Contents and Distrıbutions of Iron Fractions in Bafra, Çarşamba and Suluova Soils and Relationshıps with Some Soil Properties

Ahmet Korkmaz[1*], Havva Sera Şendemirci[2], Güney Akınoğlu[1], Ayhan Horuz[1], Abdülkadir Sürücü[3]

[1]Ondokuz Mayıs University, Agricultural Faculty, Department of Soil Science and Plant Nutrition, 55139 Samsun, Turkey,
akorkmaz@omu.edu.tr
[2]Research Institute Center of Soil, Fertilizer and Water Funds, 06900 Ankara, Turkey
[3]Bingöl University, Agricultural Faculty, Department of Soil Science and Plant Nutrition, 12000 Bingöl, Turkey
*Corresponding author

Abstract

The aim of this study was to determine contents and distributions of iron fractions in Bafra, Çarşamba and Suluova soils and relationships with some soil properties. For this aim, 26 soil samples were taken from 0-20 cm depth of agricultural fields of Bafra, Çarşamba and Suluova districts. Beside some physical and chemical soil properties, exchangeable iron (Exch-Fe), organic bounded iron (OM-Fe), manganese oxides bounded iron (MnOX-Fe), amorph iron oxides bounded iron (AFeOX-Fe), crystal iron oxides bounded iron (CFeOX-Fe) and residual iron (R-Fe) contents of soils were determined. According to mean iron fraction values, iron fractions ordered as follows; R-Fe (7800-19400 ppm Fe) > CFeOX-Fe (6000-11300 ppm Fe) > AFeOX-Fe (1100-6700 ppm Fe) > MnOX-Fe (3.90-158.9 ppm Fe) > Exch-Fe (0.8-2.4 ppm Fe) > OM-Fe (0.6-1.6 ppm Fe). The total iron content of the soil were found between 20000-34000 ppm.

Manganese oxides bounded iron form had significant negative correlations with soil pH (r=-0.448*), total lime (r=-0.556**) and active lime (r=-0.448*) contents. There was a significant positive relationship (r=0.674**) between MnOX-Fe and available Mn contents of soils. While sand contents of soils gave significant negative correlations with CFeOX-Fe (r=-0.382*) and total iron contents (r=-0.467*), clay contents of soils had a significant positive correlation with total iron content (r=0.386*). In another word, total iron contents of soils increased with increasing clay contents in soils. It has been determined that sum of exchangeable + organic + manganese oxides bounded iron is diagonistic (effective) on the extractable iron by 0.005 M DTPA + 0.01 M CaCl2 + 0.1 M TEA (pH=7.3). The extractable iron content by 0.005 M DTPA + 0.01 M CaCl2 + 0.1 M TEA (pH=7.3) increased with increasing sum of exchangeable + organic + manganese oxides bounded iron of soils.

Keywords: Amorph iron oxides, exchangeable, crystal, organic, manganese oxides, residual, sequential method.

1 Introduction

Iron is the most abundant element in the Earth's crust, which has at the 5% level after from oxygen, silicon and aluminum contents. It was indicated that the iron content of basalt rocks, granite rocks, limestone rocks, sandstone, schist, and generally soils were to be 86000 ppm, 27000 ppm, 3800 ppm, 9800 ppm, 47000 ppm, and 10000-100000 ppm, respectively [1].

Total trace element contents of soil depend on the chemical composition of the rocks despite the changes in of the fragmentation as a result of rock and minerals in the soil formation. The total microelements content of the soils also depend on the climatic conditions which stated that the formation of soil degradation on the situation faced by the rocks [2]. The same researcher informed that texture and organic matter content of the soils were the important factors. Trace elements of fine-textured (clay and silty) soils which consisted of high in total trace element that contained the easier degradable minerals have been mentioned and reported to be fine-textured soils that are high micro element content but its content of rough-textured soils are low due to terms of total trace elements in these soils have minerals occurred poor and difficult pieces. Also, it was reported that the increasing of soil organic matter content until 5-7% increased the total trace elements mineral of the soil; but total trace elements higher from 7-10% due to the effect of reducing the scope of volume weight of organic matter in soil containing organic matter is low.

Trace elements in the soil is composed of forms into 5 groups. These are the water-soluble and variable, adsorbed, chelate creating with complex compounds, secondary clay minerals, forms insoluble metal oxide minerals, and primary minerals. Water-soluble, changeable, adsorbed or form in chelates to be present as balance in the soil is noted and to be important for plants in nutrition. Therefore extraction of soil micro-elements to determine the amounts which used by plants have to used in the extraction solution, especially should be extracted the three forms of the micro elements [3].

As a result of the dissolution of the ferrous minerals in rocks, Fe^{2+} cation is added into the soil, as long as it reacts acid conditions or continues in airworthy of soil, and in the oxidation with $Fe(OH)_3$ of ferrus iron is formed the Fe^{3+} cation by converting to the $^{+}2$ valence of iron to the $^{+}3$ valence iron cations in the soil [4]. Researcher also has revealed that relationships to the solubility of $Fe(OH)_3$ as depending on pH of available Fe in the soil, the pH increases, the iron in this form is insoluble and has also been decreased the amount of dissolved iron used by plants in the soil. Also changing the form of +2 valence iron in solution form of the iron during the formation of soil, adsorbed Fe^{+2} form, in the form of ferric oxide and ferrous compounds can now also specify different forms.

Krauskopf [5] has stated that 4 major form of iron found in the soil. These include: a-colloidal form, b-soluble and may vary form, c-Pseudo-soluble form, d-crystalline form. The researcher also informed that is the $Fe(OH)_3$ of the colloidal iron form, on the negative charge of the clay with a positive charge, or that the clay layers into fixed may ferric hydroxide form with electro clay as in the brown earth and help the formation of clay-humus complex by a bridge between electro humus stated the olds. Ferric hydroxide which is the color of the clay investigators, according to the climatic conditions of the color can vary from red to brown was also noted.

Tagliavini and Rombol [6] stated that in soil iron largely amorphous iron is found in inorganic forms such as goethite, hematite and ferrihidrit, the pH dependent solubility of iron oxide, and in the aerobic, alkaline and calcareous soil conditions in is very low the plant-available form of iron, and not meet plant requirements.

Kryc et al. [7] established that in their made works in order to determine different fractions such as Al, Ti, Fe, Cu, Mn, P and B elements in various sediments were between 54.1 to 849 μmol/g of the total amount of iron by the sequential method; loosely bound iron vary from 0.066 to 0.201 μmol/g; exchangeable iron vary from 0.069 to 0.699 μmol/g in; carbonate depends on iron vary from 0.671 to 9.71 μmol/g; Fe and Mn oxide depend on iron from 19.6 to 220 μmol/g; organically bound iron vary from 4.69 to 51.5 mmol / g; opal fraction depend on iron vary from 2.77 to 201 μmol/g; and residual iron vary from 9.94 to 443 μmol/g.

Dabkowsk - Naskret [8] informed that exchangeable iron contents in Poland soils vary between 1.5 to 2.2 ppm, the carbonates bound iron content of 0.3 to 2.6 ppm, the manganese oxide bound iron content of 9.1 to 101.9 ppm; the organically bound iron content of 223.3 to 1808.7 ppm, the amorphous oxide bound iron content of 398.2 to 3060.0 ppm and the crystal iron oxide bound iron content of 223 to 3987. Besides, the researcher reported that were also between 12659.6 to 23431.0 of residual iron fraction residual, total iron content of 16600 to 28400 ppm, and labile fractions of iron is relatively low, due to carbonate bound fraction to the mid-labile, and the most extractable iron fraction determined to the crystalline iron oxide bound.

Feng et al. [9] reported that in Chinese soils of amorphous iron oxide was varied between 0.20 to 1.04 %, crystalline iron oxide between 32.9 to 13.1 %. The crystalline iron form consist by crystallizing around the sand particles of ferric iron oxide or beads as a simple film may occur in the cement form connecting one another to the particles. The ferric oxide can crystallize in the form of $Fe_2O_3.2H_2O$ in humid conditions and Fe_2O_3 in dry conditions [10].

The aim of this study was to determine the content, distribution and its relationship with certain soil characteristics of iron fractions in the Bafra, Çarşamva and Suluova soils.

2 Materials and Methods

2.1 Locations received of soil samples, and some physical and chemical properties

Research soils were taken from the 0-20 cm soil depth by a hard plastic shovel at agricultural land of Bafra, Çarşamba and Suluova. The locations received of soil samples, and some physical and chemical properties are given in Table 1.

Texture [11], $pH_{1:2,5}$ [12], total lime with Scheibler calcimeter [13], active lime [14]), organic matter [15], available phosphorus [16], CEC [17], available Fe, Mn, Zn and Cu [18] were determined in soil samples.

Using sequantial methods, exchangeable iron (Exch.-Fe), organically bound iron (OM-Fe), manganese oxide bound iron (MnOX-Fe) by Shuman [19] and Chao and Zhou [20], amorphous iron oxide bound iron (AFeOX-Fe) by McKeague and Day [21], crystal iron oxide bound iron (CFeOX-Fe) by Shuman [19] and residual iron (R-Fe) by Shuman [22] in the soil samples were determined.

3 Results and Discussion

3.1 Some physical and chemical prperties of soil

Some physical and chemical properties of soils are presented in Table 1. Analyzing the texture, clay soils from Carsamba to get those 30% , 33% of those from Bafra , it constituted 42.9 % of those from Suluova . The clay loam soils with 30% of those from Carsamba, 44.4 % of those from Bafra, has constituted 28.6 % of those from Suluova. Loam-textured soils from Carşamba, and 10 % of the 11.1 % of those from Bafra, constituted 28.6 % of those from Suluova. In addition, 30% of silty clay soil Chiefs from Carsamba, 20% within a silty loam, while 11.1% of the land taken from Bafra, has a sandy loam texture. Accordingly, a large part of the trial soils are clay and clay loam.

Soils pH values are in the range 6-7 in Çarşamba to get those 50% , from 11.1 % of Bafra, and constituted 11.3 % of those from Suluova. pH value in the range of 7-8 % of those who received land from Çarşamba 50 %, 77.8 % of those from Bafra, constituted 85.7 % of those from Suluova. The pH of the soils in the 5-6 range, which only accounted for 11.1% of the land taken from the Bafra and received. Accordingly, the pH of the majority of the land is between 7-8.

Lime content of the soils usually was between about 5-15%. However about the half from Suluova, it is between 5-15% and the other half was found to contain 15-25% lime. Soils containing lime between 5-15%, 40% of those from Çarşamba, 44.4% of those from Bafra constituted 57.1% of those who received Suluovad. The soils of containing lime 15-25%, 10% of those from Carsamba, created the 42.9% from Suluova, it did not contain lime soils that range from Bafra. On the other hand, covering less than 1% lime soils from Çarşamba to get those 20%, which constitutes 33.3% of those from Bafra. The soils containing lime between 1-5%, 30% from Carsamba, when it accounted for 22.2% of Bafra. Suluova between soils from less than 1% and there is no lime to the soil covering between 1-5%.

Organic matter content of soils is usually between 2-3% were moderate. Soils with moderate organic matter content, 60% of those from Çarşamba, 55.6% of what is taken from Bafra, is taken from Suluova has constituted 42.9%. The poor soil organic matter content between 1-2% from the 30% Çarşamba, 11.1% of what is taken from Bafra, is taken from Suluova has constituted 57.1%. In addition, under the very low level of 1% from Carsamba's territory covers 10% of the organic material is taken from Bafra, it has constituted 11.1%. In addition, 11.1% of the land taken from Bafra, a high level of 3-4%; If more than 4% and 11.1% contained very high levels of organic matter. The available phosphorus of 60% of the land taken from Carsamba, when 78% from Bafra, 85.7% of from Suluova was very high in terms of scope. 10% of the land taken from Carsamba which contain very low levels of available phosphorus, phosphorus were determined to contain an intermediate level of 30%. The content available phosphorus of soils from Bafra and Suluova founded very high, this is linked to the excessive use of phosphorus fertilizers in the cultivation of sugar beet made since a long time.

CEC of 42,30% of soils was high ranged from 25 to 40 me/100g, moderate 38,46% of soils from 12 to 25 me/100g, very high >40 me/100g of 11,53% soils, very low ≤6,0 me/100g of 3,8% of soils.

For Lindsay and Norvell [23] method, according to the threshold values announced by Boer and Reissenau [24] 6 ppm Fe), soils from Suluova–Saluca, Uzunoba, Kurnaz and Saygılı, with soil taken from Bafra- Fenerköy soils had deficiency level of iron. Extractable iron content with DTPA of 11.1% of the soil recieved from Bafra, 57.1% of soil from Suluova had lower than 6 ppm. All of the land was taken from Carsamba include iron over 6 ppm.

For DTPA extractable method, according to iron evaluation criteria reported Loué [4], the soils of Suluova (Saluca, uzunoba, Yüzbey, Kurnaz, Saygılı, Eraslan, Hacıbayram) and Bafra (Kalaycılı, Fenerköyü) who has less iron than 10 ppm the DTPA method, had a high iron deficiency risk.

However, soils received from Çarşamba, Çınarcık, Karabahce, Hurriyet, Ahubabai Kurtahmetli, Bafraçalı, Koşuköy with Y. Donurlu and Bafra's the Şeyhören and Adaköyü who has the 10-20 ppm of available iron was very low iron deficiency risk.

According to Loué [4], available Mn content of 96,15% of soils were 8-80 ppm and it was found sufficient. Only one soil who contained 6.1 ppm available Mn (Suluova-Uzunoba), had a risk of moderate level of manganese deficiency (between 4-8 ppm Mn deficiency moderate risk).

According to Lindsay and Norvell [18], available zinc content of 23,07% of soils was <0,5 ppm, it was founded deficiency. The zinc content of plant-available form 50% of the land is between 0.5-1 ppm marginally deficient, and plant-available form of zinc content of 23.08%, was found > 1 ppm was sufficient.

According to Lindsay and Norvell [23], available copper content of all soils was higher than 0,2 ppm, it was sufficiency level.

3.2 The content of iron fraction and the percent of their distribution in soils

The content of iron fraction and the percent of their distribution in soils are given Table 2 and Table3

Examined together with Table 2 and Table 3, the total iron content in the soil samples are from 20000 to 34000 ppm. The content of exchageable, organically bound, manganese oxide bound iron of soil, represented only a small fraction would not be considered as important as the total iron. Exchangeable iron forms varied between 0.8-2.4 ppm; organically bound iron forms between 0,6-1.6 ppm; manganese oxide bounden iron was found between 3.9 to 158.9 ppm. These iron forms constitued 0.006%, 0.004% and 0.009% of the total iron as average, respectively. The content of amorphous oxide bounded iron forms was between 1100-6700 ppm, crystalline iron oxide bounded iron form 6000-11300 ppm, also residue iron form was found between 7800-19400 ppm. These iron forms constituted as an avaerage 14.38%, 37.67% to 48.23% of the total iron, respectively. In other words, amorphous iron oxide bounded iron, crystalline iron oxide bound iron and residue iron forms constitued an important part of total iron. Considering the average iron content of the soil related to iron forms iron fractions was arrenged such as R-Fe>CFeOX-Fe>AFeOX-Fe>MnOX-Fe>Exch.-Fe>OM-Fe

Shumen and Hargrove [25] reported that the content iron forms were arrenged depending on the amount of soil in the form of exchangeable iron < organically bound iron < manganese oxide bounded iron < amorphous iron oxide bounded iron < residual iron < crystaline iron oxide bounded iron form.

3.3 The relationship between some properties and the content of iron fraction of soils

The correlation coefficients of the relationship between some properties and the content of iron fraction of soils are given in Table 4.

As can be seen from table 4, the correlation cofficient of the relations between the content of exchangeable, organically bound, amorphous iron oxide bounded, and residue Fe and the some propertiee of the soils found not statistically significant. The correlation coefficients between the content of manganese oxide bounded iron forms and pH of soil, total and active calcaire contents founded significantly and negative, these correlation coefficients were r = -0.448 *, r = -0.556 ** and r = -0.448*, respectively. In other words, the content of manganese oxide bounded Fe decreased significantly due to increasing of pH, total and active calcaire content of soils (Figure 1 and Figure 2).

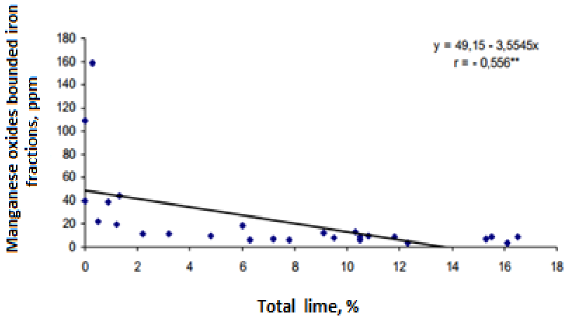

Figure 1: The relationship between the content of Mn oxide bounded-Fe and total lime in soils

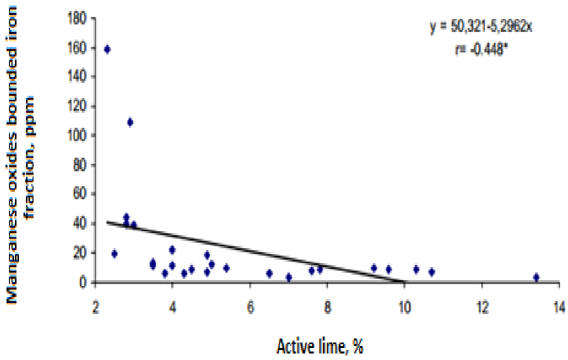

Figure 2. The relationship between the content of Mn oxide bounded-Fe and active calcaire in soils

The correlation cofficient of the relations between the content of manganese oxide bounded iron and available Mn of soils was found positive and statistically significant, the correlation coefficient of this relation was $r=0.674^{**}$. Manganese oxide bounded Fe content increased significantly due to increasing available Mn content of soils.

The correlation cofficient of relations between the content of manganese oxide bounded iron and sand, silt, clay, organic matter, available phosphorus, copper, zinc content of soils was not founded significantly.

The correlation coefficient of relations between crystalline iron oxide bound iron and total iron and sand content of soils founded negative and significant, its correlation coefficients were $r=-0.382^{*}$ and $r=-0.467^{*}$, respectively. In other words, due to the sand content of the soil increases, the crystal form of iron oxide inclusions and the total iron content of iron was decreased significantly (Figure 3).

The positive relation significantly between clay content and total Fe of soils were determined, which the correlation coefficient was $r=0.386^{*}$. In other words, increasing clay content of soils, total Fe increased. The correlation coefficiency of relations between the content of crystalline iron oxide bounded iron form and mil, clay content, pH value, total and active calcaire contents, organic matter, available phosphorus, Mn, Cu and Zn, and CEC value of soils were not stasistacally significant. Also, The correlation coefficiency of relations between the content of total iron and mil, pH value, total and active calcaire contents, organic matter, available phosphorus, Mn, Cu and Zn, and CEC value of soils were not stasistacally significant.

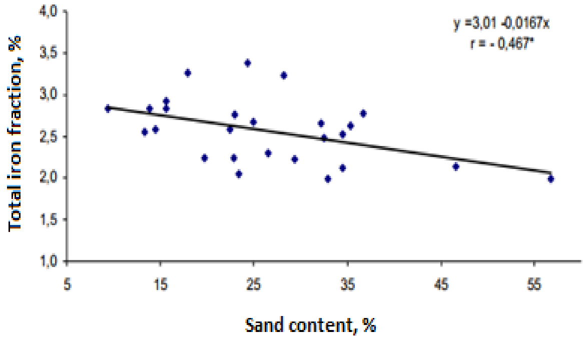

Figure 3: The relationship between the total iron and sand contents in soils

3.3 The ralationships between DTPA extractable iron content and individual iron fraction and the sum of iron fraction of the soils

The equation and the correlation coefficient of multiple ralation between DTPA extractable iron content and individual iron fraction are given in Table 5.

As can be seen from table 5, the equation multiple ralation between DTPA extractable iron content and individual iron fraction was founded $Y = -3.8 + 3.87x_1 - 12.4x_2 + 0.26x_3 + 0.0033x_4 - 0.00002x_5 + 0.00077x_6$ and the correlation coefficiency of multiple relation are $r=0.833^{**}$. This result showed that iron fraction 6 different forms on the extractable Fe with the 0.005M DTPA + 0.01M $CaCl_2$ + 0.1M TEA (pH:7.3) was determinant (Tablo 5). Also, the correlation coefficients of relation between DTPA extractable Fe content of soils and the sum as $x_1 + x_2$, $x_1 + x_2 + x_3$, $x_1 + x_2 + x_3 + x_4$, $x_1 + x_2 + x_3 + x_4 + x_5$ and $x_1 + x_2 + x_3 + x_4 + x_5 + x_6$ of iron fraction given in Table 6. As can be seen from Table 6, the correlation coefficients of relation between DTPA extractable content of soils and the sum triple of excahangeable iron + organic bounded iron +

manganese oxide bounded iron and the sum senary of exchangeable iron + organic bounded iron + manganese oxide bounded iron + amorphous iron oxide bounded iron + crystal iron oxide bounded iron + residue iron (total iron content) was founded as r = 0.655** and r = 0.394*, respectively. This result show that the sum of exchangeable iron + organic bounded iron + manganese oxide bounded iron on the DTPA extractable iron was determinant. In other words, the form of exchangeable iron + organic bounded iron + manganese oxide bounded iron was extracted by the DTPA. Increasing the sum of exchangeable iron + organic bounded iron + manganese oxide bounded iron of soils, DTPA extractable iron increased.

The correlation coefficient of relation between DTPA extractable iron content and the sum of exchangeble iron + organic bounded iron was not founded significant. Besides, the correlation coefficients of relation between DTPA extractable iron content and the sum of exchageable iron + organic bounded iron + manganese oxide bounded iron + amorphous iron oxide bounded iron and the sum of exchageable iron + organic bounded iron + manganese oxide bounded iron + amorphous iron oxide bounded iron + crystal iron oxide bounded iron was not founded significant.

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Table 1. Some physical and chemical properties of the soils

Soil No	Location	Sand	Mil	Clay	pH	Lime	Active lime	OM	CEC	Available	Extractable micro elements with DTPA, ppm			
		%				%	%	%	me/kg	Kg P_2O_5/da	Fe	Mn	Zn	Cu
1	Çarşamba (Çınarcık)	32.5	37.0	30.5	7.6	15.5	7.3	1.3	20.9	7.2	15.4	14.2	0.5	3.0
2	Çarşamba (Karabahçe)	15.7	60.3	24.0	6.9	3.2	3.0	2.7	19.8	15.2	19.5	19.1	1.1	7.8
3	Çarşamba (Ovacık)	24.3	27.4	48.3	6.9	1.3	2.3	2.2	33.5	42.9	41.4	19.3	1.2	7.2
4	Çarşamba (Hürriyet)	28.2	39.2	32.6	6.6	6.0	4.4	1.6	22.8	18.4	13.6	13.9	0.5	5.6
5	Çarşamba (Ahubaba)	18.0	36.4	45.6	6.5	0.5	3.5	2.4	32.2	24.1	15.6	10.8	0.6	5.0
6	Suluova (Saluca)	36.7	27.3	36.0	7.6	16.5	9.8	1.9	25.4	14.4	4.4	8.1	0.7	1.4
7	Suluova (Uzunoba)	25.0	22.8	52.2	7.3	16.1	12.9	1.6	34.5	137.6	4.9	6.1	0.8	2.5
8	Suluova (Yüzbey)	32.9	42.6	24.5	7.5	12.3	6.5	1.1	16.7	18.2	8.0	13.8	0.7	2.0
9	Suluova (Kurnaz)	34.5	27.8	37.7	7.2	15.3	10.2	1.5	25.6	14.3	4.8	9.0	1.3	3.6
10	Suluova (Saygılı)	29.4	27.0	43.6	6.9	9.5	7.1	2.3	30.7	29.2	3.9	10.7	1.0	4.4
11	Suluova (Eraslan)	14.5	25.0	60.6	7.5	11.8	9.1	2.1	40.6	25.4	7.3	11.8	0.6	3.9
12	Suluova (Hacıbayram)	46.6	28.9	24.5	7.4	9.1	4.5	2.3	19.3	10.4	6.4	20.9	1.2	2.9
13	Çarşamba (Kurtahmetli)	13.9	36.5	49.6	6.8	0.9	2.5	2.0	33.7	52.0	15.6	23.0	1.1	6.2
14	Çarşamba (Muşçalı1)	9.4	49.0	41.6	7.7	10.8	8.7	2.5	29.6	6.3	29.2	22.4	0.6	6.7
15	Çarşamba (Bafraçalı)	32.2	46.0	21.8	7.3	6.3	3.3	0.8	19.7	2.0	11.7	13.2	0.6	2.2
16	Çarşamba (Muşçalı2)	23.0	55.0	21.9	7.2	7.8	3.8	2.5	18.2	12.6	35.7	24.8	0.8	9.9
17	Çarşamba (Y. Donurlu)	35.3	36.0	28.7	7.6	1.2	2.0	1.6	20.5	7.7	14.2	22.7	0.8	3.2
18	Bafra (Doğanca1)	15.7	20.3	64.0	7.1	0.0	2.3	3.0	44.4	17.6	30.3	21.0	0.5	6.9
19	Bafra (Koşuköyü)	34.5	45.6	19.9	7.7	10.5	4.0	1.9	15.7	10.4	15.6	17.7	0.5	4.0
20	Bafra (Şeyhören)	26.5	30.1	45.3	7.6	2.2	3.5	2.3	31.8	28.4	13.4	16.6	0.4	6.0
21	Bafra (Kalaycalı)	23.4	44.0	32.6	7.3	7.2	4.4	2.4	24.4	12.0	9.3	16.6	0.6	7.7
22	Bafra (Adaköyü)	22.9	44.5	32.6	7.4	10.5	6.0	2.5	24.6	13.6	15.9	13.6	0.7	5.3
23	Bafra (Fenerköyü)	56.8	35.7	7.50	7.2	10.3	3.0	0.7	6.0	20.8	5.3	9.7	0.3	2.7
24	Bafra (Sarıkaya)	19.7	45.3	35.0	5.2	0.0	2.4	2.0	25.0	51.9	33.3	68.5	0.9	4.4
25	Bafra (Doğanca2)	22.5	38.0	39.5	7.3	0.3	1.8	2.2	28.1	17.3	42.5	29.5	1.1	7.4
26	Bafra (Sahilkent)	13.4	29.0	57.6	6.7	4.8	4.9	4.1	42.7	23.3	21.9	17.4	0.9	9.2

Table 2: The content of iron fraction in the soil samples

Soil No.	Iron Fractions, ppm						
	Exch.-Fe	**OM-Fe**	**MnOX-Fe**	**AFeOX-Fe**	**CFeOX-Fe**	**R-Fe**	**Total Fe**
1	1.3	0.9	9.20	4500	9400	10800	25000
2	1.5	1.1	11.7	4400	10100	14800	29000
3	1.9	0.7	44.4	6600	7800	19400	34000
4	1.1	1.4	18.3	5600	10100	16600	32000
5	1.1	1.3	22.0	3900	9700	18900	33000
6	0.9	0.8	8.60	4800	11300	11700	28000
7	1.3	0.9	4.00	1100	9800	16000	27000
8	1.5	0.8	3.90	2200	6000	11700	20000
9	2.0	1.0	7.00	3500	12600	9100	25000
10	1.1	0.9	8.00	2900	8800	10600	22000
11	1.0	0.7	8.60	2800	10400	12600	26000
12	1.0	1.0	12.30	2200	8400	10700	21000
13	1.1	1.1	39.4	4600	11300	12500	28000
14	1.6	1.1	9.4	5100	10700	12400	28000
15	0.9	1.0	5.80	6100	9900	10500	27000
16	1.1	0.8	6.00	6700	10300	10500	28000
17	0.9	0.9	19.9	4800	8800	12600	26000
18	1.5	1.0	39.6	2400	10100	15700	28000
19	1.8	0.6	8.60	2600	9100	9400	21000
20	1.4	0.9	11.5	1800	9200	12000	23000
21	0.8	0.9	7.50	2500	10100	7800	20000
22	1.9	1.0	6.0	4000	9800	8700	22000
23	2.4	1.2	13.10	3500	7100	9300	20000
24	1.7	0.9	109.4	2100	8800	11600	22000
25	1.2	1.6	158.9	2300	9000	14400	26000
26	1.5	1.1	9.90	4100	8900	12500	25000
Minimum	0.8	0.6	3.90	1100	6000	7800	20000
Maximum	2.4	1.6	158.9	6700	11300	19400	34000
Mean	1.37	0.98	23.19	3734.62	9519.23	12415.18	25615.38

Exch. Fe: Excchangeable Fe; OM-Fe: Organic bounded Fe; MnOX-Fe: AFeOX-Fe:Amorf iron oxide bounded-Fe; CFeOX-Fe:Cristaline iron oxide bounded-Fe; R-Fe:Residue-Fe;

Table 3: The distribution of iron fraction in the soil samples, %

Soil No.	Iron Fractions, %						
	Exch.-Fe*	OM-Fe	MnOX-Fe	AFeOX-Fe	CFeOX-Fe	R-Fe	Total Fe
1	0.005	0.004	0.04	18.00	37.60	43.20	0.005
2	0.005	0.004	0.04	15.17	34.83	51.03	0.005
3	0.006	0.002	0.13	19.41	22.94	57.06	0.006
4	0.003	0.004	0.06	17.50	31.56	51.88	0.003
5	0.003	0.004	0.07	11.82	29.39	57.27	0.003
6	0.003	0.003	0.03	17.14	40.36	41.79	0.003
7	0.005	0.003	0.01	4.07	36.30	59.26	0.005
8	0.008	0.004	0.02	11.00	30.00	58.50	0.008
9	0.008	0.004	0.03	14.00	50.40	36.40	0.008
10	0.005	0.004	0.04	13.18	40.00	48.18	0.005
11	0.004	0.003	0.03	10.77	40.00	48.46	0.004
12	0.005	0.005	0.06	10.48	40.00	50.95	0.005
13	0.004	0.004	0.14	16.43	40.36	44.64	0.004
14	0.006	0.004	0.03	18.21	38.21	44.29	0.006
15	0.003	0.004	0.02	22.59	36.67	38.89	0.003
16	0.004	0.003	0.02	23.93	36.79	37.50	0.004
17	0.003	0.003	0.08	18.46	33.85	48.46	0.003
18	0.005	0.004	0.14	8.57	36.07	56.07	0.005
19	0.009	0.003	0.04	12.38	43.33	44.76	0.009
20	0.006	0.004	0.05	7.83	40.00	52.17	0.006
21	0.004	0.005	0.04	12.50	50.50	39.00	0.004
22	0.009	0.005	0.03	18.18	44.55	39.55	0.009
23	0.012	0.006	0.07	17.50	35.50	46.50	0.012
24	0.008	0.004	0.50	9.55	40.00	52.73	0.008
25	0.005	0.006	0.61	8.85	34.62	55.38	0.005
26	0.006	0.004	0.04	16.40	35.60	50.00	0.006
Minimum	0.003	0.002	0.01	4.07	22.94	36.40	0.003
Maximum	0.012	0.006	0.61	23.93	50.50	59.26	0.012
Mean	0.006	0.004	0.09	14.38	37.67	48.23	0.006

*:The percent of total-Fe;
Exch. Fe: Excchangeable Fe; OM-Fe: Organic bounded Fe; MnOX-Fe: AFeOX-Fe:Amorf iron oxide bounded-Fe; CFeOX-Fe:Cristaline iron oxide bounded-Fe; R-Fe:Residue-Fe;

Table 4. Correlation coefficients of the relationship between some properties and the content of iron fraction of soils

Soil properties	Iron fractions						
	Exch.-Fe	OM-Fe	MnOX-Fe	AFeOX-Fe	CFeOX-Fe	R-Fe	Total Fe
Sand	0.179	- 0.095	- 0.205	- 0.084	- 0.382*	- 0.316	- 0.467*
Mil	0.032	0.100	- 0.000	0.111	-0.000	- 0.122	- 0.055
Clay	- 0.170	0.000	0.145	- 0.200	0.310	0.322	0 386*
pH	- 0.118	- 0.251	- 0.448*	0.000	0.045	- 0.344	- 0.190
Total calcaire	0.089	- 0.361	- 0.556**	- 0.095	0.155	- 0.259	- 0.315
Active calcaire	- 0.032	- 0.277	- 0.447*	- 0.200	0.349	- 0.063	- 0.071
OM	-0.084	0.077	0.084	- 0.032	0.195	0.122	0.173
Available P	0.055	- 0.084	0.100	-0.366	- 0.000	0.279	0.130
Available Mn	0.077	0.032	0.674**	- 0.095	- 0.126	0.000	- 0.105
Available Cu	0.000	0.237	0.226	0.255	0.161	0.122	0.295
Available Zn	- 0.045	0.126	0.311	0.071	0.152	0.346	0.237
CEC	- 0.167	0.000	0.145	- 0.190	0.311	0.308	0.374

Table 5: The equation and the correlation coefficient of multiple ralation between DTPA extractable iron content and individual iron fraction

Chemical method Y	The multiple regression equation	Correlation coefficient (r)
0.005 M DTPA + 0.01 M $CaCI_2$ + 0.1 M TEA (pH:7) method	$Y= -3.8+3.87x_1-12.4x_2+0.26x_3+0.0033x_4-0.00002x_5+0.00077x_6$	0.833**

**: Significant at the 0.01 level
x_1: Replaceable Iron, x_2: Organic Bound Iron, x_3: Mn Oxy. Bound Iron, x_4: x_5 depends on Amorphous Iron Oxy Crystal Iron Oxy. Iron Bound; x_6: Now Iron

Table 6: The correlation coefficient of relation between DTPA extractable iron content of soils and the sum of dual, triple, four and the five, senary of iron fraction

Chemical method	Total iron fractions				
	x_1+x_2	$x_1+x_2+x_3$	$x_1+x_2+x_3+x_4$	$x_1+x_2+x_3+x_4+x_5$	$x_1+x_2+x_3+x_4+x_5+x_6$ (total Fe)
0.005 M DTPA + 0.01 M $CaCI_2$ + 0.1 M TEA (pH:7) method	0.219	0.655**	0.313	0.167	0.394*

*: $p < 0.05$ significant level, **: $P < 0.01$ level of significant
x_1: Changeable iron, x_2: organically bound iron, x_3: Mn ox. bound iron, x_4: amorphous iron ox. bound iron
x_5:Crystal iron ox. iron bound; x_6: residue iron