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Effects of Shoot Girdling and Urea Combined with 6 -Benzyl Adenine on Abscission of Inflorescence Buds in "Ohadi" Pistachio Cultivar (*Pistacia vera* L.)

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ABSTRACT

The effect of shoot girdling and urea combined with 6 -benzyl adenine (BA) on the abscising inflorescence buds on trees of 'Ohadi' cultivar of pistachio were investigated during 2000 - 02. Girdling treatments were carried out at the base of shoot on June 10 and July 12 of each year. In addition, 0.5% of urea combined with four concentrations of 6 -benzyl adenine (BA) (0, 25, 50, 100 mg L^{-1}) was used foliarly either on early June before kernel development or on early July during the kernel development and initial period of bud abscission. Results showed that girdling treatment decreased the percentage of inflorescence bud abscission. It was 27.35%, 41.51% and 66.74% for June and July girdling treatments and control, respectively. June girdling was more effective and increased dry weight of selected current year's shoots. Also, 6 -benzyl adenine reduced inflorescence bud abscission compared to control but no significant difference was found among different concentrations of BA. Both treatments, foliar application of BA combined with urea and shoot girdling, could be used for relative control of the abscission of inflorescence buds in pistachio orchards.

Key Words: Pistachio; Inflorescence bud; Abscission; Girdling; 6 -benzyl adenine

INTRODUCTION

Although alternate bearing is common among fruit tree species but in pistachio (*Pistacia vera* L.) it is considered as a masting un-usual phenomenon and is not the result of poor flower initiation as other fruit trees, it arises as a result of inflorescence bud abscission, which usually occurred through "On" year and bud retention through "Off" year (Crane & Nelson, 1971; Stevenson & Shackel, 1998). Although this phenomenon is still elusive, Monselise and Goldschmidt (1982) described the possible external and internal factors, which may cause alternate bearing in pistachio and other fruit trees: environmental and genetic factors play an important role. These factors affect carbohydrates, plant growth substances (i.e. promoters & inhibitors), mineral elements balance, metabolites levels etc. Initially Crane and Nelson (1972) showed that de-fruiting, girdling and auxin application substantiated the notion that dominance of developing ovaries and seeds over the inflorescence buds in competition for metabolites was primarily responsible for bud abscission. The role of carbohydrates in inflorescence bud abscission in pistachio has also been investigated. Other studies by Crane *et al*. (1976) and Crane and Alshalan (1977) found that sugar and starch concentrations were similar in fruiting and non-fruiting branches but Takeda *et al*. (1980) indicated that carbohydrate deficiency could be responsible for bud drop. Takeda and Crane (1980) found that inflorescence buds on de-fruited trees accumulated twice as much ^{14}C-photosynthates as those on fruiting trees indicating that carbohydrate deficiency may be responsible for the bud drop. Nzima *et al*. (1997) and Vemmos (1999) also reported that accumulation of starch in inflorescent buds of "Off" trees was higher than "On" trees. Talaie *et al*. (2003) showed that soluble carbohydrate declined from June to August in "On" and July to August in "Off" trees and caused flower bud abscission.

Porlingis (1974) suggested that hormones produced in seeds move to the inflorescence buds and acts on the bud base to create abscission zone. Also, in relation to plant growth substances, neither abscisic acid levels in developing kernels nor in the developing inflorescence buds themselves were found to be related to abscission of inflorescence buds (Takeda & Crane, 1980) and the levels of gibberellins like substances in developing fruits and inflorescence buds have no relation to abscission (Lin *et al*., 1984). Crane and Nelson (1972) evaluated the effect of auxin and Vemmos *et al*. (1994) studied the effect of ethylene on abscission of inflorescence buds in pistachio. Auxins like 2, 4 -D and para-chloro phenoxy acetic acid (PCPA) decreased the abscission percentage when applied on whole trees (Ferguson & Maranto, 1989) but none of them were directly implicated in bud abscission. Additionally, un-balanced nutrition was not the primary cause of bud abscission (Crane & Al-shalan, 1977). Wolpert nd Ferguson (1990) expressed that although final bud retention was positively correlated with nitrogen concentration in leaves, nitrogen sprays did not alter bud abscission. Vemmos (1999) showed

that concentration of K was higher in leaves and buds of "Off" trees compared with "On" trees and explained the possible role of K in bud retention. It is known that girdling shoots or branches may cause a series of physiological changes above the "ring", such as reduced growth, accumulation of carbohydrates and/or other organic substances, which affect the hormonal balance of the shoot (Hartman *et al.*, 2002). Thus girdling has often been used to manipulate tree growth, flower initiation, fruit set and development, fruit size, yield and quality (Goldschmidt *et al*., 1985; Cutting & Lyne, 1993; Vemmos, 2005). Lovatt and Ferguson (1994) reported that neither separate application of 6 -benzyl adenine nor urea was so successful in controlling abscission of inflorescence buds but the effect of foliar application of urea combined with 6 -benzyl adenine in decreasing inflorescence bud abscission in 'Kerman' cultivar in an "On" year led to increase the next year yield. However, in previous studies the effect of different concentrations of 6 -benzyl adenine and shoot girdling times were not experienced. Also, most of studies in this field were restricted only to 'Kerman' cultivar in California.

The objective of this study was to investigate either determination of girdling times or application of urea combined with different concentrations of 6 -benzyl adenine on abscission of inflorescence buds and subsequent control of alternation in 'Ohadi' which is the most important Iranian pistachio cultivar.

MATERIALS AND METHODS

These experiments were conducted on bearing 'Ohadi' cultivar at Pistachio Research Station, Kerman, Iran, during 2000 - 02. Urea (0.5%) combined with four concentrations of benzyl adenine (BA) (0, 25, 50, 100 mg L^{-1}) were used as foliar application on whole selected bearing trees in the morning either on early June before kernel development or on early July during the kernel development and initial period of bud abscission. Also, two trees in each block with four replicates were selected and 10 shoots on each tree were chosen for uniformity in length, diameter and number of inflorescence buds. A 5 mm wide ring of bark was removed on June 10 at the base of the shoot each year. In addition, 10 shoots were sampled at random for each treatment on late September and the mean of bud abscission percentage of these branches was determined as abscission percentage of each treatment. In order to measure dry weight (DW) of current year's shoots, selected branches were placed in an oven at 70°C until dry weight stabilized. Statistical analysis was performed as randomized complete block design and mean differences were examined using Duncan's Multiple Range test.

RESULTS AND DISCUSSION

Results showed that girdling decreased flower bud abscission ($P < 0.05$). No significant difference was found between June and July girdling treatments but June girdling was more effective and increased DW of selected current year's shoots (Table I) and the effect of year was not significant ($P > 0.05$). Wolpert and Ferguson (1990) in particular, determined that bud retention was proportional to branch size. Overall, these results showed that bud abscission can be strongly influenced by the presence of fruit on the same or adjacent shoots. Fruit removal from individual shoots enhanced bud retention (Porlingis, 1974; Wolpert & Ferguson, 1990; Caruso *et al.*, 1992). These studies confirmed the role of fruits as a strong sink and its role in bud abscission. Girdling treatment probably changes sink-source relationships and temporarily prevents translocation of assimilates, hormones and nutrient elements to the roots. Greater bud retention on shoots treated with girdling is possibly due to the separation of inflorescence buds from the strong assimilates and nutrient sink of the fruits. It may be concluded that a reduction in metabolites reaching the inflorescence buds followed by reduced bud growth could trigger inflorescence bud abscission as other developing organs such as leaves, flowers and fruits (Schneider, 1977).

Studies by Goldschmit and Huber (1992), Zhow and Quebedeaux (2003) showed that increased sucrose and starch accumulation in leaves, caused by girdling reduced the rate of photosynthesis. Subsequent work by Vemmos (2005) confirmed that girdling sharply decrease the rate of photosynthesis in pistachio. Therefore, the accumulation of starch in leaves of girdled shoots possibly reduced photosynthetic rates with a consequent decrease in the levels of primary photosynthetic products such as fructose and in some cases, inositol and glucose. Reduced concentration of most nutrients in leaves caused by girdling appears to be an indirect effect. It is believed that phloem tissue in girdle zone is never produced and continuous girdling decreases transition stages gradually (Hartmann *et al*., 2002). Dry weight of each year's shoots girdled in June was higher compared to those of July ($P < 0.01$). Results also showed that 6 -benzyl adenine reduced bud abscission compared to the control shoots but the effects of several concentrations of BA and year were not significant (Table II).

Probably benzyl adenine as a cytokinin and urea as a nitrogen supply compound delayed the senescence stages of buds and increased the entrance of photosynthetic compounds, hormones and other metabolites to inflorescence buds, which are so important for preventing bud abscission. Earlier studies by Porlingis (1974) showed that competition for nitrogen absorption between floral buds and developing nuts might lead to decrease the nitrogen level in floral buds and subsequent indirect abscission. Lovatt and Ferguson (1994) reported that cytokinins like isopentenyladenine and zeatin riboside decreased during the time of bud abscission. They also studied the effect of foliar application of urea combined with 6 -benzyl adenine on inflorescence bud abscission in 'Kerman' cultivar. They concluded that urea combined with BA prevented the

Table I. Effect of girdling time on percentage mean of inflorescence bud abscission and dry weight of current year's shoots (DW) during 2000 and 2002

Treatment	Abscission %	DW (g)
June	27.35 b	5.05 a
July	41.51 b	1.53 b
Control	67.43 a	1.63 b
Coefficient of variability %	24.00	26.30

Values followed by a different letter are statistically different for the comparison of treatment means (P<0.05) for abscission percentage and (P<0.01) for DW.

Table II. Effect of different concentrations of 0.5% urea combined with 6-benzyl adenine on percentage mean of inflorescence bud abscission during 2000 and 2002

BA (mg/L) + 0.5 % urea	Abscission %
0	69.74 a
25	39.62 b
50	43.70 b
100	39.76 b
Coefficient of variability %	22.70

Values followed by a different letter are statistically different for the comparison of treatment means (P<0.05).

abscission of inflorescence buds 2 - 3 fold compared to control shoots and our results confirmed these findings. We found that either application of urea combined with BA or shoot girdling were effective in preventing abscission and controlling alternate bearing in 'Ohadi' pistachio cultivar. It seems that both cultivars 'Ohadi' in Iran and 'Kerman' in California had similarity in responding to urea combined with BA. Urea (0.5%) combined with 25 mg L^{-1} BA decreased abscission 2 fold compared to control and could be practical and advisable to orchardists regard to cultivar response, orchard location and management, environmental conditions, etc. Although June girdling was considerably effective in preventing abscission of inflorescence buds 2 - 3 fold in comparison to control shoots, considering physiological and morphological traits of trees and also skills during shoot girdling is necessary.

High quality and quantity of production with logical orchard management programs based on controlling alternate bearing are necessary for constant presence and continuous competition in the pistachio world-wide markets. Although these experiments could control the abscission of inflorescence buds but more research is imperative in this field.

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