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The effect of soil and leaf nutrients on pistachio yield in the Rafsanjan area, Iran

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Abstract. The objectives of this study were to determine the effect of soil and leaf nutrients on pistachio yield in the Rafsanjan area, central Iran. Six pistachio orchards which were similar on management, pistachio cultivar, water quality and irrigation period but consisted of different parts regarding growth and yield were selected and divided into two desired and undesired parts. In each part, three replicates and in each replicate three trees were selected. Mean of pistachio yield was determined for each replicate. Leave samples of trees were collected in three different times (nut filling, common sampling time in the region and after harvest) and their macro and micro nutrients were measured. Also, soil sampling was done in 0-40 and 40-80 cm depths to determine the above mentioned nutrients. Results showed that sodium and boron concentration of in the soil and leaves are two dominant restricted factors to decrease pistachio yield in the region. Proper management is recommended to reduce soil salinity.

Keywords. Pistachio – Yield – Soil – Leave – Nutrients.

L'effet des nutriments du sol et des feuilles sur la production des pistachiers dans la zone de Rafsanjan en Iran

Résumé. *Les objectifs de cette étude étaient de déterminer l'effet du sol et des nutriments des feuilles sur les pistachiers et leur rendement dans le domaine de Rafsanjan, au centre de l'Iran. Six vergers de pistachiers qui étaient similaires en matière de gestion, cultivar de pistachier, qualité de l'eau et période d'irrigation, mais différents en ce qui concerne la croissance et le rendement, ont été sélectionnés et répartis en deux parties désirées et indésirables. Dans chaque partie, trois répétitions ont été effectuées, et dans chaque répétition, trois arbres ont été sélectionnés. La production moyenne de pistaches a été déterminée pour chaque répétition. Des échantillons de feuilles d'arbres ont été recueillis en trois fois (remplissage du fruit, période d'échantillonnage général dans la région et après la récolte) et leurs macro- et micro-nutriments ont été mesurés. En outre, l'échantillonnage du sol a été fait sur 0-40 et 40-80 cm de profondeur afin de déterminer les éléments nutritifs mentionnés ci-dessus. Les résultats ont montré que la concentration de sodium et de bore dans le sol et les feuilles sont deux principaux facteurs de baisse limitée de la production de pistaches dans la région. Une bonne gestion est recommandée afin de réduire la salinité des sols.*

Mots-clés. *Pistache – Production – Sol – Feuilles – Eléments nutritifs.*

Introduction

Pistachio is one of the most important exportable products in Iran. The Rafsanjan region in Kerman province has been recognized as one of the largest regions for pistachio cultivation in the world. This area located in the arid Kerman province, central Iran and is facing a serious deficiency in quantity and quality of pistachio due to the different problems like high salinity and clay content of the soils (Heydari, 2006), poor quality of groundwater (Hosseinifard *et al.,* 2006), high boron concentration (Hosseinifard *et al.*, 2005a) and poor management in the region (Hosseinifard *et al.*, 2005b).

The main problem with a high sodium concentration is its effects on chemical and physical properties of soils. It contributes directly to the total salinity and toxicity of sensitive crops and has negative effect on the structure of the soil that reduces its capacity to conduct water and air through its profile (Castellanos *et al.,* 2002). This, in turn, decreases soil fertility, because in addition to affecting aeration, it also increases pH and reduces the availability of Fe and Zn. High sodium concentration also has an antagonistic competition with K uptake and causes cell injury (Grattan and Grieve, 1998). In addition, imbalances in plant-available nutrients in salt-affected soils may affect plant growth (Qadir and Schubert, 2002).

Boron (B) is an essential micro-nutrient for normal growth of plants. This microelement plays an important role in nucleic acid metabolism, cell division, sugar biosynthesis and translocation, and membrane function (Brown *et al.,* 1995). Toxicity of this nutrient occurs in arid and semi-arid areas because of high levels of its concentration in soils and irrigation waters (Goldberg, 1997). Although fruit and nut tress are the most sensitive species to high B concentration (Ashworth *et al.,* 1995; Goldberg, 1993), pistachio as a tolerant tree has been reported (Ferguson, 2003). Normal amount of boron in soil has been reported from 0.8 to 1 mg kg^{-1} (Sepaskhah *et al.*,1988). Hosseinifard *et al.* (2005a) reported a high boron concentration in pistachio orchards (500 mg l^{-1}) of Rafsanjan. They also reported these pistachio orchards have more leaf and soil boron concentration rather than other pistachio growing areas of Iran. In species for which B is immobile (e.g.: pistachio and walnut), it moves with the transpiration stream and accumulates in the leaves. In contrast, in species that B is mobile (e.g.: almond and apple), B concentration is the highest in fruit tissues (Brown and Hu, 1998). In spite of different problems in pistachio growing area of Rafsanjan, little investigation was conducted about the status of nutrient concentration and their effect on pistachio yield in this area. Regarding that soil and leaf nutrients can affect pistachio growth, yield and quality, study of these properties seems be necessary for more and sustainable production of this crop. The objective of this study was to determine the relationships of leaf and soil macro and micro-nutrient concentration and their effect on pistachio yield in the Rafsanjan area, central Iran.

Materials and methods

The Anar area located in 75 Km from north-east of Rafsanjan was selected for investigation. This area has a size of approximately 2100 km^2 and located between 30° 32′ and 31° 07′ N and 54° 41′ and 54° 57′ E in Kerman province, central Iran. It has an annual rainfall of 100 mm and evaporation of 3500 mm with an altitude of 1500 m above the sea level (Fig. 1).

Pistachio is the main crop in this area and the age of pistachio trees is about 30 to 40 years. After primary studies and consulting with garden owners and experts, orchards which were similar on management, pistachio age (30 years old), pistachio cultivar ('Fandoghi'), water quality and irrigation period but consisted of different parts regarding growth and yield were selected. Finally, six gardens were chosen and each garden was divided into two parts (desired and undesired). In each part, three replicates and in each replicate three trees were selected. Mean of pistachio yield were determined for each replicate. Leave samples of the trees were collected in three different times (nut filling, common sampling time in the region and after harvest) and N, P, K, Ca, Mg, Na, Fe, Zn, Mn, Cu and B nutrients were measured. Also, soil sampling was done in 0-40 and 40-80 cm depths to determine the above mentioned nutrients.

Results and discussion

Results showed that a significant difference ($p < 0.001$) for mean of pistachio yield between desired and undesired parts of the orchards (12.7 and 6 kg/tree, respectively). To understand better this difference, soil and leaf nutrients in two different parts of the orchards and their relationship with pistachio yield have been investigated.

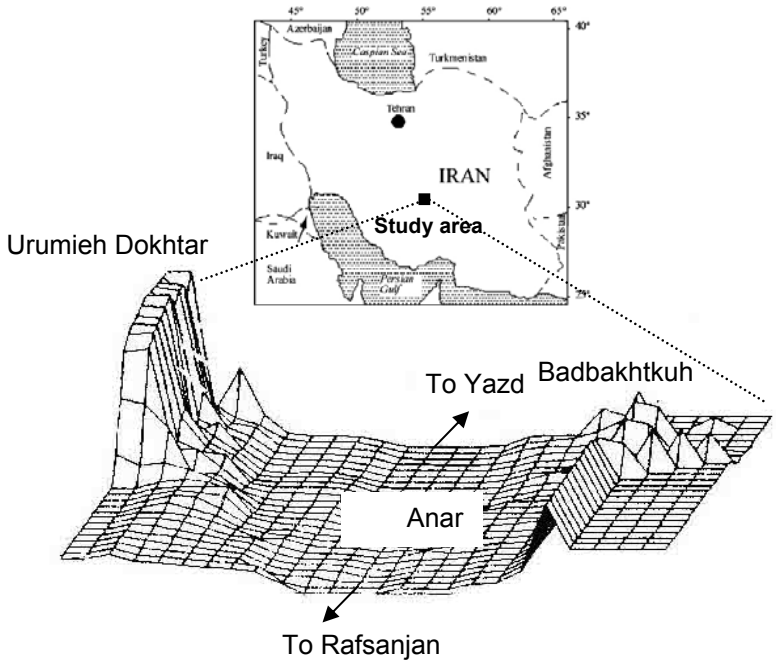

Fig. 1. Location of the study area in central Iran.

Among leaf nutrients, sodium in three different time of sampling in undesired part of the orchards and also in common sampling time in undesired part of each orchard was significantly higher (Figs. 2 and 3). Variation trend of Cu, Fe, Mn and Zn was similar in three different time of leaf sampling so that they surprisingly show a higher content in undesired part of the orchards (data not shown). This may indicate that high Na concentration prevent consumption these micro-nutrients by fruit. These nutrients show an increasing trend from nut filling to common sampling time and a decreasing trend to after harvest. Maximum concentration of these nutrients in the middle of growing season may be also related to photosynthesis and evapotranspiration (Vemmos, 1999). Trend of leaf nutrients in three different time of sampling was somewhat different and did not show a regular trend. Therefore, soil and leaf analyses seem not to be sufficient to fertilizer recommendations. Among soil nutrients, boron and potassium concentration in both depths and sodium in 0-40 cm depth of the soils was significantly higher in undesired parts of the orchards (Table 1). Significant negative correlation between soil boron and Na concentration of the leaves with pistachio yield was also observed (Table 2). Sepaskhah *et al.* (1988) reported that 'Fandoghi' is the most sensitive cultivars of pistachio to high boron concentration. These results can suggest that sodium and boron toxicity are two dominant restricted factors in pistachio growing areas of Rafsanjan. Groundwater analysis also suggests that boron can be provided through water resource of this region (Hosseinifard *et al.,* 2005b). Because of relatively high boron concentration in soil and leaf samples, the use of fertilizers containing boron is not recommended in the study area. Low potassium content in undesired part of the orchards and its negative correlation with pistachio yield can be due to high clay content of the soils (Heydari, 2006) and/or antagonistic competition of Na with K uptake (Grattan and Grieve, 1998).

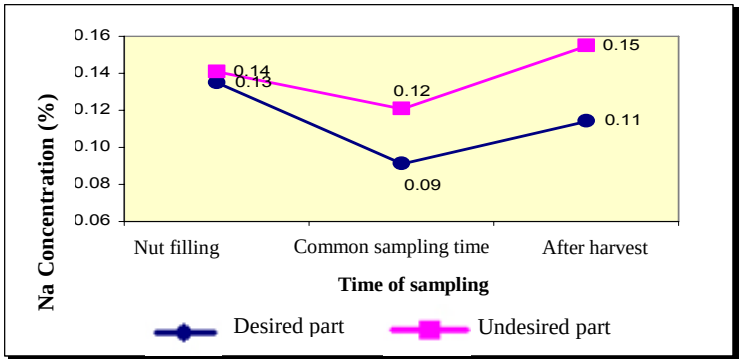

Fig. 2. Na concentration in pistachio leaves at three different times of sampling.

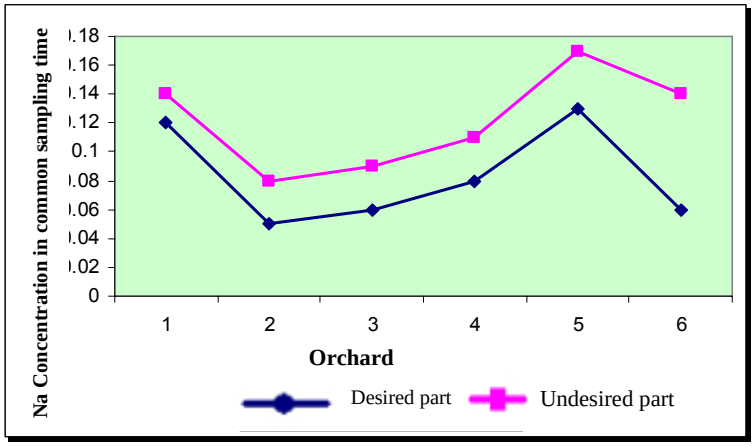

Fig. 3. Na concentration in desired and undesired parts of each orchard.

Table 1. Analysis of variance (nested) for soil nutrients in two depths.

Source	df	K (0-40)	K (40-80)	Na (0-40)	B (0-40)	B (40-80)
Orchard	5	31247**	41498**	7981**	5.15**	3.68**
Desired and undesired parts	1	19367**	48767**	8178**	8.37	3.98**

Table 2. Correlation coefficients among pistachio yield and selected soil and leaf nutrients.

Pistachio yield	Property
-0.48**	K (0-40)
-0.51**	K (40-80)
-0.41*	B (0-40)
-0.35*	B (40-80)
-0.48**	Na (Common sampling time)

We could not find any logical relationship between leaf and soil nutrients although two soil depths and three leaf sampling time have been investigated. Hosseinifard *et al.* (2005a) declared a significant positive correlation between leaf boron concentration and soil boron by saturation extraction method and believed that this method should be used to evaluate soil B concentration in the study area. Therefore, our results also indicate that routine methods are probably not suitable for nutrients extraction in saline and alkali soils. Also, boron concentration was significantly higher in undesired parts of each orchard (Fig. 4).

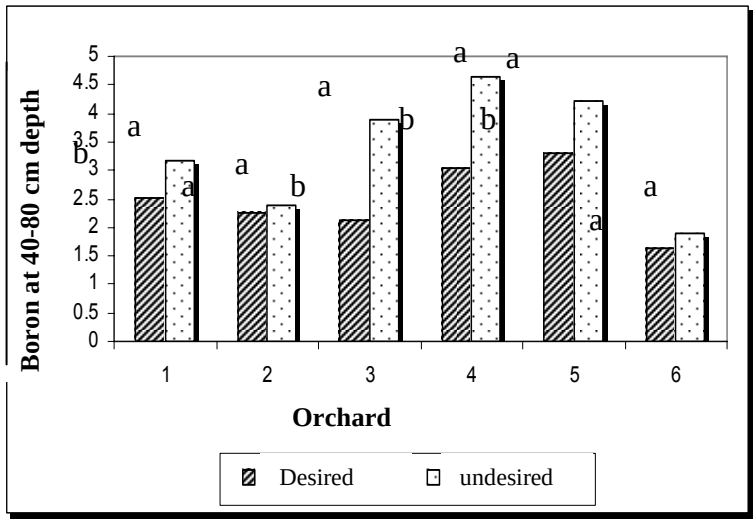

Fig. 4. Boron concentration in different parts of each orchard. Different letters show a significant difference at 95% confidence interval.

Conclusion

Based on the results obtained, boron and sodium toxicity are two dominant restricted factors to decrease pistachio yield in the region. The use of fertilizers containing boron is not recommended in the study area. It seems that high sodium concentration decrease the positive effects of other nutrients. There was not relationship between leaf and soil nutrients. This can suggest that routine methods are probably not suitable for nutrients extraction in saline and alkali soils. Proper management is needed to reduce soil salinity in the study area.

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