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Some Parameters in Relation to Iron Nutrition Status of Peach Orchards

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ABSTRACT

This study was conducted to determine DTPA extractable iron contents and some soil properties of peach (Prunus persica L.) orchards, total and 1N HCl extractable iron contents of leaves and investigate their relations with chlorosis. For this purpose, nine peach orchards, each of which included green, slightly chlorotic and severe chlorotic peach trees, were selected. Soil and leaf samples were taken from these orchards for chemical analysis. Soil samples were collected from the top 30 cm and from a 30-60 cm depth from the soils under the peach trees variously affected by iron induced chlorosis. Soil analysis revealed that results, in the top 30 cm, soil extractable iron contents were negatively correlated with pH, EC and lime (r= -0.260*, -0.621 and -0.298**) respectively. Negatively significant correlations between extractable iron and exchangeable cations, were also found, but correlations were positively significant with organic matter at both soil depths (r=0.595**, 0.608**). Most of the DTPA extractable soil iron contents were found higher than the critical concentration range (4.5 mg kg^{-1}) despite visually and analytically iron chlorosis determined in the plants. DTPA method is not capable of estimating and monitoring of iron chlorosis in the plants grown on calcareous soils. 1 N HCl extractable active iron contents of the leaves were found relevant with the chlorosis degrees (r= -0.839**) and recognized as a better nutritional iron indicator than total iron.**

Key Words: DTPA, iron chlorosis, 1N HCl extractable iron, peach, soil properties, total iron,

INTRODUCTION

Iron is an essential element for plant growth and iron-deficiency induced chlorosis is a widespread nutritional problem. This disorder becomes evident as a typical yellowing of young leaves of plants in many crops and affects leaf and flower mineral composition and is responsible for significant decreases in yield, crop size and the quality of many species (Tagliavini and Rambola 2001). Although most soils contain adequate total iron, amounts that are available to plants might be inadequate dependent on various soil factors. Especially on calcareous soils, high pH and $CaCO_3$ content, ion imbalance and poor physical properties such as very high or low soil temperature, high humidity, poor soil aeration, and compaction can induce iron deficiency (Köseoğlu 1995; Başar 2000; Lucena 2000). A significant part of the fruit industry in Europe and especially in the Mediterranean area is located on calcareous or alkaline soils, which favor the occurrence of iron chlorosis (Tagliavini and Rambola 2001). Turkish soils also contain high amounts of lime and peach has economic and traditional importance among the crops grown in the Bursa region. Başar (2003a) reported that Fe induced chlorosis is responsible for a 20–30% reduction in peach production in the region. And peach is not the only affected species. Many agronomic and horticultural species grown in the region also exhibit symptoms of iron chlorosis.

Soil tests provide an indication of nutrient level in the soil and together with plant analysis are important agronomic tools for determining crop nutrient needs. The concentration of an essential element in a field grown plant indicates the soil's ability to supply that nutrient. Nutrient concentrations in the plant are also related to the quantity of the available nutrient in the soil. For iron it is well recognized that soil and plant testing is not very reliable in predicting iron induced chlorosis. For example the concentration of total Fe in iron chlorotic leaves can be higher than in green leaves (Marschner 1995) and although the DTPA extractable soil iron amounts were over the critical concentration range, visual and analytical symptoms of iron chlorosis can be seen on the leaves (Katkat et al 1994; Başar 2000; Başar 2005).

The objective of this study was to examine some soil properties, DTPA extractable iron amounts, active and total iron status of severe chlorotic, chlorotic and healthy peach leaves and their relations with iron chlorosis.

MATERIALS AND METHODS

Nine peach (*Prunus persica* L. cvs. Jerseyland, Glohaven, Dixired, J.H.Hale and Nectared) orchards, each of which included green, slightly chlorotic and severe chlorotic peach trees were selected from the Bursa province in Turkey (39° 35′ and 40° 40′ N latitude, 28° 10′ and 30° 00′ E longitude). Three experienced people scored the degree of chlorosis of the trees by independent observation and classified them as green,

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slightly chlorotic and severely chlorotic. Twenty-seven leaf samples were obtained from these orchards. At least 90 fully expanded leaves were selected from the 3^{rd}-6^{th} leaves in the annual shoots of each tree (Köseoğlu 1995). Samples were taken when the length of the annual shoots was 30-35 cm, with fruits 3-5 cm in diameter (Başar and Özgümüş 1999; Başar 2005). Soil samples were collected from under the canopy of the trees, from which the leaf samples were taken. Fifty-four soil samples were collected from 0-30 and 30-60 cm depths considered as the rooting depth of peach trees (Chapman et al. 1961).

The leaf samples were immediately transported to the laboratory in closed polyethylene bags. Plant materials were washed in tap water and then twice with deionised water, dried in a forced air oven at 70°C for 72 h; then ground. The ground plant samples were wet digested using a HNO_3 -$HClO_4$ mixture at a volume ratio of 4:1. and Fe determined by atomic absorption spectrophotometry (Philips PU 9200x, Pye Unicam Ltd. GB) (Kacar 1972); Active Fe^{++} contents were determined in dry plant parts incubating 24 h in 1 N HCl extraction solution (1:10) modified by Llorente et al. (1976). Soil samples were air-dried in the laboratory, crushed with wooden pestle, screened through a 2 mm sieve, and analysed to determine some physical and chemical characteristics. pH and E.C were determined in saturation extractant (Soil Survey Manual 1951). Soil texture by Bouyocous hydrometer method (Bouyoucos 1962), organic matter by modified Walkley-Black (Jackson 1962), lime by Scheibler calcimeter method (Hızalan and Ünal 1966), exchangeable potassium, calcium, magnesium, and sodium by 1 N ammonium acetate (pH 7.0) (Pratt 1965), available Fe, Cu, Zn and Mn by DTPA (pH 7.3) method (Lindsay and Norvell 1978).

All the analyses were conducted in triplicate. The results were subjected to statistical analysis and the mean values were compared by using LSD (Least Significant Differences) multiple range test and simple correlations were measured with the computer program Tarist (1994).

RESULTS

According to the results given in Table 1, the soil textures of the orchards were clay to sandy clay loams. There was no salt problem. Organic matter contents of the soils found between 0.45% - 2.63% a depth of (0-30 cm), the amounts being higher than in the deeper part of the profile. $CaCO_3$ contents of the soils generally differ from 0.42% to 48.71% and at the (30-60 cm) depth contained much more $CaCO_3$ than the upper profile. Exchangeable Ca^{++} contents of the soils found between 20.40-47.67 me100g^{-1} and their pH values were between 7.17-7.85. Exchangeable potassium contents of the soils differed between 0.28 and 2.20 me100g^{-1} and at first level (0-30 cm) exchangeable potassium was found higher than second (30-60 cm). DTPA extractable iron contents of the soils were found between 3.95-14.43 mg kg^{-1}. Although available Copper and Manganese were found sufficient, Magnesium, Zinc, and total Nitrogen were detected as insufficient in some soil samples.

Table 1. Some Physical and Chemical Properties of the Soils

Depth (cm)	Chlorosis Degree	Texture Class	pH	EC. mScm^{-1}	$CaCO_3$ %	Organic Matter %	Total N, %	Exchangeable Ions me100 g^{-1}				DTPA Extrractable Micronutrients mg kg^{-1}			
								Na	K	Ca	Mg	Fe	Zn	Cu	Mn
0-30	Green	C-SCL	7.29-7.79	0.48-0.97	0.42-20.82	1.40-2.63	0.08-0.16	0.11-0.34	0.65-1.98	22.48-46.02	0.67-8.50	4.97-11.93	0.32-1.29	2.88-16.56	8.04-17.28
	Chlorotic	C-SCL	7.51-7.78	0.32-0.95	1.25-30.39	1.01-2.36	0.06-0.16	0.10-0.29	0.52-1.65	22.11-46.89	0.59-9.59	4.43-11.92	0.27-1.07	1.44-15.12	5.88-15.48
	Severe Chlorotic	C-SCL	7.17-7.77	0.30-1.02	0.62-33.72	0.99-2.31	0.06-0.15	0.12-0.27	0.52-2.20	20.40-47.35	0.76-9.60	3.95-14.43	0.26-1.07	1.68-12.36	5.16-15.84
30-60	Green	C-SCL	7.26-7.82	0.31-0.91	0.83-41.63	0.88-1.49	0.05-0.09	0.09-0.33	0.33-1.05	23.47-47.67	0.51-11.03	4.59-11.27	0.13-0.97	1.08-6.48	5.64-19.68
	Chlorotic	C-SCL	7.58-7.85	0.32-0.93	4.58-48.71	0.45-1.48	0.02-0.09	0.09-0.34	0.28-1.06	23.25-45.53	0.51-11.52	4.18-10.02	0.14-0.67	0.24-5.04	3.48-13.08
	Severe Chlorotic	C-SCL	7.51-7.77	0.34-0.96	2.71-41.63	0.67-1.44	0.04-0.09	0.10-0.30	0.32-1.49	25.78-47.34	0.59-12.20	5.18-13.29	0.20-0.42	0.84-5.40	4.68-15.00

Minimum and maximum values of the soils.

C: Clay SCL: Sandy Clay Loam

The correlation coefficients between iron contents of the soil and soil properties are shown in Table 2. According to the table, the soil DTPA extractable iron contents were negatively correlated with pH, EC and lime respectively in the top 30 cm (r= - 0.260*, - 0.621** and - 0.298**). Correlations between extractable iron and pH were not be found significant in the soil from 30-60 cm but were found negatively significant with EC and lime (r= - 0.317**, - 0.430**) respectively. The correlations between extractable iron and exchangeable cations were also found negatively significant. Correlations between extractable iron and organic matter (r= 0.595**, 0.608**) and total N (r= 0.617**, 0.596**) were found positively significant at the both depths. Also with Mn (r= 0.758**, 0.442**), Zn (r= 0.779**, 0.315**) and Cu (r= 0.692**, 0.357**) the correlations were found to be positively significant at the both depths.

The concentrations of average total iron in leaf samples were found between 127.33-165.89 mg kg^{-1} and the highest value was observed from chlorotic orchard (Table 3). The average active iron concentration of the leaves was found between 33.07-60.53 mg kg^{-1} and the highest value was taken from green orchard. 1 N HCl extractable active iron amounts of the green and slightly chlorotic leaves were found higher than the critical value (≥30mgkg^{-1}) from the findings of Başar (2003a). The relationship between total iron and chlorosis was not found to be significant, but a negatively significant relationship occurred between chlorosis and active iron with a correlation coefficient r= - 0.839**.

Table 2. Plant and Soil Iron in Relation to Some Soil Parameters

		Plant		Soil										
		Total Fe	Active Fe	E.C	pH	$CaCO_3$	Organic matter	Total N	Exchangeable			DTPA Extractable Fe		
									K	Ca	Mg	Cu	Zn	Mn
Plant Active Fe		0.243*												
Chlorosis		ns	-0.839**											
DTPA	0-30 (cm)	ns	ns	-0.621**	-0.260*	-0.298**	0.595**	0.617**	-0.327**	-0.698**	-0.359**	0.692**	0.779**	0.758**
Extractable Soil Fe	30-60 (cm)	ns	ns	-0.317**	ns	-0.430**	0.608**	0.596**	-0.346**	-0.444**	ns	0.357**	0.315**	0.442**

**Significant at p<0.01 *Significant at P<0.05 level ns: Not significant

Table 3. Total and Active iron Amounts of the Leaves

	Green	Chlorotic	Severehlorotic	Green	Chlorotic	Severe chlorotic
Min.	109.67	79.33	54.67	49.20	37.80	19.80
Max.	220.33	276.00	216.00	73.20	52.80	50.40
Mean*	151.19 b	165.89 a	127.22 c	60.50 a	44.53 b	33.07 c
		*$LSD_{0.01}$ = 2.193			*$LSD_{0.01}$ = 0.479	

DISCUSSION

From the analytical results obtained it can be seen that they differed greatly for each parameter investigated. Organic matter contents of the soils varied between very low and medium classes (Jackson 1962). According to FAO (1990), the potassium levels were from adequate to excess. Lime contents were from low to very high. Exchangeable Ca^{++} contents of the soils were high and their pH is slightly alkaline. Excess amounts of lime in soil decreases iron uptake by the effect of HCO_3^-, pH, and redox potential are also effective on degradation of iron uptake. Mengel and Kirkby (1987) pointed out that at high pH levels the solubility of inorganic iron was highly dependent on soil pH, ferric iron activity in solution decreasing 1,000 fold for each pH unit rise to reach a minimum within the range from 7.4 to 8.5. The chemical soil analysis results, especially high pH and $CaCO_3$ amounts of the orchards were found as factors that closely affected iron chlorosis. Besides, there was a close positive relation between organic matter contents of the soils and chlorosis degrees. Başar (2003b) reported significant negative correlations between active iron in leaves and lime as well as positive correlations with soil organic matter which we also observed. Soil analyses results also agree with the findings of Başar (2000). In his research with soils of this region, he recorded positive correlations between soil iron and organic matter, total N, P, Zn, and Mn but negative correlations with pH and lime.

DTPA extractable iron contents of the soils were found higher than the critical concentration range (4.5 mg kg^{-1}) given by Lindsay and Norvell (1978). The results obtained from our observations were similar to the findings of other researchers (Özgümüş 1988; Katkat et al 1994; Başar 2000; Özgüven and Katkat 2001; Başar 2003b). Although the amounts found higher than the critical value, the plants showed slight or severe chlorosis symptoms. The results of other numerous workers on available-Fe analyses reported soil iron concentrations above the critical concentration range despite visually and analytically iron chlorosis determined in the plants (Özgümüş 1988; Gedikoğlu 1990; Katkat et al 1994; Eyüpoğlu and Talaz 1996; Başar 2000). Thus, using commonly accepted method (DTPA, diethylene triamine pentaacetic acid + $CaCl_2$ + TEA, triethanolamine) for determining available iron in calcareous soils is not a reliable assessment of iron nutrition status of plants (Başar 2005). Especially for calcareous soils, we must suggest that there is a widespread need for another extraction method for this purpose.

The highest concentrations of average total iron in leaf samples were observed from chlorotic orchard. This agrees with the findings of Chapman (1973), Saatçi and Yağmur (2000). In some pot experiments with calcareous soil and field experiments under certain conditions a higher total iron concentration can be found in young chlorotic leaves than in green leaves. This phenomenon is called "the chlorosis paradox" and it has been concluded by an iron inactivation in the plant by an alkalinization process (Römheld 1997; Römheld 2000). In contrast to total iron, the highest average active iron concentration of the leaves was found in green orchard as also observed by Katkat et al. (1994), Köseoğlu (1995), Karaman (1999), Başar (2000), Saatçi and Yağmur (2000).

Higher concentrations of active Fe were found in the non chlorotic leaves. These results are in accordance with other researchers (Katkat et al 1994; Köseoğlu 1995; Karaman 1999; Başar 2000; Saatçi and Yağmur 2000). High concentrations of total iron in chlorotic leaves show that total iron is not a good indicator of the iron status of plants (Katkat et al 1994; Sönmez and Kaplan 2004). This is evident from the negative correlation between active Fe and the degree of chlorosis (Katyal and Sharma 1980; Katkat et al 1994; Köseoğlu and Açıkgöz 1995; Sönmez and Kaplan 2004). For evaluation of plant responses to various factors affecting Fe availability in the soil and Fe nutrition in plants, the concentration of active iron in leaves is recognized as a better nutritional iron indicator than total iron and has been also suggested by Scholl (1979), Dekock (1979), Katyal and Sharma (1980) and Mengel et al. (1984).

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REFERENCES

Başar H. (2000). Factors affecting iron chlorosis observed in peach trees in the Bursa region. Turk J Agric For 24: 237-245.

Başar H. (2003a). Analytical methods for evaluating iron chlorosis in peach trees. Communications in Soil Science and Plant Analysis. 34 (3-4): 327-341.

Başar H. (2003b). The methods to be used in determination of available iron status in peach grown soils at the Bursa plain. Ankara University, Journal of Agricultural Sciences. 9 (1): 103-110.

Başar H. (2005). Methods for estimating soil iron availability to chlorotic peach trees. Communications in Soil Science and Plant Analysis. 36 (9): 1187-1198.

Başar H. and Özgümüş A. (1999). Effects of various iron fertilizers and rates on some micro nutrients contents of peach trees. Turk J Agric For 23: 273-281.

Bouyoucos G. (1962). Hydrometer method improved for making particle size analysis of soils, Agronomy Journal, 54: 464-465.

Chapman N.D., Pratt P.F., and Parker F. (1961). Methods of Analysis for Soils, Plant and Waters. University of California, Division of Agricultural Sciences. Berkeley, California.

Chapman H.D. (1973). Diagnostic Criteria for Plants and Soils. Uni.Calif. Riverside.

DeKock P.C., Hall A. and Inkson R.H.E. (1979). Active iron in plant leaves. Ann. Bot. 43, 737-740.

Eyüpoğlu F., and Talaz S. (1996). Klorotik Elma Ağaçlarına Topraktan Uygulanan Demirin Bakiye Etkisi. Toprak ve Su Kaynakları Araştırma Yıllığı. Ankara.

FAO (1990). Micronutrient, Assessment at the Country Level: An International Study (M.Silanpa. Ed.). FAO Soil Bulletin 63. Rome-Italy.

Gedikoğlu İ. (1990). Ankara Yöresinde Armut Ağaçlarında Görülen Mikro Besin Maddeleri Noksanlıklarının Teşhisi ve Tedavisi; Toprak ve Gübre Araştırma Enstitüsü Müdürlüğü Genel Yayın No: 163, Rapor Serisi No: 85, Köy Hizmetleri Genel Müdürlüğü, Ankara.

Hızalan E., and Ünal H. (1966). Important Chemical Soil Analysis. Ankara University Agricultural Faculty Publications 278, Ankara.

Jackson M.L. (1962). Soil Chemical Analysis, Prentice-Hall, Inc., Englewood Cliffs, N.S.

Kacar B. (1972). Chemical Analysis of Plant and Soil, II. Plant Analysis. Ankara University Agricultural Faculty Publications. No:453, Ankara, Turkey.

Karaman M.R. (1999). Investigation of chlorosis in peach trees growing in the Tokat region using soil and plant analysis and the effects of soil moisture on the determination of the amounts of DTPA-extractable Fe, Cu, Zn and Mn. Turk J Agric For 23 (3): 707-719.

Katkat A.V., Özgümüş A., Başar H., and Altınel B. (1994). Iron, manganese, zinc and copper nutrition of peach trees growing in the Bursa region. Turk J Agric For 18; 447-456.

Katyal J .C., and Sharma B.D. (1980). A new technique of plant analysis to resolve iron chlorosis. Plant Soil 55:105-108.

Köseoğlu A.T. (1995). Effects of iron chlorosis on mineral composition of peach leaves. Journal of Plant Nutrition 18(4):765-776.

Köseoğlu A.T., and Açıkgöz V. (1995). Determination of iron chlorosis with extractable iron analysis in peach leaves. Journal of Plant Nutrition 18(1):153-161.

Lindsay W.L., and Norvell W.A. (1978). Development of a DTPA Soil Test for Zn, Fe, Mn and Cd. Soil Sci Soc Amer Proc 42:421-428.

Llorente S., Leon A., Torrecillas A., and Alcaraz C. (1976). Leaf iron fractions and their relation with iron chlorosis in citrus. Agrochimica 20(2-3): 204-212.

Lucena J.J. (2000). Effects of bicarbonate, nitrate and other environmental factors on iron deficiency chlorosis. A review. Journal of Plant Nutrition 23(11-12): 1591-1606.

Marschner H. (1995). Mineral Nutrition of Higher Plants.2nd Ed. Academic Press Inc., San Diego, USA.

Mengel K., Breininger M.T. and Bübl W. (1984). Bicarbonate the most important factor inducing iron chlorosis in vine grapes on calcareous soil. Plant and Soil 81: 333-344.

Mengel K., and Kirkby E.A. (1987). Principles of Plant Nutrition. 4th Ed. International Potash Institute. Bern, Switzerland.

Özgümüş A. (1988). Bursa yöresindeki şeftali ağaçlarında görülen klorozun bitki ve toprak analizleri ile incelenmesi. Uludağ Üniversitesi Yayınları No: 7-016-0176 Bursa.

Özgüven N., and Katkat A.V. (2001). Plant available zinc status of the soils of Bursa and the methods used for the determination of zinc content of these soils. Journal of Faculty of Agriculture Uludag University 15: 177-190.

Pratt P.F. (1965). Methods of Soil Analysis. Part 2. Chemical and Microbiological properties. Ed. C.A. Black. Amer. Soc. Agr. Inc. Publisher Agro. Series No 9., Madison, USA.

Römheld V. (1997). The chlorosis paradox: Fe inactivation in leaves as asecondary event in Fe deficiency chlorosis. Abstracts of the 9th international symposium on iron nutrition and interaction in plants: 10. Stuttgart, Germany.

Römheld V. (2000). The chlorosis paradox: Fe inactivation as a secondary event in chlorotic leaves of grapevine. Journal of Plant Nutrition 23(11&12) 1629-1643.

Saatçi N., and Yağmur B. (2000). Relationships between the concentrations of iron, macro and micro nutrients in satsuma mandarine leaves. Journal of Plant Nutrition 23(11-12)1745-1750.

Scholl W. (1979). Erfahrungen mit der chlorose der weinreben in der Bundesrepublik Deutschland. Mitt Klosterneuburg 29: 186-193.

Soil Survey Manual (1951). U.S.Department of Agriculture, Handbook No:18, Grout Print Office, Washington D.C. p.209.

Sönmez S., and Kaplan M. (2004). Comparison of various analysis methods for determination of iron chlorosis in apple trees. Journal of Plant Nutrition 27(11): 2007-2018.

Tagliavini M., and Rambola A.D. (2001). Iron deficiency and chlorosis in Orchard and Vineyard Ecosystems. European Journal of Agronomy 15:71-92.

Tarist (1994). General Statistic Version 4.01 DOS, Egean Forestry Research Institute Karşıyaka/İzmir- Egean Univ. Agricultural Faculty, Field Crops. Bornova, İzmir.