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Effect of Kaolin Application on Water Stress in Pistachio cv. 'Ohadi'

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Abstract

Effects of kaolin applicati on were evaluated on water stress in pistachio cv. 'Ohadi'. This experiment was conducted in one of research sites at the Pistachio Research Institute in Rafsanjan (Kerman province) in 2009. The results show that individual and interaction effects of all treatments were significant on nutrition absorption in leaves, although there was not a steady effect on all the elements. On the majority of the factors, control with 30 days irrigation period and lower kaolin application had more effect on nutrients absorbed by the leaves. Lower irrigation and upper concentration of kaolin application boosted soluble solids content. Increasing of prolin concentration was more impacted by the interaction of kaolin 2.5% and low irrigation treatments and also leaf area showed decreasing trend by single kaolin application, but in this regard, interaction of kaolin with low irrigation has boosting effect on this factor. Lower irrigation period decreased total nut production, blankness percentage, and increased fresh weight (nearly 50%), percentage of split nut, percentage of early split nut, percentage of irregular cracking nuts and ounce index. More kaolin concentration increased fresh weight, percentage of closed nut and lowering the total pistachio production, blankness and early split nut. Interaction effect caused increasing fresh weight, percentage of closed nut, ounce of nut, and decreased total pistachio production, spit nut, blankness and early split nut.

Keywords: Blankness, Earlysplitting, Kaolin, Ohadi cultivar, Pistachio nuts.

Introduction

Pistachio is believed to have been cultivated for 3,000-4,000 years in Iran (Fadaei, 2010). Nowadays, Iran is the world's largest producer and exporter of pistachio with cultivation area of 251000 ha and total production of 447000 t (FAO, 2010). Pistachio is the largest orchard product in Iran in terms of area under cultivation and in terms of foreign exchange revenues (an average of one billion dollars per year) and accounts for 60 percent of agricultural exports (custom, 2011). During last decade prolong drought climate severely have decreased the water quality, and in some cases, EC of water reach to 20 ds/m (Pistachio Research Institute,2010). This severe condition in pistachio producing areas have forced different problems as low productivity, slender trees, and many physiological problems, as early splitting nuts that is the main factor to boost aflatoxin in pistachio nuts. It has shown that there is a direct correlation between aflatoxin contamination and water stress.

Particle film technology (i.e. spraying canopies with a suspension of particles of various kinds of clay, leaving a film on the leaves) has long been used to limit the impact of water and heat stress on crops. Kaolin may be effective in this regard, but, So far, not many cases were reported on the effect of kaolin on pistachio nuts.

The experiment by Fumiomi Takeda (2005) showed that 4-cm hydrophobic kaolin mulch applied after planting can suppress weeds without affecting blackberry productivity (Fumiomi Takeda, 2005). A reflective Kaolin spray was found to decrease leaf temperature by increasing leaf reflectance and to reduce transpiration rate more than photosynthesis in many plant species grown at high solar radiation levels (Nakano, 1996). Early studies demonstrated that the reflective Kaolin improved water status and yield of water-stressed apple seedlings, while it did not reduce carbon assimilation (Glenn, 2003)

The effects of pinolene-base Vapor Gard (VG) emulsion type film and Kaolin (Surround WP) particle type film antitranspirants were investigated by Ansary *et al.* (2005) on stomata behavior, water status, carbon assimilation and transpiration rate of tuberose (*Polianthestuberosa L.*) under the different irrigation regimes of 100, 80 and 60% of total evapotranspiration (ET) values show that both types of antitranspirants effectively enhanced the performance and physiological activities of water-stressed plants particularly, at the 80% ET. However, the particle type (Kaolin) was more effective than the emulsion type (VG) due to its ability to reduce leaf temperature. Water use efficiency (WUE) of Kaolin–sprayed leaves was significantly higher than that of VG–sprayed leaves. (Al-Humaid, 2005).Kaolin applied as a suspension to plant canopies forms a film on leaves that increases reflection and reduces absorption of light. Photosynthesis of individual leaves is decreased while the photosynthesis of the whole canopy remains unaffected or even increases (Adolfo Rosati, 2007).Earlier work, focused primarily on crop yield, has suggested that particle film applications, in some crops and under some conditions, increases yield, for example in sorghum (Stanhill, 1976), cotton (Moreshet, 1979),

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to (NK, 1986), peanut (SoundaraRajan MS, 1981) and apple (Glenn, 2001). More recent and detailed work, carried out using a kaolin particle film, suggests that it generally reduces photosynthetic rates of individual leaves (Grange, 2004; Wu¨nsche, 2004) except under high temperature and/or heat stress (Glenn, 2003; Jifon JL, 2003). The decrease in leaf photosynthesis is related to the reduction in light reaching the photosynthetic apparatus, due to a 20–40 % increase in reflection and decreased absorption (AbouKhaled, 1970; Moreshet, 1979; Wu¨nsche, 2004; Adolfo Rosati, 2007). The effects of kaolin application on canopy photosynthesis have rarely been measured. Wu¨nsche *et al.* (2004) found that it did not decrease canopy photosynthesis despite a reduction in photosynthetic rates of individual leaves; indeed, Glenn *et al.* (2003) found an increase in canopy photosynthesis. These data agree with unaffected or increased yields with kaolin application, respectively. What remains unclear is why decreased leaf photosynthesis does not decreased canopy photosynthesis. Wu¨nsche *et al.* (2004) suggested that this is due to improved light distribution within the canopy, but no studies have tested this hypothesis.

Surround is specially formulated to reflect harmful infrared and ultraviolet radiation away from plant surfaces while allowing beneficial Photosynthetically Active Radiation (PAR) into the leaf. Surround-treated trees are typically several degrees cooler than untreated trees, and a cooler tree leads to: 1) reduced heat stress, 2) increased photosynthesis and greater plant vigor, and 3) potentially higher yields. And, Surround does not block leaf stomata so gases (O_2 and CO_2) and water continue to move in and out of the plant, maintaining the plant's natural photosynthetic and cooling processes (www.novasource.com).

Materials and Methods

This experiment was designed to determine the role of kaolin application on quantitative and qualitative characteristic of pistachio nuts. The kaolin used in this study was supplied by Kimia Sabzavar Corporation (SEPIDAN™).

The effectiveness of Kaolin particle film was determined in a 2-ha pistachio plantation (15-yr-old 'Ohadi' bearing trees) situated in the Pistachio Research Institute of Iran (Rafsanjan city, Kermen Province). The orchard was a high density plantation (1000 trees/ha). The trees (E2.5m tall by 2m diameter) were irrigated and planted in rows spaced 4m apart. The environmental climate at the experimental area during summer were high with a mean annual rainfall of 99.5 mm, air temperature at mid-day 43°C, and relative humidity of 25% with high solar radiation levels. Trees were arranged in a randomized complete block design with two different factors of irrigation periods of 30, 50 and 70 days intervals and kaolin application of 2.5% and 5% with three replications.

During August samples from mature leaves were taken for nutrient analysis consisting Ca, Mg, P, K, Fe, Zn, Mn, Cu, B (Tekin *et al.*, 1995), Soluble Solid, Col a, Col b, Total Col, prolin, RWC, leaf area, simultaneously more samples obtained for prolin (Bates *et al.*, 1973) and water content measures. During harvest time, late October, the quantitative and qualitative factors of nuts, such as fresh nut amount, dried nut amount, blankness percentage, once and splitting, etc) were evaluated.

Results

Differences between the experimental treatments were determined using analysis of variance (ANOVA) at the 5% level in three different parts naming: nutritional indexes, growth indexes and quantitative and qualitative indexes.

Nutritional values comprise the contents of Ca, Mg, P, K, Fe, Zn, Mn, Cu and B (Table 1).

Table 1. Effect of kaolin concentration on nutrient indices of pistachio trees, "Ohadi" CV. under different irrigation periods

Variations	M.S.								
	Ca	Mg	P	K	Fe	Zn	Mn	Cu	B
Irr. Period	0.014^{ns}	0.007^{ns}	0.0^{ns}	0.005^{ns}	1045.6**	77.8**	41.4**	1.2**	100573**
K.concentration	0.009^{ns}	0.03**	0/0^{ns}	0/042**	4183/9**	18/9*	51/8**	9.9**	22406/5**
Irr.×K	0.114**	0.066**	0.0^{ns}	0.046**	2321.7**	46.87**	70.72**	2.48**	9026.6**

Ns, * and **: Non significant, significant at 5% and 1% probability levels, respectively

The results show that individual and interaction effects of all treatments were significant on nutrition absorption of leaves, although there was not a steady effect on all the elements. On the majority of the factors, control with 30 days irrigation period and lower kaolin application had more effect on nutrients absorbed by the leaves.

Table 2. Effect of kaolin concentration on growth indices of pistachio trees, "Ohadi" CV. under different irrigation periods

Variations	M.S.										
	Soluble solid	Col a	Col b	Total col	prolin	RWC	Leaf area	Leaf length	Leaf width	Leaflet length	Leaflet Width
Irr. Period	0.089**	0.0^{ns}	0.0^{ns}	0.0^{ns}	0.021^{ns}	39.9^{ns}	1768951.8^{ns}	1.63^{**}	3.61^{**}	1.76^{**}	0.34^{**}
K.concentration	0.001^{ns}	0.0^{ns}	0.0^{ns}	0.0^{ns}	0.031^{ns}	23.8^{ns}	94099578.8^{**}	12.90^{**}	38.1^{*}	10.67^{**}	1.06^{**}
Irr.×K	0.01^{ns}	0.0^{*}	0.0^{*}	0.0^{*}	0.07^{ns}	53.7^{ns}	4908808.9^{ns}	6.49^{**}	2.71^{**}	5.06^{**}	0.76^{**}

Ns, * and **: Non significant, significant at 5% and 1% probability levels, respectively

Growth indices as chlorophyll, prolin, water content, have affected by kaolin application, but interaction of the treatments had not significant effect (Table 2). Lower irrigation and upper concentration of kaolin application causes the boosting of soluble solids content. Chlorophyll content was not affected. Prolin concentration was affected and increased by the interaction of these treatments. Leaf area decreased by kaolin, but interaction with low irrigation increased that.

Table 3. Effect of kaolin concentration on nut quantitative and qualitative indices of pistachio trees, "Ohadi" CV.Under different irrigation periods

Variations	M.S.									
	With kernel	Fresh weight	Total Nut	Split nuts%	Closed nuts%	Half kernel%	Blankness%	Early split%	Uneven crack%	Split ounce
Irr. Period	165.35^{**}	36.03^{*}	8219.3^{*}	209.19^{ns}	98.26^{ns}	0.348^{ns}	51.29^{ns}	5.93^{*}	23.84^{**}	29.56^{**}
K.concentration	152.25^{**}	69.23^{**}	21658.5^{**}	147.89^{ns}	244.42^{*}	0.72^{ns}	46.15^{ns}	12.64^{**}	16.03^{**}	6.01^{ns}
Irr.×K	31.44^{**}	12.29^{ns}	5571.1^{ns}	172.84^{ns}	319.80^{**}	5.81^{ns}	18.94^{ns}	0.97^{ns}	13.01^{**}	19.13^{**}

Ns, * and **: Non significant, significant at 5% and 1% probability levels, respectively

There was significant effect on quality and quantity characteristics of pistachio nuts by the treatments (Table 3). Lower irrigation period decreased total nut production, blankness percentage, and increased fresh weight, percentage of split nut, percentage of early split nut (Fig. 1), percentage of irregular crack nut and ounce of nut. More kaolin concentration increased fresh weight, percentage of closed nut and lowering the total pistachio production, blankness and early split nut (Fig. 2). Interaction effect caused increasing fresh weight, percentage of closed nut, ounce of nut, and decreased total pistachio production, spit nut, blankness and early split nut (Fig. 3).

Discussion

In the field of nutrient indices, although there was not any clear effect by the treatments of kaolin and irrigation periods and also with the interaction effects of those on nutrient uptake by plant, considering the environmental factors influence on production as, water and soil salinity that negatively affect the yield, and also there is not any literature on this issue, it is not possible to result that the variation in nutrient uptake by the trees would be due to the treatments.

Kaolin application has not negative effect on chlorophyll and water content of the leaves. Pistachio leaves can tolerate water potential lower than -6 (Bars), and will show temporary withered state. By depression of water potential of leaves in pistachio to -6 (Bars), the turgidity maintain, but in others, as apple tree water potential of -3 (Bars) result in zero turgidity (Ansari, 1994). Slow trend in water content of pistachio leaves may be due to water transport from lower leaves to them, because of continuous activity of ostioles in the leaves and producing a negative pressure due to transpiration. Low resistance of ostioles in pistachio leaves and maintaining open during drought condition can cause normal activity of them and so photosynthesis and respiration will be normally active (Ansari, 1994). Regulatory mechanism of ostiole and continuous assimilation is one of main tolerance indices against drought condition (Paleg & Aspinall, 1981; Levitt, 1980).

Soluble sugar content is affected by the interaction of kaolin application and irrigation period and by increasing irrigation period from 30 days to 50 and 70, sugar content show increasing trend that may be due to decreasing the ratio of water content to the sugar content.

Kaolin application, alone, did not show any significant effect on prolin content, but by increasing the irrigation period, accompanied by increasing kaolin application concentration, prolin accumulation show up trend. According Zamani *et al.* (1995), prolin accumulation is due to lowering the natural consumption of prolin in Kerebs cycle and protein assimilation. Their studies show that prolin accumulation may not introduce as an index to assessing of pistachio trees resistance to drought condition, since, prolin accumulation more is due to injury of tension till a mechanism of tolerance to drought (Zamani, 1994). Accumulation of prolin amino acid following drought tension is reported on other crops as tomato, barley, sorgom, triticum and citrus (Al-Lacaki *et al.*, 1996; Hanson *et al.*, 1977; Handa *et al.*, 1986; Syvertsten & Smith, 1983).

Leaf area slightly affected by kaolin application and decreasing the length and width leaf and also length and width of leaflets caused decreasing the leaf area in treated trees, although that was not significant. Drought tension, though in short periods, will affect the growth of pistachio trees (Zamani, 1994). This effect may be due to drought tension on treated pistachio trees, instead kaolin application. Decrease of leaf area fallowing different irrigation treatment was also reported on apple trees (Robinson *et al.*, 1990; Treder *et al.*, 1997; Konopacki & Treder, 1997; Fernandez *et al.*, 1997), in peach (Boland et al,. 1993; Chalmers *et al.*, 1983) and grape (Smart & Coombe, 1983).

Kaolin application caused increasing fresh weight of nuts and also the interaction of these treatments had the same effect that may be due to covering of leaves by kaolin film and diminishing evaporation.

Total pistachio nuts were adversely affected and decreased by the applications, although there is not any significant effect on the yield. Other nut quality factors, also, not significantly affected by kaolin application.

One of the issues that are very important in pistachio nut production in Iran is early split that is the main factor of aflatoxin contamination of the products. The main objective of these kind trials is to find ways to mitigate drought tension and accordingly lowering the contamination. Splitting nut percentage was boosted by increasing irrigation period from 30 to 70 days (Fig. 1), but increasing the concentration of kaolin treatment resulted in significantly diminishing this factor (Fig. 2 and Fig. 3).

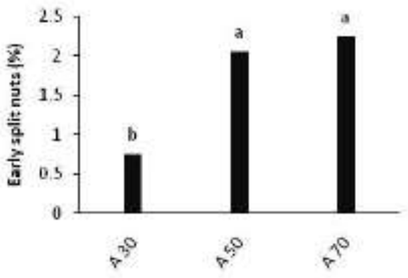

Fig. 1. Effect of irrigation period on the percentage of early split nuts

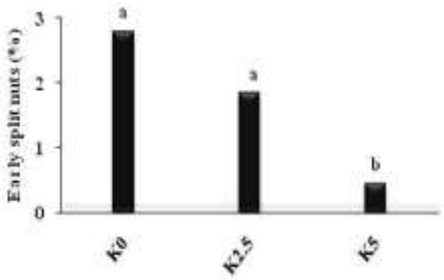

Fig. 2. Effect of kaolin concentration on the percentage of early split nuts

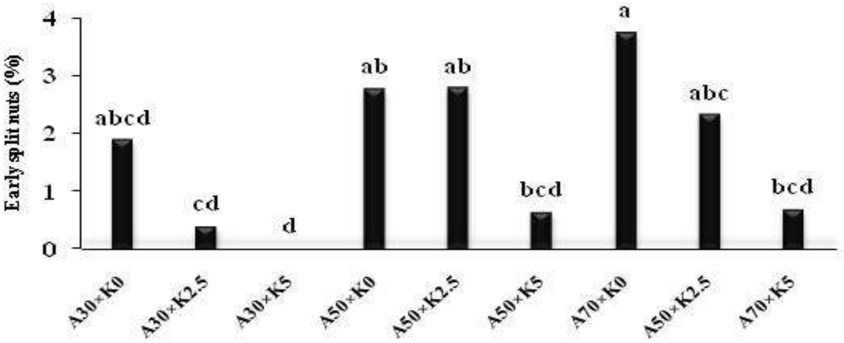

Fig. 3. Effect of interaction of kaolin concentration and irrigation period on the percentage of early split nuts

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