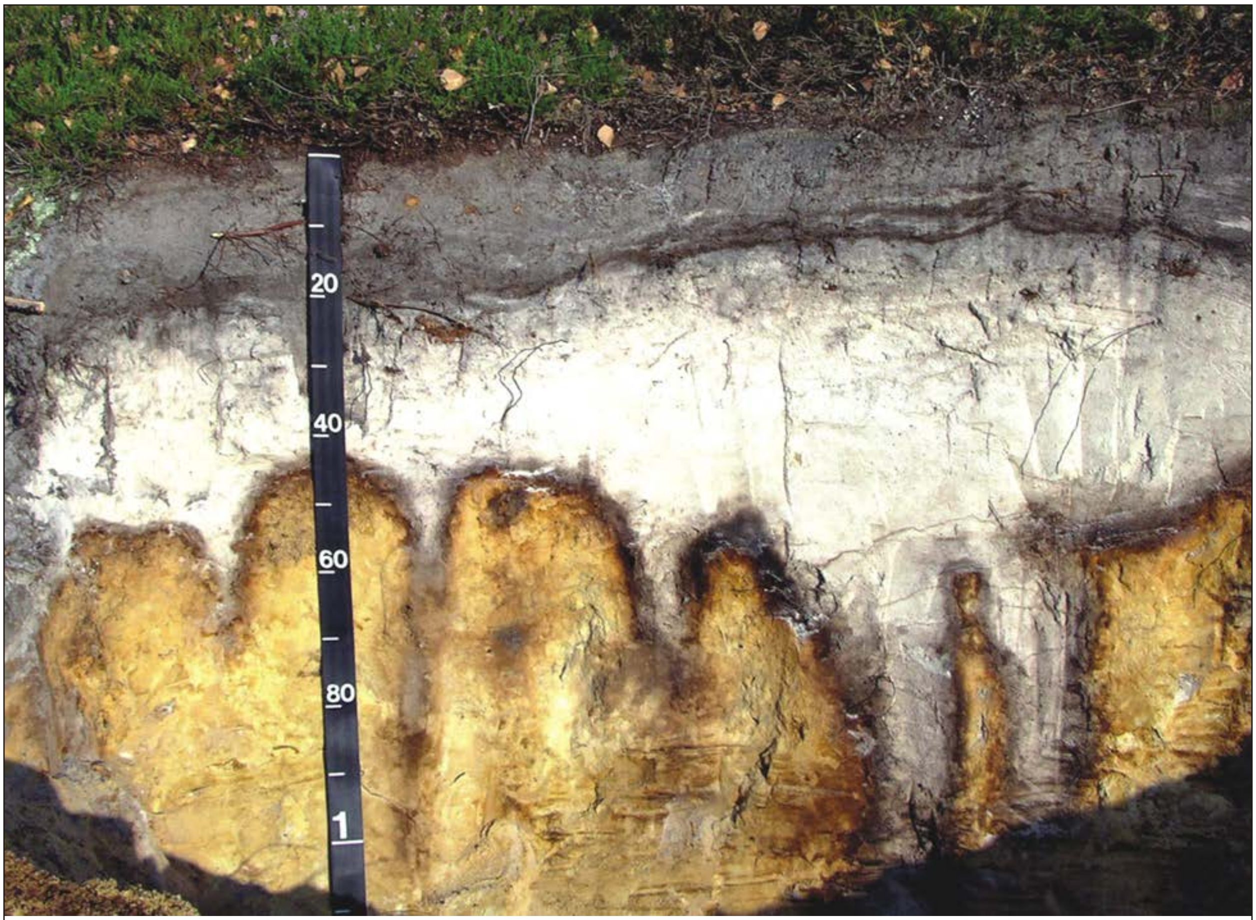

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Some Physical Soil Properties and Potassium as an Intensified Factor on Iron Chlorosis

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Abstract: This research was conducted to determine some physical properties, potassium and iron status of the soils, to examine the amounts on the green and chlorotic peach (*Prunus persica* L.) trees and to investigate the relationship between some causal physical soil properties associated with iron chlorosis. For this purpose nine peach orchards including green, slightly chlorotic and severe chlorotic peach trees all together, were selected from Bursa province. Soil samples were taken around the canopy of the trees at 0-30 and 30-60 cm depths. Leaf samples were collected from the trees, which the soil samples were taken. DTPA extractable iron and exchangeable potassium contents were found sufficient at both soil depths. Soil extractable iron contents were negatively correlated with pH, EC and lime (r = -0.260*, -0.621**, -0.298**). Relationship between DTPA extractable iron and exchangeable potassium was found negatively significant at both depths (r = -0.327** r = -0.346**). Physical soil properties, which lead to iron chlorosis, found affective to the uptake and availability of potassium positively and in chlorotic orchards, it increased the uptake of potassium much more than iron. While the amounts of potassium in the leaves increased with chlorosis degrees (r = 0.342**), the relationship between chlorosis and active iron was found negatively significant (r = -0.839**).

Key words: Active iron, iron chlorosis, potassium, peach, soil properties

INTRODUCTION

Balanced nutrition of the plants is one of the main factors that affect the yield and quality of the fruit trees. Although potassium is regarded as one of the major nutrient elements that affect the yield and quality, iron chlorosis is an important factor, which is responsible for significant decreases in yield and quality of fruits. When chlorotic symptoms in orchards develop, fruit yield and quality can be severely depressed in the current year and next year fruiting as fruit buds poorly develop (Tagliavini and Rambola, 2001).

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 Fe chlorosis (Tagliavini and Rambola, 2001). Fruit trees differ as to their susceptibility to iron chlorosis; peach, pear and kiwifruit known as the most susceptible to Fe chlorosis (Korcak, 1987).

Chlorotic symptoms vary from year to year because of several tree and environmental variables such as fruit species, yields, temperatures and rains (Tagliavini and Rambola, 2001). It is known that besides the physiological effectiveness of iron in plant tissues, iron chlorosis is also related with soils' bad physical properties such as very high or low soil temperature, high humidity, poor soil aeration and compaction, high pH, HCO_3^- and $CaCO_3$ content (Başar, 2000; Lucena, 2000; Köseoğlu, 1995).

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Above mentioned physical soil properties which lead to iron chlorosis are affective to the uptake and availability of potassium positively. According to Tepe (1979), waterlogging of the soil reduces the activity of iron ions by about half, whereas the activities of calcium, manganese, aluminium and sulphate ions increase considerably and the activity of K^+ ions also increase rapidly as soon as the moisture content of the soil rises (Bergmann, 1992). High soil temperature lessens availability and uptake of iron by causing excess formation of CO_2 and HCO_3 (Inskeep and Bloom, 1986) and microbiological degradation of phytosiderophores (Award *et al*., 1988). On the other hand, it increases root activity of the plants and the potassium uptake by increasing the concentration of potassium in soil solution (Ching and Barber, 1979).

Excess amounts of lime in soil decreases iron uptake by HCO_3 effect, pH and redox potential are also effective on degradation of iron uptake. Besides heavy texture, extreme applications of irrigation water or rain, lead to bad aeration and cause to increase the effect of HCO_3 in calcareous soils (Chaney, 1984). It leads to some deformations on root tips and causes to degradation on the iron uptake capacity of root system (Lindsay, 1984). At the same time soil moisture helps to release potassium which is fixed in dry conditions and became available for plants (Hu and Schmidhalter, 2005; Kacar and Katkat, 1998).

On the other hand, iron toxicity is known in various rice growing areas and is especially frequent on heavy soils and is often associated with K^+ deficiency (Tanaka *et al*., 1973). Trolldenier (1973) reported that when K^+ nutrition is inadequate the capability of rice roots to oxidize Fe^{+2} to Fe^{+3} is impaired. We know that iron toxicity effects can be ameliorated or eliminated by heavy potash dressings to reduce the uptake of Fe^{+2} (Çakmak, 2005; Becker and Asch, 2005; Li *et al*., 2001; Trolldenier, 1973; Tanaka *et al*., 1973). Li *et al*. (2001) pointed out that increasing amount of potassium reduced iron concentration in leaves by at least 2-fold and improved plant growth. A large body of literature supports the ameliorative effects of phosphorus, potassium and zinc fertilizer application under iron toxic conditions (Becker and Asch, 2005). Ameliorating effects of potassium may be attributed to the antagonistic effect of potassium on iron absorption and translocation to shoots (Li *et al*., 2001). Urrestarazu *et al*. (1994) also pointed out that plants take potassium much more than iron and excess amounts of potassium inhibits uptake and translocation of iron in plants and leads to iron deficiency. Similar to iron toxicity, excess applications of potassium or increasing amounts of potassium release under suitable soil conditions can inhibit the iron uptake and may affect the degree of iron chlorosis.

This study was conducted to determine some physical properties, potassium and iron status of the soils, to examine the amounts on the healthy (green) and chlorotic peach trees and to investigate the relationship between some causal physical soil properties associated with iron chlorosis.

MATERIALS AND METHODS

Nine peach (*Prunus persica* L.cvs. Jerseyland, Glohaven, Dixired, J.H.Hale and Nectared) orchards, which include green, slightly chlorotic and severe chlorotic peach trees all together, were selected from the Bursa province in Turkey (39° 35' and 40° 40' N latitude, 28° 10' and 30° 00' E longitude) in 2004. Chlorosis degrees of the trees were scored by the independent observations of three experienced persons. Total of fifty four soil and twenty seven leaf samples were obtained from these orchards. Soil samples were taken around the canopy of the trees at 0-30 and 30-60 cm depths considering rooting depth of peach trees (Chapman *et al*., 1961). Leaf samples were collected from the trees, which the soil samples were taken. We select at least 90 fully expanded leaves (3rd-6th leaves in the annual shoots of each tree) (Köseoğlu, 1995), when length of the annual shoots was 30-35 cm, with fruits 3-5 cm in diameter (Başar, 2005; Başar and Özgümüş, 1999).

The leaf samples were immediately transported to the laboratory in closed polyethylene bags putting in a fridge. Plant materials were washed in tap water and then twice with deionized water, dried in a forced air oven at 70°C for 72 h and ground respectively. The ground plant samples were wet digested using a HNO_3-$HClO_4$ mixture at volume ratios of 4:1. Iron contents in digest were determined by atomic absorption spectrophotometer (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) by the method of Oserkowsky (1933) which was modified by Llorente *et al*. (1976) and amounts were measured by atomic absorption spectrophotometer. Soil samples were air-dried in the laboratory, crushed with wooden pestle screened through a 2 mm sieve and analyzed to determine some physical and chemical characteristics. pH and E.C determined in saturation extractant (Anonymous, 1951). Soil texture by Bouyoucos 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) and available iron by DTPA (pH 7.3) method (Lindsay and Norvell, 1978).

All the analyses were conducted in triple. The mean values were compared using LSD (Least Significant Differences) multiple range test and simple correlations were measured with the computer program Tarist (1994).

RESULTS AND DISCUSSION

According to the results given in Table 1, the soil textures of the orchards were usually clay and sandy clay loam. There is no salt problem. Organic matter contents of the soils were found 0.45-2.63%; changes between very low and medium classes (Jackson, 1962). Organic matter at first depths (0-30 cm) found higher than the second depths. pH is between 7.17-7.85 and found neutral and slightly alkaline. $CaCO_3$ contents of the soils generally differ from 0.42 to 48.71%; have low and very high lime. The second depth (30-60 cm) has much more $CaCO_3$ than first depth. Excess amounts of lime in soil degreases iron uptake by HCO_3 effect, pH and redox potential are also effective on degradation of iron uptake. Mengel and Kirkby (1987), have pointed out that the solubility of inorganic iron is highly dependent on soil pH at high pH levels, ferric iron activity in solution decreases 1,000 fold for each pH unit rise and reaches a minimum within the range from 7.4 to 8.5. According to the physical soil analysis results, especially high pH and $CaCO_3$ amounts of the orchards were found close related factors that affect iron chlorosis.

Available iron contents of the soils found between 3.95-14.43 mg kg^{-1} (Table 1). According to the critical values defined by Lindsay and Norvell (1978), soils have middle and high amounts of iron. The available iron contents of the soils were negatively correlated with pH at first depth ($r = -0.260^{*}$), the second depth it could not find significant. Available iron contents of the soils were also negatively correlated with EC and lime at both depths ($r = -0.621^{**}$ and -0.298^{**}) ($r = -0.317^{**}$, -0.430^{**}) respectively (Table 2). Relations between available iron and organic matter found significant at both depths ($r = 0.595^{**}$, 0.608^{**}).

The concentrations of average total iron in leaf samples were found between 127.33-165.8 mg kg^{-1}, the highest value was taken from chlorotic orchards and the second high amount was taken from green ones (Table 3). The average active iron concentration of the leaves was found between 33.07-60.53 mg kg^{-1}, the highest amount was taken from green orchard. Although the relationship between chlorosis degree and total iron amounts of leaf samples was found not significant, the relationship between active iron was found negatively significant ($r = -0.839^{**}$) (Table 2). The active iron results were also found relevant with the chlorosis degrees by other researchers (Başar, 2000; Saatçi and Yağmur, 2000; Karaman, 1999; Köseoğlu, 1995; Katkat *et al*., 1994). According to the results, total iron doesn't match with the chlorosis degrees and not a good indicator

Table 1: Some physical and chemical properties of the soils

Depth (cm)	Chlorosis degree	Sand (%)	Silt (%)	Clay (%)	Texture class	pH 1:2.5 Soil: Water	EC (mS cm^{-1})	$CaCO_3$ (%)	Organic matter (%)	Exchangeable K (me 100 g^{-1})	Available Fe (mg kg^{-1})
0-30	Green	28.40-58.40	12.00-22.00	21.60-55.60	C-SCL	7.29-7.79	0.48-0.97	0.42-20.82	1.40-2.63	0.65-1.98	4.97-11.93
	Chlorotic	26.40-56.40	12.00-22.00	23.60-57.60	C-SCL	7.51-7.78	0.32-0.95	1.25-30.39	1.01-2.36	0.52-1.65	4.43-11.92
	Severe chlorotic	28.40-54.40	14.00-24.00	25.60-55.60	C-SCL	7.17-7.77	0.30-1.02	0.62-33.72	0.99-2.31	0.52-2.20	3.95-14.43
30-60	Green	24.40-56.40	12.00-28.00	25.60-58.88	C-SCL	7.26-7.82	0.31-0.91	0.83-41.63	0.88-1.49	0.33-1.05	4.59-11.27
	Chlorotic	28.40-54.40	12.00-24.00	27.60-57.60	C-SCL	7.58-7.85	0.32-0.93	4.58-48.71	0.45-1.48	0.28-1.06	4.18-10.02
	Severe chlorotic	26.40-56.40	12.00-22.00	25.60-59.60	C-SCL	7.51-7.77	0.34-0.96	2.71-41.63	0.67-1.44	0.32-1.49	5.18-13.29

C: Clay, SCL: Sandy Clay Loam

Table 2: The correlation coefficients between some soil properties and leaves potassium, total and active iron amounts in peach orchards

		Leaf				**Soil**				
Properties	**Depth (cm)**	**Chlorosis degree**	**Total Fe**	**Active Fe**	**K**	**pH**	**E.C**	**$CaCO_3$**	**Organic matter**	**Exchangeable K**
Leaf										
Total Fe		-								
Active Fe		-0.839**	0.242*							
K		0.342**	-	-						
Soil										
pH	0-30	-	-	-	-					
	30-60	-	-	-	-					
E.C	0-30	-	-	-	-	-				
	30-60	-	-	-	-	-				
$CaCO_3$	0-30	-	-	-0.298**	-	-	-0.251*			
	30-60	-	-	-0.244*	-	-	-			
Organic matter	0-30	-	-	0.234*	-	-	-0.402**	-		
	30-60	-	-0.351**	-	-	-	-	-0.613**		
Exchangeable K	0-30	-	-	-	-	-	0.456**	-	0.375**	
	30-60	-	-	-	0.224*	-	0.651**	-	-	
Available Fe	0-30	-	-	-	-	-0.260*	-0.621**	-0.298**	0.595**	-0.327**
	30-60	-	-	-	-	-	-0.317**	-0.430**	0.608**	-0.346**

Table 3: Potassium, total and active iron amounts of the peach leaves

	K (%)			**Total Fe (mg kg^{-1})**			**Active Fe (mg kg^{-1})**		
Chlorosis degree	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Green	1.57	2.80	2.08	110	220	151.11	49.20	67.80	60.53
Chlorotic	1.16	2.68	1.81	79	276	165.78	37.80	52.80	44.53
Severe chlorotic	0.86	3.91	2.70	55	216	127.33	19.80	50.40	33.07

of the iron status of the plants (Sönmez and Kaplan, 2004; Katkat *et al*., 1994). The concentration of active iron in leaves said to be a better nutritional iron indicator than total iron because of a negative correlation with chlorosis degree (Sönmez and Kaplan, 2004; Köseoğlu and Açıkgöz, 1995; Katkat *et al*., 1994; Katyal and Sharma, 1980).

Exchangeable potassium contents of the soils differ between 0.28 and 2.20 me 100 g^{-1} (Table1) and according to FAO (1990) potassium levels change from adequate to excess. At first level (0-30 cm) exchangeable potassium found higher than the second (30-60 cm). Although the relationship between available iron and EC found negatively significant, the relation between potassium and EC was found positively significant (r = 0.456** and 0.651**) at both depths. The relation between organic matter found significant at only first depth (r = 0.375**). The correlations between exchangeable potassium and DTPA extractable iron were found negatively significant at both depths (r = -0.327**, -0.346**) (Table 2).

The concentrations of average potassium in leaf samples were found between 1.81-2.70% (Table 3). The highest value was taken from severe chlorotic orchards (Table 3). In addition, a positive correlation was found between leaf potassium and exchangeable potassium taken from second depth (30-60 cm) (r = 0.224*). Correlation between leaf potassium and chlorosis degree was also found positively significant (r = 0.342**) (Table 2). In agreement of the researchers, chlorotic leaves have higher potassium than nonchlorotic leaves (Torres *et al*., 2006; Saatçi and Yağmur, 2000; Köseoğlu, 1995; Dong, 1987; Abadia *et al*., 1985; Wallihan, 1955; McGeorge, 1949; Bennett, 1945). Başar (2000) and Karaman (1999) found similar results in their researches. Belkhodja *et al*. (1998) observed an increase in the concentration of potassium in leaves of peach trees deficient in iron. Scherer (1978) also reported that in his research leaf samples of maize (*Zea mays* L.) and sunflower (*Helianthus annuus* L.) plants, which show iron deficiency, have high amounts of potassium. Welkie and Miller (1993) relate the accumulation of potassium to the increase and accumulation of organic acids (malic and citric) that are present in iron deficient organs. Belkhodja *et al*. (1998) announced the increase in the concentration of potassium because of iron chlorosis attributed to an increase in the excretion of hydrogen by plasma membrane ATPase in root cells, favoring the absorbtion of potassium. On the other hand Li *et al*. (2001) and Urrestarazu *et al*. (1994) reported potassium as a factor reducing the translocation of Fe^{++} from roots to shoots, especially to the upper leaves attributed to the antagonistic effect. Neue *et al*. (1998) also proposed that adequate supply of potassium enhances root-oxidizing capacity for iron, thereby preventing its uptake.

CONCLUSIONS

According to the results of the peach grown soils in Bursa province, potassium amounts are found sufficient and some of them are over sufficiency range and iron contents found in middle and high amounts. Although most of the soils have adequate amounts of iron; high lime, pH, humidity and heavy texture properties of the soils cause insufficient iron uptake or to lose physiological effectiveness of iron in the plants and it became possible to see iron chlorosis in the peach orchards. Physical soil properties, which lead to iron chlorosis, found affective to the uptake and availability of potassium positively and in chlorotic orchards, it increased the uptake of potassium much more than iron. Excess applications of potassium or increasing amounts of potassium release under suitable soil conditions can inhibit the iron uptake and may affect the degree of iron chlorosis. This situation may expose high levels of potassium a factor to become intensified of iron chlorosis. There seems a need for detailed further researches about this subject.

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