

## Effects of Paclobutrazol on Vegetative and Reproductive Growth and Leaf Mineral Content of Mature Apricot (*Prunus armeniaca* L.) Trees

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### ABSTRACT

In the absence of dwarfing rootstocks for apricot (*Prunus armeniaca* L.), techniques that reduce vegetative growth while enhancing fruit quality and yield are important in the orchard management system. Four year old mature apricot trees cultivars Nasiri, 35Shahroodi, Jahangiri, Shahroodi and Noori on apricot seedling rootstocks, planted at a density of 1250 trees ha<sup>-1</sup> and grown at Tarbiat Modarres University (TMU) orchard were used. The effect of soil applied paclobutrazol (0.5 and 2 g tree<sup>-1</sup> a.i.) on apricot trees was studied over three years period during 1998-2000 seasons. Treatment effects on vegetative and reproductive growth characteristics and the leaf nutrient status of the apricot trees were determined. Results indicated that paclobutrazol (PBZ) significantly reduced vegetative growth during the experiment. The total pruning dry weight, shoot growth and trunk cross sectional area (TCSA) of treated trees were lower than those of the controls. Although, results showed that fruit load, crop density and total soluble solids (TSS) of fruits were not affected by applied treatments compared with the control. In addition, PBZ decreased nitrogen (N) concentration, but, phosphorus (P), potassium (K) and calcium (Ca) concentrations were not affected by the treatments. Chemical name of PBZ is: (2*RS*, 3*RS*)-1- (4-chlorophenyl)-4,4-dimethyl-2-(1*H*-1,2,4-triazol-1-yl)pentan-3-ol.

**Keywords:** Apricot, Fruit, Growth, Nutrient, Paclobutrazol, *Prunus armeniaca* L.

### INTRODUCTION

In the absence of dwarfing rootstocks for apricot, techniques that reduce vegetative growth are important in orchard management systems (Arzani, 1994). Elfving (1988) divided the management of vegetative growth into two categories; physiological and horticultural factors. Physiological factors are those inherent in the plant genome and genetic potential for scion and rootstock growth. This gives the possibility of controlling vegetative growth via managing horticultural factors such as shoot and root pruning, training systems, water control or using some plant growth regulators such as paclobutrazol (PBZ). Gaash (1986) stated that

1000-4000 ppm of PBZ on Canino apricot cultivar increased the yield and decreased the lateral shoot length. Kuden *et al.* (1995) considered that 250 ppm of PBZ decreased the shoot growth about 34.1-42.4% and increased the number of fruit buds. Blanco (1988) stated that PBZ decreased the shoot development and increased the average fruit size and yield of Crimsongold nectarines. In addition, Kaska *et al.* (1991) investigated the effect of PBZ on the reproductive and vegetative development of cherries, and indicated that the application of PBZ shoot elongation decreased and flower bud formation and yield were increased. Browning *et al.* (1992) investigated the effect of PBZ on the translocation of endogenous IAA (indol-3-acetic acid) in Doyenne du Comice pear cultivar,

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and found that PBZ caused a slower movement of IAA in shoot tips.

The usual application of paclobutrazol has been either by foliar spray or soil drenching. With foliar spray applications, absorption through mature leaves was limited and PBZ may be taken up through stem absorption (Barrett and Bartuska, 1988) or from excess dripping onto the soil. Elfving and Proctor (1986) have reported that protecting the soil from foliar drip reduced the PBZ-induced inhibition of extension growth in apples. When applied to the soil, a continuous supply of PBZ taken up by the roots is translocated acropetally via the xylem, thus maintaining the concentration of PBZ above the threshold required for the inhibition of gibberellin biosynthesis (Davis *et al.*, 1988). Paclobutrazol is physiologically an inhibitor of vegetative development of the plants.

Manipulations that successfully restrict vegetative growth at the critical periods for fruit set, growth, and maturation, enhance fruit set, increase fruit size, advance fruit maturation, and may improve fruit quality (Martin, 1989). Proebsting *et al.* (1989) suggested that successful fruit growing requires good management in maintaining sufficient vegetative and root growth to support maximum carbon fixation and assimilate partitioning for good fruit size, yield and quality. Lakso *et al.* (1989) noted the importance of maximizing early fruit development to increase carbohydrate partitioning into the fruit component over the whole season.

Kuden *et al.* (1995) reported that shoot growth in the apricot cv. Precoce de Colomer and Canino was affected by PBZ with increasing concentrations compared with the control where the shoot growth rate was reduced to 57.06% (Canino) and 65.67% (Precoce de Colomer). There were significant increases in both cultivars where the average number of fruit buds on 100 cm of shoot were obtained from 500 to 1000 ppm PBZ applications (Kuden *et al.* 1995). Paclobutrazol reduced shoot length, thickness, internode number and wood pruning weight per tree (Hussein *et al.*, 1998). Arzani *et al.*

(2000b) reported that PBZ application advanced flowering of five-year-old vigorous Sundrop apricot trees by 2-4 days, and increased fruit set, final fruit number, crop density and yield efficiency.

The use of growth retardants on the leaf mineral content of apricots has not been sufficiently investigated (Werner, 1993). Rieger (1990) reported that on Nemaguard peach trees using a hydroponics system showed that PBZ decreased N, P, K, Fe and Mo, whereas levels of Ca, Mg, B and Mn were increased. This indicated that the magnitude of changes in foliar nutrition were proportional to the degree of growth suppression. Another study on Fuji apple trees showed that differences in the total dry matter accumulated per kg of leaves were negligible (Huang *et al.* 1995). On the other hand, the leaf content of N, Ca, Mn, Zn and B contents increased under PBZ treatment while P, K, and Cu contents decreased in mango (Werner, 1993). Triazols influence root growth and morphology, which can alter the mineral uptake and plant nutrition (Pequerul *et al.*, 1997). It is not surprising that the PBZ-treatments increased N, P, K, Ca, Mg, B, Zn and Sr content in the leaves of pear trees (Wang *et al.* 1985). Rieger and Scalabrelli (1990) demonstrated in peach trees that the foliar concentrations of N, P, K and Fe decreased slightly, while Ca, Mg, B and Mn increased. On the contrary, Wieland and Wample (1985) explained that PBZ does not influence the foliar content of N, P, K and Mg in apple trees. Atkinson (1986) reported that growth regulators produced greater modifications in the vegetative growth than in fruits, which implies demand for certain elements and additional decreases of others. Monge *et al.*, (1993, 1994) showed an increase in Mn leaf concentration in peach trees.

The objective of this study was to explore and monitor the effect of two levels of PBZ on the vegetative, reproductive, and leaf nutrient content of important commercial Iranian apricot cultivars.

**Table 1.** Characteristics of the orchard soil.

| Description  | Depth (cm) | Saturation (%) | EC ( $\mu\text{mhos cm}^{-2} \text{ s}^{-1}$ ) | pH of paste | T.N.V. <sup>a</sup> % | Organic Carbon (%) |
|--------------|------------|----------------|--|-------------|-----------------------|--------------------|
| Between rows | 2.5-20     | 31             | 1.4  | 7.8         | 6                     | 0.86               |
| Between rows | 20-40      | 34             | 1.7  | 7.8         | 6                     | 0.98               |
| Inside rows  | 2.5-20     | 35             | 1.1  | 7.9         | 9                     | 1.00               |
| Inside rows  | 20-40      | 34             | 0.8  | 7.9         | 6                     | 0.76               |

| Description  | Depth (cm) | Total N (%) | P Ppm | K ppm | Cu ppm | Mn Ppm | Fe ppm | Zn ppm |
|--------------|------------|-------------|-------|-------|--------|--------|--------|--------|
| Between rows | 2.5-20     | 0.09        | 6.4   | 420   | 0.65   | 7.2    | 1.7    | 6.2    |
| Between rows | 20-40      | 0.1         | 4.6   | 160   | 0.44   | 4.3    | 1.2    | 2.9    |
| Inside rows  | 2.5-20     | 0.1         | 14.6  | 420   | 0.74   | 4.2    | 2.6    | 9.4    |
| Inside rows  | 20-40      | 0.08        | 7.6   | 320   | 0.64   | 2.2    | 2.4    | 8.3    |

<sup>a</sup> T. N. V. = Total Neutralizing Value

## MATERIAL AND METHODS

The experiment was carried out from the 1998 to the 2000 growing season in the research orchard, Department of Horticultural Science, Faculty of Agriculture, Tarbiat Modarres University (TMU), Tehran, Iran. The plant material selected were four year old apricot trees on apricot seedling root-stock, cultivars were Nasiri, 35Shahroodi, Jahangiri, Shahroodi and Noori.

The soil type was sandy clay loam with gravelly coarse sand. Soil samples were obtained at 0 to 20 and 20 to 40 cm depths and analyzed for some factors such as electrical conductivity (EC), pH and mineral nutrient concentration (Table 1). The experiments were strip plot based on a randomized complete block design (RCBD) with apricot cultivars as 5 horizontal factors and PBZ as 3 vertical factors and with 4 replications. Paclobutrazol treatments were 0, 0.5 and 2 g tree<sup>-1</sup>. The PBZ was a growth retardant, formulated as Cultar a 250 g l<sup>-1</sup> in suspension concentrate (ICI, New Zealand Limited). Paclobutrazol was applied to the soil as a trunk base drench at two rates of 0.5 g tree<sup>-1</sup> (L-PBZ) and 2 g tree<sup>-1</sup> a. i. (H-PBZ) dissolved in water and poured into a 5 cm deep soil furrow within 25 cm around the trunk and applied at the beginning of the flowering period in the 1998 growing season.

The trunk circumference of each tree 10 cm above the graft union was measured 28, 90 and 153 days after full bloom (DAFB) during the 1998, 1999 and 2000 growing seasons. Data collected was used to calculate trunk cross sectional area (TCSA).

The length of eight tagged shoots in the middle region of the canopy on each tree was recorded using a metric tape at the end of the 1998 and 1999 growing seasons. The mean values of eight-recorded shoot lengths were used for data analysis on shoot growth. During the winter, pruning practices performed were done to remove excessive vegetative growth after allowing for renewal of fruiting sites. In the 1998 growing season, all the pruned limbs were collected, and placed in labeled paper bags, oven dried at 70°C for two weeks, and weighed.

The number of fruits at harvest time on each tree were counted in the 1998 and 1999 growing seasons and crop density (CD) was calculated using the following formula:  $CD = NF/TCSA$ ; where CD is fruit number cm<sup>-2</sup> TCSA; NF is the total number of fruits at the time of fruit harvest and TCSA is the trunk cross sectional area (Lombard *et al.* 1988).

In addition, fruit were harvested at commercial maturity based on background color and were picked on four dates in the 1998 season, so this data and mean fruit weight (fruit size) were not statistically analyzed

**Table 2.** The effect of paclobutrazol (PBZ) application and cultivar on shoot growth and pruning dry weight in apricot trees.

| Cultivars                  | Year | Shoot growth (cm) |           |             | Pruning dry weight (g) |           |          |
|----------------------------|------|-------------------|-----------|-------------|------------------------|-----------|----------|
|                            |      | Control           | L-PBZ     | H-PBZ       | Control                | L-PBZ     | H-PBZ    |
| Nasiri                     | 1998 | 74.97 a           | 66.22 abc | 64.97 abcd  | 204.4 a                | 62.24bc   | 50.96 bc |
|                            | 1999 | 26.69 abcd        | 20 bcde   | 18.56 cde   |                        |           |          |
| 35Shahroodi                | 1998 | 69.2 ab           | 57.62 bcd | 50.24 d     | 150.8 ab               | 70.40 bc  | 60.93 bc |
|                            | 1999 | 24.25 abcde       | 16.13 e   | 20.56 bcde  |                        |           |          |
| Jahangiri                  | 1998 | 70.60 ab          | 62.62abcd | 63.62 abcd  | 50.63 bc               | 81.53 abc | 60.43 bc |
|                            | 1999 | 23.63 abcde       | 18de      | 16.81 e     |                        |           |          |
| Shahroodi                  | 1998 | 61.15 abcd        | 60.47abcd | 55.90 bcd   | 99.32 abc              | 146.6 abc | 12.3 c   |
|                            | 1999 | 29.31 a           | 26.88abc  | 21.13 abcde |                        |           |          |
| Noori                      | 1998 | 68 ab             | 50.18d    | 52.66 cd    | 91.15abc               | 51.95 bc  | 57.1 bc  |
|                            | 1999 | 28.2 ab           | 16.24e    | 18.47 cde   |                        |           |          |
| All cultivars <sup>a</sup> | 1998 | 68.79 a           | 59.42b    | 57.48 b     | 119.3 a                | 82.54 ab  | 48.34 b  |
|                            | 1999 | 26.38 a           | 19.45b    | 19.11 b     |                        |           |          |

<sup>a</sup> Pooled data<sup>Z</sup>Mean separation between cultivars or between PBZ concentrations by Duncan multiple range tests at  $P \leq 0.05$ .

and used just for visual observation for treatment evaluation. Also, total soluble solids (TSS) of fruits were recorded using a hand-held temperature compensating Atago N-20 refractometer (brix range from 0-20% at 20°C).

Measurements of major leaf mineral nutrients such as N, P, K and Ca, from the mature leaves were made around the middle canopy zone from current season shoots in late July 2000. One hundred leaves per tree were sampled and oven dried at 70°C for 48 hours. Potassium was determined by atomic emission spectroscopy in a flame photometer apparatus. Atomic absorption spectrometry and spectrophotometer measured Ca and P, respectively. Nitrogen was determined by the Kjeldahl method. The data were analyzed statistically using the analysis of variance and Duncan's multiple range test ( $P \leq 0.05$ ) to evaluate the significance of differences between treatment means.

## RESULTS

### Shoot Growth and Pruning Dry Weight

Based from the results obtained, there was

no significant difference observed between the varieties (in control) in terms of shoot growth during the 1998 and 1999 growing seasons (Table 2). However, PBZ treatments significantly ( $P \leq 0.05$ ) reduced shoot growth compared with the control in the both 1998 and 1999 growing seasons (Table 2). Apricot cultivar Jahangiri (control) had the lowest pruning dry weight in the 1998 growing season and the differences among most of cultivars were not significant (Table 2). The amount of new season shoot growth in terms of pruning dry weight was significantly decreased ( $P \leq 0.05$ ) by PBZ treatments when compared with the control but the differences among two concentrations was not significant.

### Trunk Cross Sectional Area (TCSA)

Changes in TCSA throughout the experiment are shown in Table 3 indicating differences between cultivars used were not significant, so with pooled data on all cultivars of PBZ treatments in the first season of 1998 where apricot trees showed no effect on TCSA (Table 3). However, in the second and third seasons (1999 and 2000), the control treatments showed significantly higher

**Table 3.** The effect of paclobutrazol (PBZ) application and cultivar on trunk cross sectional area (TCSA) in apricot trees.

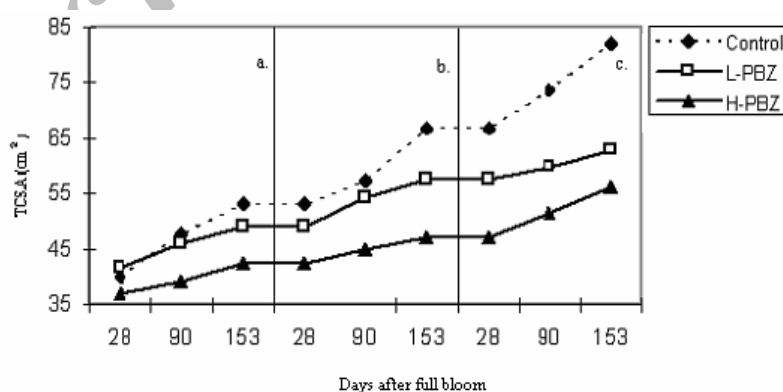
| Cultivars                  | Year | Trunk cross sectional area (cm <sup>2</sup> ) |            |            |
|----------------------------|------|---|------------|------------|
|                            |      | Control                                       | L-PBZ      | H-PBZ      |
| Nasiri                     | 1998 | 46.88 abcd                                    | 45.5 abcd  | 39.47 bcd  |
|                            | 1999 | 59.02 ab                                      | 53.66 abcd | 44.73 cd   |
|                            | 2000 | 74.11 ab                                      | 59.19 bcd  | 51.53 d    |
| 35Shahroodi                | 1998 | 48.03 abc                                     | 46.88 abcd | 40.11 bcd  |
|                            | 1999 | 57.05 abcd                                    | 54.37 abcd | 45.12 bcd  |
|                            | 2000 | 74.39 ab                                      | 68 abc     | 55.51 cd   |
| Jahangiri                  | 1998 | 39.26 bcd                                     | 36.58 cd   | 35.96 d    |
|                            | 1999 | 52.23 abcd                                    | 43.97 cd   | 43.51 d    |
|                            | 2000 | 68.63 abc                                     | 54.71 cd   | 52.79 d    |
| Shahroodi                  | 1998 | 44.83 abcd                                    | 44.47 abcd | 46.34 abcd |
|                            | 1999 | 54.54 abcd                                    | 51.33 abcd | 52.23 abcd |
|                            | 2000 | 69.63 abc                                     | 59.39 bcd  | 63.09 abcd |
| Noori                      | 1998 | 54.16 a                                       | 41.45 bcd  | 49.09 ab   |
|                            | 1999 | 61.68 a                                       | 46.06 bcd  | 57.63 abc  |
|                            | 2000 | 77.47 a                                       | 59.98 bcd  | 69.41 abc  |
| All cultivars <sup>a</sup> | 1998 | 46.63 a                                       | 42.98 a    | 42.20 a    |
|                            | 1999 | 56.90 a                                       | 49.88 b    | 48.64 b    |
|                            | 2000 | 72.85 a                                       | 60.26 b    | 58.47 b    |

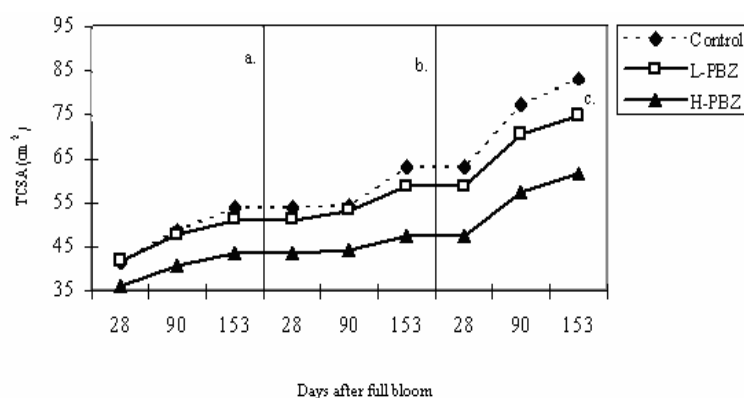
<sup>a</sup> Pooled dataZ Mean separation between cultivars or between PBZ concentrations by Duncan multiple range tests at  $P \leq 0.05$ .

TCSA than PBZ treatments ( $P \leq 0.05$ ), but the differences among the two PBZ treatments were not significant (Table 3; Figures 1, 2, 3, 4 and 5).

### Fruit Number, Crop Density, TSS, Yield and Fruit Maturity

The influence of treatments on fruit number, crop density and TSS were not signifi-

**Figure 1.** Effect of paclobutrazol treatment on TCSA of apricot cv. Nasiri a) 1998 b) 1999 and c) 2000 growing seasons.



**Figure 2.** Effect of paclobutrazol treatment on TCSA of apricot cv. 35 Shahroodi a) 1998 b) 1999 and c) 2000 growing seasons.

cantly different (Table 4 & 5). In the first growing season (1998) it shows significant differences in fruit number among cultivars and so this differences led to the differences in harvestable yield (Table 4). The highest yield was showed in Jahanghiri cultivar and the lowest was in 35Shahroodi (Figure 6).

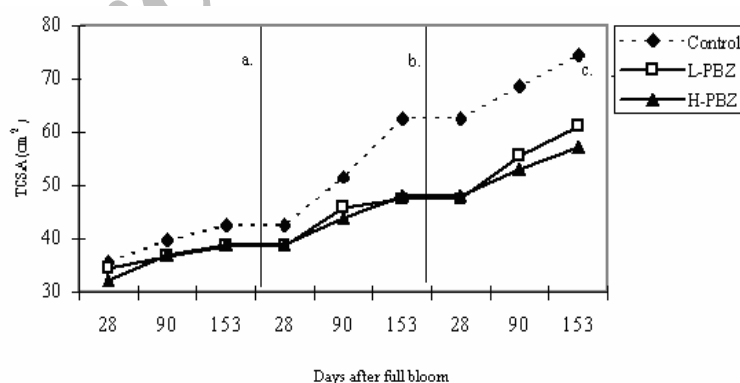
### Leaf Nutrients

The results obtained on leaf nutrients (Table 6) indicated significant differences among cultivars used; the significant differ-

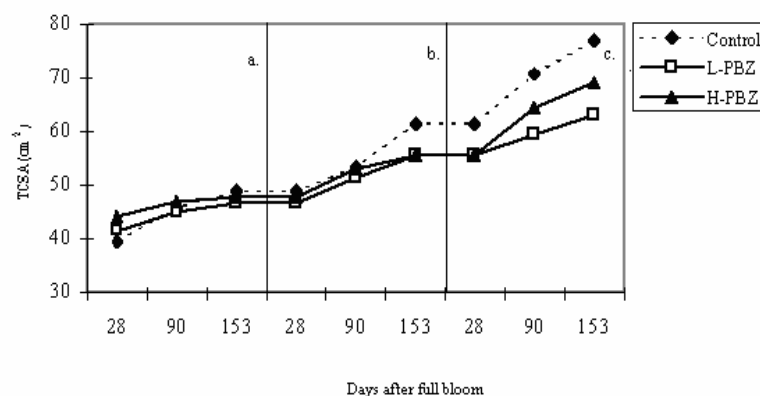
ences were observed in leaf nitrogen content ( $P \leq 0.05$ ), L-PBZ and control treatments; but on P, K and Ca the differences were insignificant.

### DISCUSSION

High vegetative growth needs special management related to high fruit production cost because of problems such as delaying the fruit ripening and low yield in apricot trees. Such phenomena relate (a) directly to the competition between vegetative and fruit



**Figure 3.** Effect of paclobutrazol treatment on TCSA of apricot cv. Jahangiri a) 1998 b) 1999 and c) 2000 growing seasons.



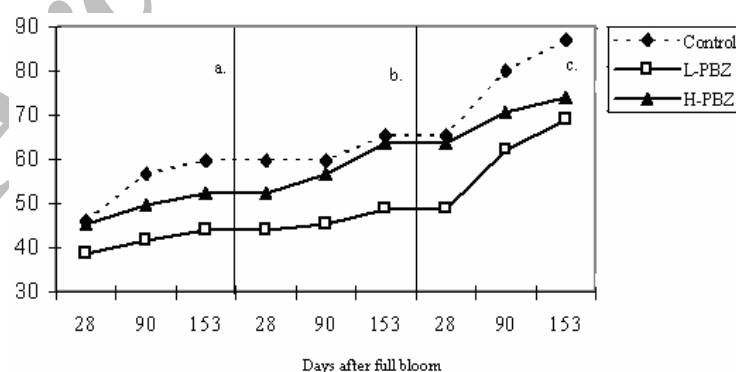
**Figure 4.** Effect of paclobutrazol treatment on TCSA of apricot cv. Shahroodi a) 1998 b) 1999 and c) 2000 growing seasons.

growth for carbohydrates, mineral elements, water and plant hormones and (b) indirectly by increasing shading within the canopy which leads to reduction in yield fruit quality and an increase in water requirements (Arzani, 1994). Therefore, higher yield and better fruit quality in apricot vegetative growth needs to be controlled. Without the need of dwarfing rootstocks for apricot trees and with restrictions and problems associated with using vigor control techniques such as root pruning and regulated deficit irrigation (RDI) (Arzani, 1994; Arzani *et al.* 1999 and 2000c), one suitable solution for

this problem is the use of plant growth regulators (Rai and Bist, 1992).

The results indicated that vegetative growth in terms of shoot growth and pruning dry weight decreased in all apricot cultivars (Table 2). Similar results have previously been reported on apricot trees (Salvador *et al.*, 1991; Arzani, 1994; Arzani, *et al.* 2000b and Kuden *et al.*, 1995).

The trunk cross sectional area (TCSA) is an important factor for vegetative growth and is inversely related to yield and fruit growth. Any factor reducing TCSA will be useful for increasing output efficiency and



**Figure 5.** Effect of paclobutrazol treatment on TCSA of apricot cv. Noori a) 1998 b) 1999 and c) 2000 growing seasons.

**Table 4.** The effect of paclobutrazol (PBZ) application and cultivar on fruit number and crop density in apricot trees.

| Cultivars                  | Year | Fruit number |           |           | Crop density (Fruit no.cm <sup>-2</sup> TCSA) |           |          |
|----------------------------|------|--------------|-----------|-----------|---|-----------|----------|
|                            |      | Control      | L-PBZ     | H-PBZ     | Control                                       | L-PBZ     | H-PBZ    |
| Nasiri                     | 1998 | 126 cde      | 84.75 cde | 150 bcd   | 3.378 bc                                      | 2.7888 cd | 4.258 b  |
|                            | 1999 | 42.5 a       | 20 a      | 28.75 a   | 0.787 a                                       | 0.437 ab  | 0.625 ab |
| 35Shahroodi                | 1998 | 0 e          | 50 cde    | 2 e       | 0 c   | 1.09 bc   | 0.063 c  |
|                            | 1999 | 0 a          | 8.5 a     | 1.25 a    | 0 b   | 0.215 ab  | 0.03 b   |
| Jahangiri                  | 1998 | 260.8 ab     | 296.5 a   | 281.5 a   | 7.448 a                                       | 9.188 a   | 8.292 a  |
|                            | 1999 | 26.25 a      | 60 a      | 11 a      | 0.615 ab                                      | 1.405 a   | 0.254 ab |
| Shahroodi                  | 1998 | 21.75 de     | 46.75 cde | 38.25 cde | 0.545 c                                       | 0.972 bc  | 0.772 bc |
|                            | 1999 | 30 a         | 30 a      | 48 a      | 0.522 a                                       | 0.54 a    | 0.8 a    |
| Noori                      | 1998 | 137 bcde     | 96.5 cde  | 168 abc   | 2.95 bc                                       | 2.54 bc   | 3.358 bc |
|                            | 1999 | 22.5 a       | 17.5 a    | 52.5 a    | 0.292 ab                                      | 0.35 ab   | 0.84 ab  |
| All cultivars <sup>a</sup> | 1998 | 109.3 a      | 114.5 a   | 127.9 a   | 2.864 a                                       | 3.317 a   | 3.349 a  |
|                            | 1999 | 24.25 a      | 27.2 a    | 28.3 a    | 0.443 a                                       | 0.589 a   | 0.51 a   |

<sup>a</sup> Pooled data<sup>z</sup> Mean separation between cultivars or between PBZ concentrations by Duncan multiple range tests at  $P \leq 0.05$ .

crop density. In this study, there was no significant difference in the TCSA growth pattern on treated and untreated trees in the 1998 growing season but in the 1999 and 2000 growing seasons, TCSA growth was restricted by both PBZ treatments when compared with the control. Arzani (1994) reported similar results on the reduction of TCSA growth of Sundrop apricot trees treated with PBZ when compared with control trees. The results obtained in this study indicated that all cultivars showed a similar response to PBZ treatments and similar patterns in term of TCSA growth during three years of study (Figures 1, 2, 3, 4 and 5).

In the present research, the fruit load of each cultivar (Table 4) in treated and untreated trees was insignificant. Although, the lack of or low number of fruit in some cultivars possibly was due to poor pollination, diverse environmental conditions and frost damage at flowering time. There was a significant difference between cultivars in the 1998 growing season in which Jahangiri showed more fruit (279.6 fruits per tree) and 35Shahroodi showed less (17.33 fruits per tree). Crop density showed a similar pattern in all cultivars, with Jahangiri giving higher crop density followed by Shahroodi > Nasiri

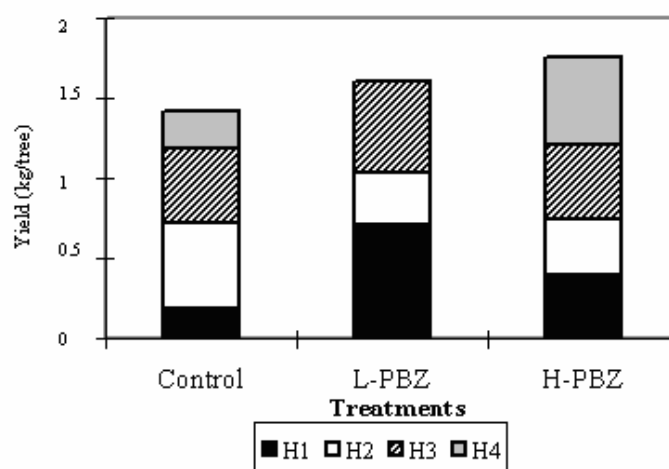
> Late Noori > 35 Shahroodi. The vegetative growth was decreased by the application of treatments, indicating positive effects on fruit growth, yield and fruit quality, which is possibly related to the allocation of more carbohydrates to the fruits at the expense of reduction in shoot growth. Arzani (1994) described how the reduction in vegetative growth leads to an increase light penetration,

**Table 5.** The effect of paclobutrazol (PBZ) application and cultivar on fruits total soluble solids (TSS) in apricot trees in the 1998 growing season.

| Treatments <sup>a</sup> | Total Soluble Solids (°Brix) |
|-------------------------|------------------------------|
| Control                 | 16.37a                       |
| L-PBZ                   | 16.61a                       |
| H-PBZ                   | 17.67a                       |
| Cultivars <sup>a</sup>  |                              |
| Nasiri                  | 17.88a                       |
| 35Shahroodi             | 18.21a                       |
| Jahangiri               | 17.32a                       |
| Shahroodi               | 14.97a                       |
| Noori                   | 16.04a                       |

<sup>a</sup> Pooled data<sup>z</sup> Mean separation between cultivars or between PBZ concentrations by Duncan multiple range tests at  $P \leq 0.05$ .



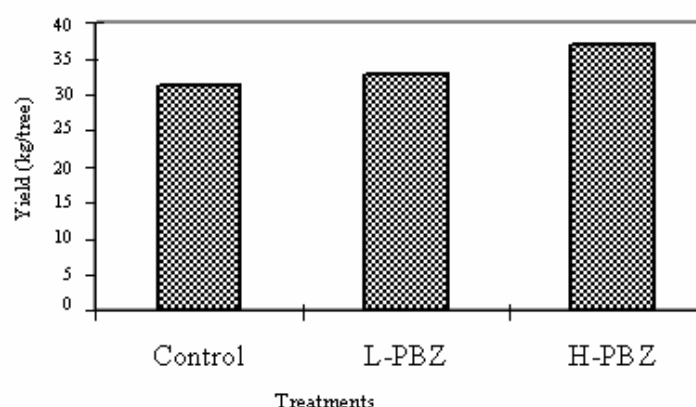


**Figure 6.** Effect of PBZ on the yield of apricot trees in the 1998 growing season. H1, H2, H3 and H4 are first, second, third and fourth fruit harvests, respectively.

improved photosynthetic activity, and better fruit quality. The amount of early maturing fruits increased at the first picking date on the PBZ treated trees, which led to higher returns for the orchardist. The effect of PBZ on fruit maturity as agreed with the previous report of Subharabadhu *et al.* (1990) and Arzani *et al.* (2000b) on apricots. The effect of PBZ, cultivars and interaction of PBZ-cultivar on TSS was insignificant.

The results of leaf analysis in the 2000 growing season showed that PBZ treatments had a negative effect on the amount of leaf

N concentration (Table 6) as well as the amount of leaf P concentration. Pequerel *et al.* (1997) reported that PBZ increased leaf the P level, but Mark (1996) and Rieger (1990) observed that PBZ decreased the P level in the leaf. The K and Ca concentrations were not affected by hormone concentration and this agreed with the results of Pequerel *et al.* (1997); but Werner (1993) on mango and Rieger (1990) writing on peaches reported that PBZ increased Ca concentrations in plants.



**Figure 7.** Effect of PBZ on the fruit size of apricot trees in the 1998 growing season.

**Table 6.** The effect of paclobutrazol (PBZ) and cultivar on leaf mineral content of apricot trees during the 2000 growing season.

| Cultivars                  | Paclobutrazol | N (% D.W) | P (% D.W) | K (% D.W)    | Ca (% D.W) |
|----------------------------|---------------|-----------|-----------|--------------|------------|
| Nasiri                     | Control       | 3.17 a    | 0.266 abc | 2.05 abcd    | 1.187 ab   |
|                            | L-PBZ         | 1.98 bc   | 0.188 c   | 1.959 abcde  | 1.149 abc  |
|                            | H-PBZ         | 2.33 bc   | 0.344 a   | 2.169 ab     | 1.21 a     |
| 35Shahroodi                | Control       | 2.59 ab   | 0.258 abc | 1.338 ef     | 1.02 bcd   |
|                            | L-PBZ         | 2.275 bc  | 0.326 a   | 1.465 cdef   | 1.03 bcd   |
|                            | H-PBZ         | 2.219 bc  | 0.3 ab    | 1.71 bcdef   | 1.12 abcd  |
| Jahangiri                  | Control       | 2.537 abc | 0.201 bc  | 2.04 abc     | 1.23 a     |
|                            | L-PBZ         | 2.2 bc    | 0.245 abc | 1.8 abcdef   | 1.25 a     |
|                            | H-PBZ         | 2.33 bc   | 0.305 ab  | 1.839 abcdef | 1.186 ab   |
| Shahroodi                  | Control       | 1.95 bc   | 0.262 abc | 2.38 a       | 1.26 a     |
|                            | L-PBZ         | 2.2 bc    | 0.341 a   | 1.867 abcdef | 1.26 a     |
|                            | H-PBZ         | 2.4 bc    | 0.29 abc  | 1.54 bcdef   | 1.09 abcd  |
| Noori                      | Control       | 2.008 bc  | 0.262 abc | 1.387 def    | 0.97 d     |
|                            | L-PBZ         | 1.89 bc   | 0.25 abc  | 1.85 abcdef  | 1.14 abc   |
|                            | H-PBZ         | 1.75 c    | 0.26 abc  | 1.307 f      | 0.99 cd    |
| All cultivars <sup>a</sup> | Control       | 2.451 a   | 0.25 a    | 1.835 a      | 1.133 a    |
|                            | L-PBZ         | 2.109 b   | 0.27 a    | 1.79 a       | 1.166 a    |
|                            | H-PBZ         | 2.206 ab  | 0.299 a   | 1.713 a      | 1.119 a    |

<sup>a</sup> Pooled dataZ Mean separation between cultivars or between PBZ concentrations by Duncan multiple range tests at  $P \leq 0.05$ .

## CONCLUSION

Apricot breeders are interested in including Iranian apricot genotypes in their apricot collection orchards and gene pools due to good fruit performance, quality and the other positive genetic attributes. According to Bailey and Hough (1975), Iran is one of the centers of origin of wild and cultivated apricots. The PBZ had been used for controlling vegetative growth of five famous and commercial apricot cultivars including Nasiri, 35Shahroodi, Jahangiri, Shahroodi and Noori under Tehran environmental conditions. There was no significant difference between the cultivars used and the data were pooled in all cultivars. Paclobutrazol as a successful growth control technique had been used on Sundrop apricot (Arzani, 1994; Arzani *et al.*, 2000b; Arzani *et al.*, 2000c). The soil condition (Table 1) led to the lesser effect of H-PBZ treatment, thus the effect of both PBZ concentrations in this study was similar. According to the ICI (Imperial Chemical Industries) technical data sheet as

reported by Beech *et al.*, (1989), the half-life of PBZ varies with soil type and climatic conditions, but is generally between 6 and 12 months. The negative effect of PBZ on vegetative growth observed in this study agrees with previously results on the other fruit trees such as apricots (Arzani, 1994). Paclobutrazol treated apricot trees showed lower vegetative growth with no negative effect on fruit load, quality and yield. In addition, there was evidence that PBZ enhanced fruit maturity in apricots.

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### اثر پکلوپوترازول بر روی رشد رویشی و رشد زایشی، و مواد معدنی برگ درختان بالغ زردآلو (*Prunus armeniaca* L.)

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#### چکیده

در یک سیستم مدیریت باغ زردآلو (*Prunus armeniaca* L.) و به منظور بهبود بخشیدن به کیفیت میوه و محصول و در شرایطی که پایه پاکوتاه کننده برای زردآلو وجود ندارد، استفاده از روش هایی که رشد رویشی را کاهش دهد از اهمیت برخوردار است. بدین منظور درختان ۴ ساله و بالغ زردآلو (بر روی پایه بذری زردآلو) شامل ارقام نصیری، ۳۵ شاهرودی، جهانگیری، شاهرودی و نوری که با تراکم ۱۲۵۰ درخت در هکتار در باغ دانشگاه تربیت مدرس کاشته شده بودند مورد استفاده قرار گرفتند. تاثیر کاربرد خاکی پکلوپوترازول (PBZ) (۰/۵ و ۲ گرم ماده

مؤثره به ازاي هر درخت) بر روي درختان زردآلو به مدت ۳ سال طی سالهاي ۱۳۷۷-۱۳۸۰ مورد مطالعه قرار گرفت. اثر تیمار بر روي خصوصیات رشد رویشي و زایشي و وضعیت مواد غذایی برگ درختان زردآلو اندازه گیری شد. نتایج نشان داد که در طول آزمایش پکلوبوترازول بطور معنی داري باعث کاهش رشد رویشي گردید. درختان تیمار شده با پکلوبوترازول در مقایسه با درختان شاهد، میزان کل وزن خشک هرس، رشد شاخه و سطح مقطع تنه (TCSA) کمتری داشتند. اگرچه نتایج نشان داد پکلوبوترازول تاثیری بر تعداد میوه، تراکم محصول (CD) و مواد جامد محلول (TSS) در میوه درختان تیمار شده در مقایسه با شاهد نداشت. بعلاوه، پکلوبوترازول باعث کاهش در میزان نیتروژن (N) گردید ولی فسفر (P)، پتاسیم (K) و کلسیم (Ca) برگ تحت تاثیر تیمار با پکلوبوترازول قرار نگرفت.