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The Effect of Salicylic Acid and Zinc on Inflorescence Bud Abscission, Leaf Chlorophyll Florescence and Characteristic of Pistachio Nut Cv. Owhadi

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Abstract: In order to determine effect salicylic acid and Zn on characteristics of pistachio nut (*Pistacia vera* L. cv. Owhadi), the experiment was carried out as factorial in the framework of CRD design with three replications. The results showed that salicylic acid and Zn increased nut fresh weight and decreased blank nut percentage. The application of salicylic acid decreased splitting percentage and kernel dry weight. Simultaneous application of 250 mg L^{-1} SA and 0.2% Zn (Zn_2SO_4) decreased inflorescent bud abscission at compared to control.

Keywords: Salicylic acid, *Pistacia vera*, Bud abscission, Chlorophyll florescence

INTRODUCTION

Pistachio (*Pistacia vera* L.) a member of Anacardaceae family is an important and exportable nut crop of Iran cultivated since old times. At this time, Iran is the leading producer of this crop followed by USA, Turkey and Syria. The majority of the pistachio production areas is located in arid and semi-arid regions adjacent to desert regions. Low irrigation water quality, soil salinity, nutrient imbalance and heat and drought stress are the most limiting factors in these areas. Under environmental stress condition, reactive oxygen species (ROS) produced in plant. In order to avoid the harmful effects of ROS, plants evolve an effective scavenging system including of non-enzymatic antioxidants and enzymatic antioxidants [1].

Salicylic acid (SA) is considered as a hormone-like substance, which plays an important role in the regulation of plant growth and development, seed germination, fruit yield, rooting of cuttings and resistance to abiotic stresses [2,3]. Ion uptake and transport [4] photosynthetic rate, stomata conductance and transpiration [5] could be affected by SA application. Exogenous SA could regulate the activities of antioxidant enzymes and increase plant tolerance to the abiotic stress [6]. Moreover, the effects of SA on reducing plant abiotic stress have reported by numerous reports [1, 7, 8, 9, 10, and 11].

Many reports were showed that Zn has an antioxidant role in plant under conditioning stress. Cakmak (2000) reported that zinc had critical roles in the defense system of cells against ROS, and thus represents an excellent protective agent against the oxidation of several vital cell components such as membrane lipids and proteins, chlorophyll, SH-containing enzymes and DNA [12]. Sharma and his colleagues (1995) also reported that Zn deficiency decrease CO_2 fixation, stomata conductance, chlorophyll level and photosynthetic efficiency in plants [13].

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Zinc deficiency is now recognized as one of the most critical micronutrient deficiency in plants grown on calcareous, saline and sodic soils with high pH values. The foliar Zn application could alleviate this problem. Esmaeilizadeh and his colleagues (2009) and Brown and his colleagues (1993) reported that foliar zinc application improved fruit weight and splitting percentage in pistachio [14, 15].

There are limited data in the literature about SA effects on fruit trees. The objective of this study was to determine the effect of SA and zinc on quantity and quality characteristics of pistachio cv. Owhadi.

MATERIALS AND METHODS

Experimental design

This research was conducted in 2009 in 35- year-old commercial orchard of *Pistacia vera* L. cv. Owhadi grafted on 'Badami-e-zarand' rootstock.

The experiment was conducted as factorial in the framework of completely randomized design (CRD) with three replications, included one plant.

Treatments

Treatments included distilled water as control (S_1Zn_1), 0.1% Zn without SA (S_1Zn_2), 0.2% Zn without SA (S_1Zn_3), 250 mg L^{-1} SA without Zn (S_2Zn_1), 250 mg L^{-1} SA plus 0.1% Zn (S_2Zn_2), 250 mg L^{-1} SA plus 0.2% Zn (S_2Zn_3), 500 mg L^{-1} SA without Zn (S_3Zn_1), 500 mg L^{-1} SA plus 0.1% Zn (S_3Zn_2), 200 mg L^{-1} SA plus 0.2% Zn (S_3Zn_3). The trees sprayed with the solutions until dripping with an atomizer.

Nut characteristics

Inflorescence bud retention was recorded during plant growth. At harvest time, the nut yield of each tree was recorded and 100 fruits from each tree were taken randomly and quantity and quality characteristics of fruit and nut (nut fresh weight, kernel dry weight, nut splitting percentage and blank nut percentage and once) were measured. For kernel dry weight determination, plant materials were dried in an oven at 75 ° C for 48 hours. Splitting nuts were determined according to Zeng and Brown (1998) [16].

Chlorophyll florescence

A chlorophyll fluorometer (Hansatech LTD Pocket PEA) was used to measure chlorophyll florescence of leaves of plants at 15 days after foliar application of the various treatments. For each plant measurements were taken at four locations on each leaf from recurrent season shoots on fully expanded leaves and then averaged.

Data analysis

Data analysis was performed using MSTATC statistical software and the means were compared using Duncan's Multiple Range Test (DMRT, P=0.05).

RESULTS

Inflorescence bud retention

Inflorescence bud retention was affected by salicylic acid and Zn so that the application of salicylic acid increased inflorescence bud retention up to 250 mg L^{-1}. The application of Zn_2SO_4 increased inflorescence bud retention so that the highest inflorescence bud retention was observed with 0.2% Zn_2SO_4. The interaction of salicylic acid and Zn_2SO_4 indicated that the highest inflorescence bud retention was observed with S_2Zn_3, however there was no significant difference compared to control (Table 1).

Nut splitting percentage

Nut splitting percentage was affected by salicylic acid and Zn, so that the application of 500 mg L^{-1} salicylic acid decreased splitting percentage compared to control.

The application of Zn increased splitting

percentage and the highest splitting percentage was observed with 0.2% Zn_2SO_4.

The results of interactive effects of salicylic acid and Zn showed that simultaneous application of salicylic acid and Zn increased splitting percentage compared to control. The highest splitting percentage was observed with S_2Zn_3 (Table 2).

Table 1. Interactive effects of salicylic acid and Zn_2So_4 on inflorescence bud retention and chlorophyll florescence of leaves.

Zn_2So_4	Salicylic acid		
	S_1 (control)	S_2 (250 mgL^{-1})	S_3 (500 mgL^{-1})
	100 nut fresh weight (g)		
Zn_1 (control)	141.03 ed	147.96 b	143.06 cd
Zn_2 (0.1 %)	144.53 c	144.50 c	148.26 b
Zn_3 (0.2 %)	159.23 a	157.43 a	139.73 e
	100 kernel dry weight (g)		
Zn_1 (control)	52.89 e	55.22 c	53.05 ed
Zn_2 (0.1 %)	54.40 cd	53.34 ed	56.54 b
Zn_3 (0.2 %)	53.02 ed	62.63 a	61.40 a
	Splitting (%)		
Zn_1 (control)	61.00 e	74.00 c	65.00 d
Zn_2 (0.1 %)	85.00 ab	62.66 e	66.00 d
Zn_3 (0.2 %)	84.00 b	86.00 a	65.00 d
	Blank (%)		
Zn_1 (control)	2.00 a	1.00 c	1.33 b
Zn_2 (0.1 %)	1.33 b	1.00 c	1.00 c
Zn_3 (0.2 %)	1.00 c	1.00 c	1.00 c

Different letters in each column and row show significant differences at 5% of Probability (Duncan's test).

Table 2. Interactive effects of salicylic acid and Zn_2So_4 on nut fresh weight, kernel weight, splitting and blank.

Zn_2So_4	Salicylic acid		
	S_1 (control)	S_2 (250 mgL^{-1})	S_3 (500 mgL^{-1})
	Inflorescence bud retention (%)		
Zn_1 (control)	5.66 ab	6.33 ab	5.66 ab
Zn_2 (0.1 %)	6.33 ab	6.66 ab	4.66 b
Zn_3 (0.2 %)	7.66 ab	8.32 a	5.66 ab
	F_V		
Zn_1 (control)	43.56 cb	93.62 ab	93.44 c
Zn_2 (0.1 %)	93.63 ab	43.71 a	43.53 cb
Zn_3 (0.2 %)	60.52 cb	60.52 cb	77.63 ab
	F_m		
Zn_1 (control)	72.23 cb	78.43 ab	61.90 c
Zn_2 (0.1 %)	76.37 ab	87.37 a	66.70 cb
Zn_3 (0.2 %)	68.90 cb	69.77 cb	80.70 ab

Different letters in each column and row show significant differences at 5% of Probability (Duncan's test).

Blank nut percentage

The results showed that the application of salicylic acid and Zn decreased blank percentage of nut. The lowest blank percentage was obtained with 0.2% Zn_2SO_4 and 250 mgL-1 salicylic acid.

The interaction of salicylic acid and Zn identified that the combined application of salicylic acid and Zn decreased blank nut in comparison with control. The highest blank percentage was obtained with S_1Zn_1 (control), and the lowest it was observed with other treatment except S_2Zn_1 S_1Zn_3 (Table 2).

Nut fresh weight

The mean comparisons indicated that the salicylic acid and Zn_2SO_4 increased nut fresh weight so that the highest nut fresh weight was observed with 0.2 % Zn_2SO_4 and 250 mgl^{-1} salicylic acid, respectively. The nut fresh weight decreased with 500 mg L^{-1} salicylic acid compared to control.

The interactive effect of salicylic acid and Zn_2SO_4 showed that the highest yield was gained with S_1Zn_3, however no significant difference was found in comparison with S_2Zn_3 (Table 2).

Kernel dry weight

Salicylic acid decreased kernel dry weight, and the lowest kernel dry weight was obtained with 500 mg L^{-1} salicylic acid, however there was no significant different in comparison with 250 mg L^{-1} Zn_2SO_4 increased it and the highest kernel dry weight was obtained with 0.2% Zn_2SO_4. The interactive effect of salicylic acid and Zn_2SO_4 showed that the highest yield was gained with S_2Zn_3, however no significant difference was found in comparison with S_1Zn_3(Table 2).

Leaf chlorophyll florescence

The results showed that F_m and F_v increased with 250 mg L^{-1} salicylic acid and then decreased with 500 mg L^{-1}. The Zn_2SO_4 increased F_v while had no effect on F_m. The maximum F_v was observed with 0.1% Zn_2SO_4. The interaction of salicylic acid and Zn on Leaf chlorophyll florescence showed that the highest F_m and F_v were observed with S_2Zn_2 (Table 1).

DISCUSSION

Pistachio is one of the most important horticultural crops in Iran. The majority of the pistachio producing regions is located in arid and semi-arid area with stress conditions. Therefore, suitable treatments are necessary for increasing yield efficiency and quality of this important nut crops. Our findings showed that zinc increased splitting percentage, nut fresh weight and kernel dry weight. It may be associated with the role of zinc in assimilation of carbohydrates to growing fruit, as reported by Esmaeilizadeh and his colleagues (2009) and Brown and his colleagues (1993) [14,15]. They showed that the application of Zn increased fruit weight and splitting percentage in pistachio. The present study indicated that salicylic acid decreased splitting percentage. The lignin compound hydrolyzes in suture layer during maturation phase and salicylic acid decreased splitting by inhibition of the hydrolysis of lignin compound by affecting polygalacturonase enzyme. Our results indicated that salicylic acid and Zn decreased blank nut. Carbohydrate pool is the main factor affecting blankness in pistachio. The high yield depletes the carbohydrates and on the other hand, Zn affects photosynthesis and assimilated carbohydrates to growing fruits. Furthermore, Zn and salicylic acid can alleviate environmental stress, which resulted to increasing photosynthetic efficiency and followed carbohydrate content [14]. The interaction of salicylic acid and Zn indicated that inflorescence bud abscission in pistachio decreased with S_2Zn_3 and it may be related to alleviating environmental stresses and increasing carbohydrate content resulted to photosynthetsys. The effects of SA and Zn on decreasing of abiotic stress and increasing photosynthesis on crop plants reported by numerous works [1, 7, 8, 9, 10, 11, 12,

13]. Roa and his colleagues (1997) reported that SA treatment increased Cu/Zn-SOD activity and also enhanced H_2O_2 content, which was independent of changes in catalase activity [17]. In corn plants pretreatment with SA increased antioxidant enzymes activity as well as chilling tolerance [18].Our findings showed that the higher concentration of salicylic acid (500 mg L^{-1}) and Zinc (0.2%) combination (S_3Zn_3) was decreased splitting and blank nut and this may be related to the effect of salicylic acid on hormonal imbalance in plant.

In conclusion, according to this study, salicylic acid and Zn were effective on nut quality of pistachio and alleviate of abiotic stress.

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