68% (30 ppm PBZ) and 67% (15 ppm PBZ), 'Frans Hals' irises applied with gibberellin inhibitors of paclobutrazol were 50% (30 ppm PBZ), 48% shorter than control. 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 *Brassica actinophylla* (Wang et al., 1990). In another study flurprimidol, paclobutrazol and uniconazole suppressed height of 'Divine Cherry Red', 'Divine Scarlet Bronze Leaf' and 'Divine White Blush' *Impatiens hawker* cultivars (Currey et al., 2016). It was reported that paclobutrazol and uniconazole application reduced plant size and stem length of Kalanchoe 'Rako' (Lee et al., 2003). Uniconazole and flurprimidol are gibberellin inhibitors like paclobutrazol. Similarly in our study gibberellin inhibitors of paclobutrazol decreased the plant height of iris cultivars (Table 2).

The shortest leaf length (26.1 and 28.2 cm) was obtained from Blue Magic irises treated with 30 and 15 ppm PBZ while the control plants of 'Blue Magic' cultivar were 38.1 cm. The longest leaf length is 42.1 cm in untreated control of 'Frans Hals' cultivar. The leaf length of 'Frans Hals' treated with 15 and 30 ppm PBZ were 34.3 and 33.9 cm, respectively. There was significant difference among the 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). The leaf size of plants applied flurprimidol was smaller than the control plants in 'Mona Lisa' lily cultivar (Pobudkiewicz and Treder, 2006). The use of flurprimidol resulted with the shorter leaves in *Ornithogalum saundersiae* (Salachana and Zawadzi ska, 2013) and *Zantedeschia aethiopica* (Gonzalez et al., 1999). Similarly in our study paclobutrazol were effective to shorten leaf length of irises during greenhouse production period.

Table 2. The effects of paclobutrazol (PBZ) on plant height and leaf length of *Iris x hollandica* cv. 'Frans Hals' and *Iris x hollandica* cv. 'Blue Magic'

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

Cultivar	Treatments	Plant height (cm)	Leaf length (cm)
<i>Iris x hollandica</i> cv. 'Frans Hals'	Control	41.5 \pm 1.07 a	42.1 \pm 0.89 a
	15 ppm PBZ	21.5 \pm 1.19 c	34.3 \pm 0.90 c
	30 ppm PBZ	20.9 \pm 0.82 c	33.9 \pm 1.00 c
<i>Iris x hollandica</i> cv. 'Blue Magic'	Control	35.6 \pm 0.43 b	38.1 \pm 0.59 b
	15 ppm PBZ	11.8 \pm 1.65 d	28.2 \pm 0.74 d
	30 ppm PBZ	11.3 \pm 0.68 d	26.1 \pm 1.15 d
Significance		0.000	0.000
Means of cultivars	'Frans Hals'	27.97 \pm 1.23	36.77 \pm 0.58
	'Blue Magic'	19.57 \pm 1.18	30.80 \pm 0.89
Significance		0.003	0.009

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

There was significant difference ($P = 0.01$) in chlorophyll content of leaves and flower diameter of 'Frans Hals' and Blue Magic' iris cultivars (Table 3). Paclobutrazol treatments caused an increase in chlorophyll content of leaves (Table 3). The highest chlorophyll content was obtained from 30 ppm paclobutrazol treatments both 'Blue Magic' (57 CCI) and 'Frans Hals' (52.9) cultivars while control plants was 32.7 CCI ('Blue Magic') and 28.8 CCI ('Frans Hals') (Table 3). In addition the lower doses (15 ppm) of paclobutrazol also increased the chlorophyll content of irises. Chlorophyll content of irises treated with 15 ppm paclobutrazol was 51.3 CCI ('Blue Magic') and 46.2 CCI ('Frans Hals'). The use of flurprimidol resulted plants with an increased relative chlorophyll content of *Ornithogalum saundersiae* (Salachna and Zawadzi ska, 2013). Paclobutrazol application for cuphea and uniconazole application for petunia produced compact and high quality plants (Ahmad et al., 2015). Similarly in our study PBZ application resulted in compact plants and more chlorophyll content of leaves in irises. There was significant ($P = 0.01$) difference for flower diameter of 'Blue Magic' iris. The smallest flower diameters were 38.83 mm from 'Blue Magic' iris treated with 30 ppm PBZ, while 'Blue Magic' control was 99.63 mm. There was no difference for flower diameter of 'Frans Hals' iris cultivar (Table 3). Flower diameter of 'Frans Hals' treated with 30 ppm paclobutrazol was 109.1 mm, control

plants of this cultivar was 112.2 mm. PBZ treatments decreased the flower diameter of 'Blue Magic' cultivar because of the incomplete opening of the flower (Figure 5). Probably gibberellin inhibitor of paclobutrazol inhibited the elongation of pedicel+ovary in 'Blue Magic' iris. Çelikel and van Doorn (2015) reported that there is a relationship between flower opening and elongation of the pedicel+ovary in 'Blue Magic' iris since sheath leaves pose a mechanical barrier for flower opening (Çelikel and van Doorn, 2012). In our study paclobutrazol decreased pedicel+ovary elongation, therefore flowers of 'Blue Magic' iris could't open completely. This resulted in a decrease of flower diameter in 'Blue Magic' iris. It was reported that the tepal 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 reduced the inflorescence and flower diameter of *Ornithogalum saundersiae* (Salachana and Zawadzka, 2013). Uniconazole reduced the flower size by reducing peduncle, sepal and peduncle length of Fuchsia x Hybrida (Kim, 1995).

Table 3. The effects of paclobutrazol (PBZ) on chlorophyll content (CCI) in leaves and flower diameter of *Iris x hollandica* cv. 'Frans Hals' and *Iris x hollandica* cv. 'Blue Magic'

Mean \pm Standard Error ($\bar{X} \pm S\bar{x}$)			
Cultivar	Treatments	Chlorophyll content (CCI)	Flower diameter (mm)
'Frans Hals'	Control	28.80 \pm 1.92 d	112.2 \pm 2.12 a
	15 ppm PBZ	46.17 \pm 1.73 c	110.0 \pm 2.43 a
	30 ppm PBZ	52.87 \pm 1.72 ab	109.1 \pm 1.44 a
'Blue Magic'	Control	32.70 \pm 1.58 d	99.63 \pm 2.35 b
	15 ppm PBZ	51.26 \pm 2.06 bc	43.60 \pm 2.16 c
	30 ppm PBZ	57.00 \pm 1.37 a	38.83 \pm 1.94 d
Significance		0.000	0.000
Means of cultivars	'Frans Hals'	42.61 \pm 1.85	110.43 \pm 1.93
	'Blue Magic'	49.99 \pm 2.02	60.69 \pm 2.04
Significance		0.000	0.000

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

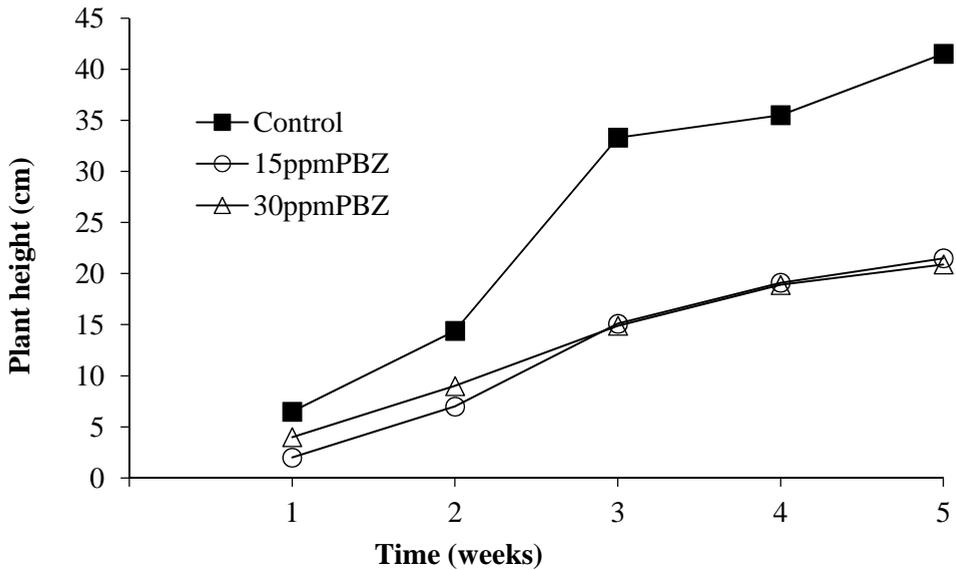


Figure 1. Effect of paclobutrazol (PBZ) treatment on plant height of *Iris x hollandica* cv. 'Frans Hals' during greenhouse production period. The plant height was started to measure 172 days after planting (1. week)

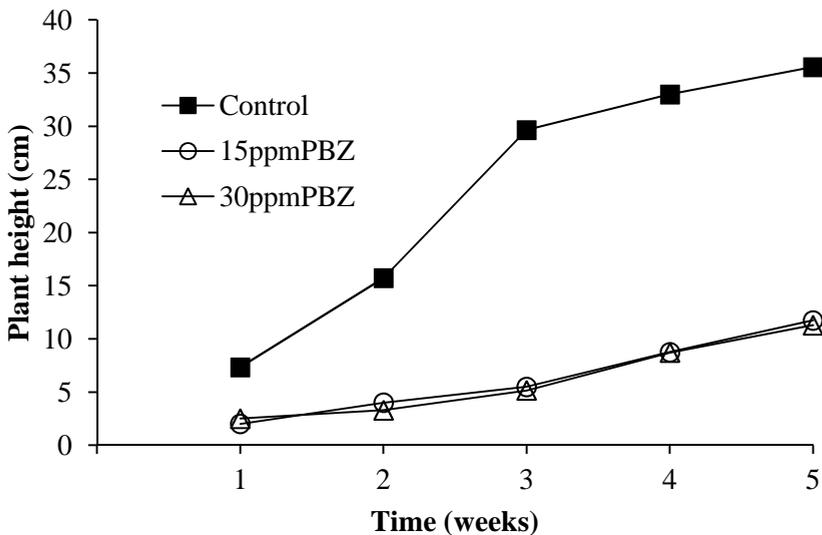


Figure 2. Effect of paclobutrazol (PBZ) treatment on plant height of *Iris x hollandica* cv. 'Blue Magic' during greenhouse production period. The plant height was started to measure 172 days after planting (1. week)

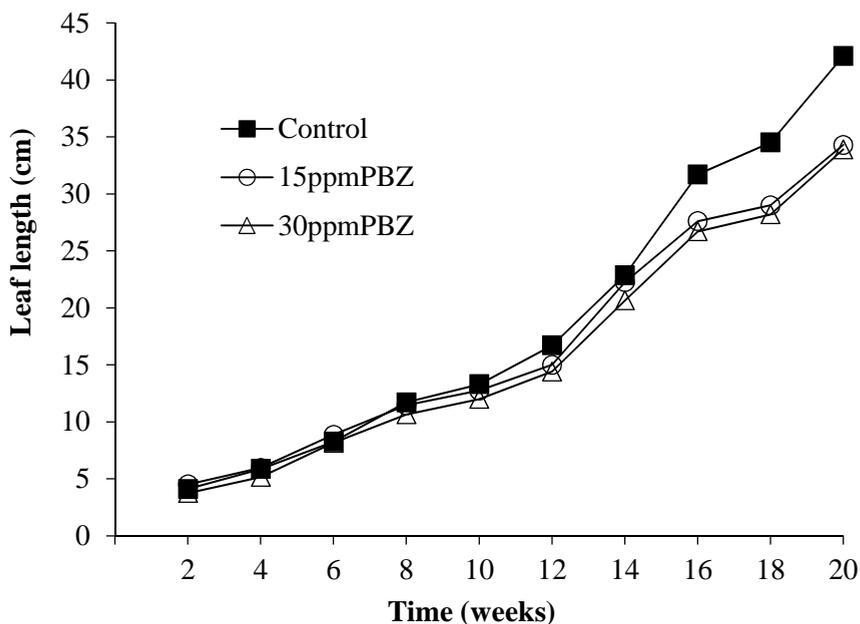


Figure 3. Effect of paclobutrazol (PBZ) treatment on leaf length of *Iris x hollandica* cv. 'Frans Hals' during greenhouse production period. The leaf length was started to measure 37 days after planting (1. week)

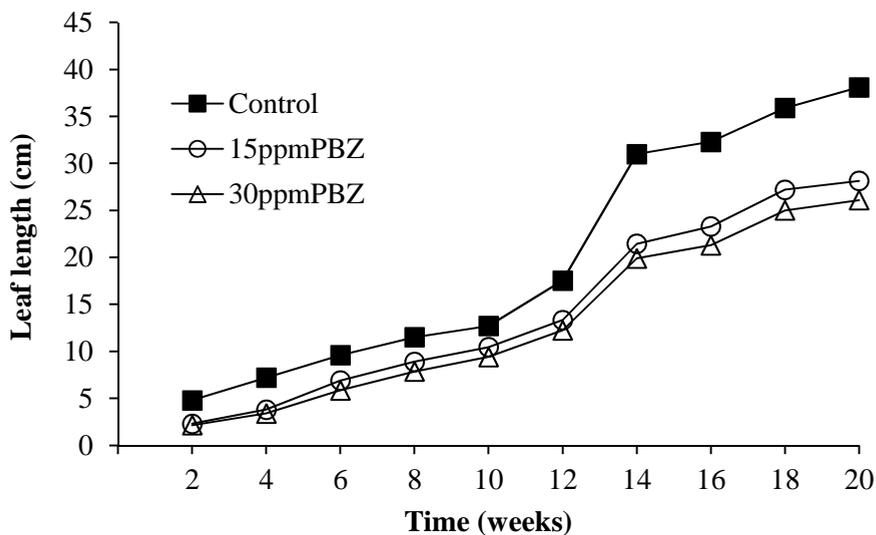


Figure 4. Effect of paclobutrazol (PBZ) treatment on leaf length of *Iris x hollandica* cv. 'Blue Magic' during greenhouse production period. The leaf length was started to measure 37 days after planting (1. week)

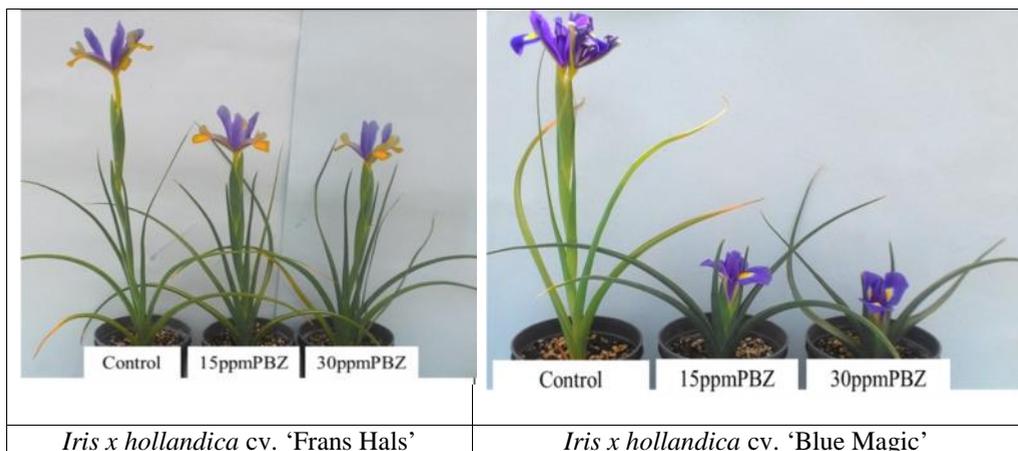


Figure 5. The effects of paclobutrazol (PB) bulb soak on *Iris x hollandica* cv. 'Frans Hals' and *Iris x hollandica* cv. 'Blue Magic'

CONCLUSIONS

Our results clearly indicated that plant growth regulators of paclobutrazol application controlled the plant height. Paclobutrazol shortened the leaf length and increased the chlorophyll content of leaves without shortening the flower life in iris cultivars. We found that paclobutrazol effectively controlled the plant height and there was no significant difference between doses. Therefore we suggest that the lower dose of paclobutrazol for 'Frans Hals' cultivar. However, paclobutrazol treatments caused excessive shortening of plant height in 'Blue Magic' cultivar which prevent the flower opening. Therefore we suggest that lower concentration of PBZ (<15 ppm) should be investigated for 'Blue Magic' cultivar.

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