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ARAŞTIRMA MAKALESİ RESEARCH ARTICLE

Relationship between some soil characteristics and contribution on available phosphorus of inorganic phosphorus fractions in calcareous soils

Kireçli topraklardaki inorganik fosfor fraksiyonlarının yarayışlı fosfora katkıları ve bazı toprak özellikleri ile ilişkileri

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Ö Z E T / A B S T R A C T

Aims: The aim of this study is to determine the amount and distribution of inorganic phosphorus fractions in soil profiles classified as Mollisol and Entisol, which are common in the Eastern Anatolian region, and to determine their soil properties and their relationships with each other, and to evaluate the contribution of inorganic phosphorus fractions to available soil phosphorus (Olsen-P).

Methods and Results: The total amount of phosphorus in these soils with calcareous and slightly alkaline reactions has been determined as 280-1713 mg kg^{-1} and an average of 713 mg kg^{-1}. Ca-P', which make up an average of 80.9% of the total phosphorus and which are determined as the first phosphorus fraction in these soils, have been determined between 163.2-951.1 mg kg^{-1}. The occluded phosphates (CDB-P), which rank second in quantity in these soils after Ca-P2, are between 2.07-105.6 mg kg^{-1}, and thirdly, phosphates (CB-P) held by carbonates during the first extraction are 0.76-52.83 mg kg^{-1}. In the fourth and last row, nonoccluded aluminum and iron phosphates (Al-P + Fe-P) were found as the least amount of phosphorus fractions in these soils between 0.09-5.0 mg kg^{-1}.

Conclusions: In summary, the order of inorganic phosphorus fractions in these soils was determined as Ca-P> CDB-P> CB-P> Al-P+Fe-P.

Significance and Impact of the Study: It was determined that two fractions contribute to phosphorus (Olsen-P), nonoccluded aluminum and iron phosphates (Al-P + Fe-P) and occluded phosphates (CDB-P) in these soils.

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INTRODUCTION

Sodium bicarbonate extraction for P (Olsen-P) (Olsen et al. 1954) is accepted methodology for estimating P availability and developing fertilizer recommendations in neutral and high-pH, calcareous soils in the Turkey. Phosphorus in soils is present in two general forms, inorganic and organic. Much of the phosphorus in soil is existent in the inorganic form such as iron, aluminum, calcium, etc. The amount of different forms of inorganic phosphorus depends on various some soil characteristics such as pH, $CaCO_3$, organic matter, clay, silt, sand (Jackson, 1962; Singh and Pathak, 1973). Since the different inorganic phosphorus forms have different solubility under various soil conditions, the assessment of these forms might give an information about availability of phosphorus in soils under specified soil conditions (Kacar, 1970; Yang and Jacobsen, 1990; Chand et al., 1991). Very little information is available on the distribution of the inorganic forms of phosphorus of soils in the East Anatolia of Turkey.

The purpose of this study was to determine the amount and distribution of different inorganic phosphorus forms, to evaluate the relationship between these different forms and some soil characteristics, and to evaluate contributions of inorganic phosphorus fractions on the available phosphorus in the soil profiles of some Mollisols and Entisols of Van in the East Anatolia of Turkey.

MATERIALS and METHODS

A total of 32 samples out of 6 soil series were collected following a soil survey undertaken, which was undertaken on the southern part of Lake Van namely the Gevaş region (Çimrin et al., 2004). Soils are classified according to the Soil Survey Staff (1999) as Mollisols and Entisols (Table 1). The annual precipitation of the Gevaş region is 478.2mm with an annual temperature of 8.9°C (Topraksu, 1971). Analyses were done in two replicate on air-dried (<2 mm) soil samples. The pH, EC and $CaCO_3$ content were determined according to Soil Salinity Staff (1951). Cation exchange capacity was determined according to Thomas (1982). Organic carbon was determined according to modified Walkley and Black methods (Walkley, 1947). Mechanic analysis was by the hydrometer method Bouyoucos (1951).

The fractionation of P (Olsen and Sommers, 1982) involved sequential extractions with (i) a solution 0.1 *M* in NaOH and 1 *M* in NaCI to remove nonoccluded AI- and Fe-bound P (AI-P+Fe-P), (ii) 1 *M* NaCI and citrate-bicarbonate (CB) to remove P resorbed during the preceding extraction (CB-P), (iii) citrate-dithionite-bicarbonate (CDB) to remove P occluded within Fe oxides and hydrous oxides (CDB-P), and (iv) 1 *M* HCI to remove Ca-bound P (Ca-P). These fractions are subsequently referred to as NaOH-P, CB-P, CDB-P, and HCI-P, respectively. Inorganic phosphorus fraction in extractions were determined on spectrophotometer (UV) in preparing samples as described by Olsen and Sommers (1982). Organic P was estimated from the difference between the HCI-extractable P in a soil sample ignited at 240°C and in an unignited sample (Legg and Black, 1955). Total P was determined by digestion with perchloric acid (Olsen and Sommers, 1982). Available phosphorus was estimated by the method of Olsen et al. (1954).

Data were analyzed by using the SPSS-22 statistical package program and evaluated according to stepwise regression procedure and Pearson' correlation analysis (Johnson and Wichern, 1988).

RESULTS and DISCUSSION

Soils some physical and chemical properties were given in Table 1. The pH values of the study area soils ranged from 7.45 to 7.94, with an average of 7.70. Accordingly, all soil samples are slightly alkaline reaction and salt-free, and their cation exchange capacities were found between 19.24 cmol kg-1 and 39.03 cmol kg-1 and an average of 28.81 cmol kg-1. The amount of lime, which generally increases with depth, is between 8.36-42.80 %, with an average of 21.69 %. Organic matter contents of the soils were found between 0.70-6.10 %, sand contents ranged between 26.04-59.70 %, silt 8.49-41.74 %, clay 24.41-56.69 % (Table 1).

The amounts of various phosphorus fractions in the soil profile used in the study and the percentage ratios of these fractions in total phosphorus are given in Table 2. As can be seen from Table 2, the total phosphorus content of the soils is determined as an average of 713 mg kg^{-1} from 280 mg kg^{-1} to 1732 mg kg^{-1}, while the available phosphorus to the plant is 0.3 mg kg^{-1} to 19.8 mg kg^{-1} on average 6.2 mg kg^{-1}, the available phosphorus is very low constitutes part of total-P.

Organic-P, which constitutes a very small part of the total-P with an average of 27.4 %, has been determined as average 210.2 mg kg^{-1} from 23.9 mg kg^{-1} to 611 mg kg^{-1} in soil profiles. Similarly, in the study named Relationship between phosphorus fractions of some selected Sudanese soil orders to phosphate availability, Ahmed et al. (2018) reported that the amount of organic phosphorus in their three soils was low and that these soils were associated with low organic matter.

Although total-P is not important in terms of available phosphorus for the plant, the amount of total-P gives an idea about the current phosphorus capacities in the soil. Tripathi et al. (1970) classified the soils as low between 300-500 mg kg^{-1}, medium between 600-1000 mg kg^{-1} and higher than 1000 mg kg^{-1} according to their total-P content. These classification values show that the research soils contain low, medium and high total-P. In the study, statistically significant relationships were determined between the amount of total-P of the soils and some soil properties and phosphorus fractions. These were significant negative correlations between total-P and salinity, CEC and Lime (Table 3), and positive correlations between Ca-P, CDB-P, CB-P and Organic-P (Table 4). Similarly, Lui et al. (2019) reported the soil organic-P had significantly positive correlations with total-P of soil.

In this study generally, the order of change in inorganic phosphorus fractions were Ca-P>CDB-P>CB-P>Al-P+Fe-P. Muhammad and Jones (1992) reported the abundant sequence of phosphorus fractions in the soil containing gypsum from Iraq and Southern Spain as Ca-P> CDB-P> Al-P + Fe-P> Organic-P. Al-P+Fe-P ranged from 0.09 to 5.00 mg kg^{-1}. Çimrin and Karaçal (1997) working in the same region have determined similar ranking. The presence of very small amounts of Al-P+Fe-P in total phosphorus in these soils, as stated by Kacar (1970), Talati and et al. (1975), Solis and Torrent (1989), may have low levels of decomposition and degradation. it may also be related to high lime amounts.

Table 1. Some chemical and physical properties of the soils

Horizon	Depth (cm)	pH	Salinity (%)	CEC (cmol kg^{-1})	$CaCO_3$ %	Org.M. (%)	Particle size distribution(%)			Texture class
							Sand	Silt	Clay	
Hasbey series (Typic Haploxeroll)										
Ap	0-12	7.78	0.028	19.24	15.05	2.61	35.96	34.18	29.86	Clay loam (CL)
A2	12-30	7.75	0.030	20.30	15.38	2.81	38.83	29.42	31.75	Clay loam(CL)
Bw1	30-55	7.76	0.023	20.84	16.89	1.88	35.20	31.29	33.51	Clay loam(CL)
Bw2	55-85	7.74	0.025	22.98	15.88	3.02	38.52	27.53	33.95	Clay loam(CL)
C	85+	7.72	0.025	19.24	14.21	2.35	35.85	29.00	35.15	Clay loam(CL)
Hasbey II series (Typic Haploxeroll)										
Ap	0-12	7.57	0.042	33.68	11.70	6.10	34.82	8.49	56.69	Clay (C)
A2	12-30	7.61	0.040	25.12	16.72	2.68	47.25	23.53	29.22	Sandy clay loam (SCL)
Bw1	30-55	7.67	0.032	23.51	16.89	2.50	38.44	23.67	37.89	Clay loam (CL)
Hasbey III series (Typic Haploxeroll)										
Ap	0-15	7.69	0.045	34.21	8.36	3.15	31.90	31.22	36.88	Clay loam (CL)
A2	15-30	7.64	0.043	26.72	10.03	2.81	27.06	41.73	31.21	Clay loam(CL)
Bw1	30-44	7.77	0.038	27.26	10.03	2.21	26.04	34.10	39.86	Clay loam (CL)
Yuva series (Calcic Haploxeroll)										
Ap	0-11	7.57	0.058	33.14	9.20	3.22	29.29	21.48	49.23	Clay (C)
Bw1	11-30	7.45	0.060	35.82	9.36	3.28	29.94	21.31	48.75	Clay (C)
Bwk2	30-42	7.85	0.047	28.33	12.87	1.68	27.74	22.07	50.19	Clay (C)
Bwk3	42-63	7.81	0.050	32.61	13.38	1.41	28.03	22.44	49.53	Clay (C)
C1	63-77	7.73	0.044	29.40	15.88	0.70	40.23	17.96	41.81	Clay (C)
C2	77+	7.94	0.043	33.68	14.88	0.56	41.91	17.34	40.75	Clay (C)
Orak series (Calcic Haploxeroll)										
Ap	0-14	7.68	0.056	37.95	28.26	2.56	37.09	20.44	42.47	Clay (C)
Bw	14-30	7.48	0.054	39.03	25.92	2.50	31.08	21.15	47.77	Clay (C)
Bwk2	30-46	7.62	0.052	35.82	31.77	2.01	39.69	13.43	46.88	Clay (C)
Ck	46-70	7.56	0.053	35.82	33.44	1.25	27.92	21.35	50.73	Clay (C)
Ck2	70+	7.74	0.040	28.33	42.80	2.56	48.34	16.31	35.35	Sandy clay (SC)
Guzelkonak series (Typic Haploxeroll)										
Ap	0-12	7.74	0.049	36.88	27.09	0.90	40.06	21.16	38.78	Clay loam (CL)
Ad	12-31	7.46	0.058	36.88	27.09	3.61	39.95	20.75	39.30	Clay loam (CL)
A3	31-57	7.67	0.053	31.54	30.60	3.15	35.81	30.00	34.19	Clay loam (CL)
A4	57-86	7.67	0.043	31.54	33.10	1.26	43.39	19.10	37.51	Clay loam (CL)
Guzelkonak II series (Typic Haploxeroll)										
Ap	0-15	7.66	0.060	28.33	29.43	0.77	45.34	21.15	33.51	Clay loam (CL)
Ad	15-35	7.90	0.032	26.19	36.78	2.46	36.51	28.16	35.33	Clay loam (CL)
A3	35-60	7.88	0.032	22.98	41.97	1.68	36.94	27.28	35.78	Clay loam (CL)
Iskele series (Lithic Xerorhent)										
Ap	0-13	7.71	0.054	35.82	16.39	1.68	31.38	33.35	35.27	Clay loam (CL)
Mulk series (Typic Xerorhent)										
A1	0-13	7.78	0.020	15.49	31.93	1.82	59.70	15.71	24.59	Sandy clay loam (SCL)
A2	13-25	7.93	0.019	13.35	31.10	0.70	55.57	20.02	24.41	Sandy clay loam (SCL)
Minimum		7.45	0.019	13.35	8.36	0.56	26.04	849	24.41	
Maximum		7.94	0.060	39.03	42.80	6.10	59.70	41.74	56.69	
Mean		7.70	0.042	28.81	21.69	2.25	37.36	23.94	38.69	

Ca-P, which constitute 40.3% to 80.9% of total-P and rank first among the inorganic phosphorus fractions in terms of abundance, have been determined as average 722.08 mg kg^{-1} between 163.17 mg kg^{-1} and 951.12 mg kg^{-1}. Briefly, it was found that Ca-P, one of the inorganic phosphorus fractions, is the dominant inorganic phosphorus fraction in all soils in the study. It has been reported by many researchers that the degree of decomposition and disintegration is proportionally low, that precipitation is not sufficient to wash the alkaline cations in the soil from the profile and that the inorganic phosphorus fraction, which is generally in the highest amount in calcareous and alkaline reaction soils, is Ca-P (Shen and Jiang, 1992; Çimrin and Karaçal, 1997; Azadi et al., 2015).

Table 2. Distribution of various forms of phosphorus in the soil profiles

Hor	Depth	Inorganic P fractions								Organic-P		Total-P	Olsen-P
		Al-P+Fe-P		CB-P		CDB-P		Ca-P					
	cm	mg kg^{-1}	%	mg kg^{-1}	%	mg kg^{-1}	%	mg kg^{-1}	%	mg kg^{-1}	%	mg kg^{-1}	mg kg^{-1}
Hasbey series (Typic Haploxeroll)													
A_p	0-12	1.26	0.07	52.83	3.05	105.67	6.10	951.12	54.9	611.0	35.0	1732	14.5
A_2	12-30	1.35	0.12	42.88	3.83	78.74	7.03	685.52	61.2	89.7	8.0	1121	7.3
B_{W1}	30-55	0.09	0.01	20.67	1.75	55.94	4.74	757.68	64.2	343.5	29.1	1181	3.9
B_{W2}	55-85	1.10	0.09	12.25	1.04	62.16	5.27	780.64	66.1	295.0	24.9	1180	2.8
C	85+	2.19	0.17	29.09	2.32	105.67	8.42	672.40	53.6	445.4	35.5	1255	11.7
Hasbey II series (Typic Haploxeroll)													
A_p	0-12	1.77	0.17	27.56	2.68	75.52	7.36	829.84	80.9	85.9	8.8	1026	10.1
A_2	12-30	1.18	0.09	1.53	0.13	35.24	2.94	675.68	56.4	435.0	36.3	1198	4.8
B_{W1}	30-55	0.34	0.04	8.42	0.88	82.88	8.72	767.52	80.8	83.7	8.8	949	3.4
Hasbey III series (Typic Haploxeroll)													
A_P	0-15	3.46	0.46	27.56	3.65	49.73	6.59	306.68	40.6	274.9	36.4	754	8.9
A_2	15-30	1.26	0.17	6.13	0.83	62.16	8.38	298.48	40.3	346.6	46.7	741	2.5
B_{W1}	30-44	0.09	0.01	3.83	0.59	4.14	0.65	285.36	44.7	322.7	50.5	638	2.3
Yuva series (Calcic Haploxeroll)													
A_P	0-11	5.00	0.79	4.59	0.73	2.07	0.33	405.08	64.2	203.2	32.2	631	17.9
B_{W1}	11-30	3.29	0.47	4.59	0.66	29.01	4.18	410.10	52.2	239.0	34.5	693	15.7
B_{WK2}	30-42	0.42	0.06	8.42	1.27	22.79	3.44	441.16	66.6	179.3	27.1	662	1.2
B_{WK3}	42-63	0.76	0.11	3.83	0.57	35.22	5.26	446.08	66.7	179.3	26.8	668	0.3
C_1	63-77	0.51	0.05	2.30	0.22	24.86	2.43	444.44	43.5	549.7	53.7	1023	1.2
C_2	77+	0.09	0.01	3.83	0.42	22.79	3.06	439.52	48.4	442.2	48.6	908	3.1
Orak series (Calcic Haploxeroll)													
A_P	0-14	0.61	0.19	20.67	6.66	37.29	12.02	188.15	60.7	59.8	19.3	310	6.4
B_W	14-30	0.09	0.02	19.14	6.84	20.72	7.40	163.17	58.3	59.8	21.4	280	3.1
B_{WK2}	30-46	0.09	0.02	15.31	3.68	26.94	6.48	198.14	47.7	155.4	37.4	415	1.2
C_K	46-70	0.61	0.15	6.90	1.68	29.01	7.08	198.14	48.4	155.4	37.9	409	2.8
C_{K2}	70+	0.09	0.03	3.83	1.10	10.36	2.98	209.79	60.4	107.6	30.9	347	1.4
Guzelkonak series (Typic Haploxeroll)													
A_P	0-12	0.95	0.16	3.06	0.51	62.16	10.38	318.02	53.1	167.3	27.9	598	8.1
A_d	12-31	0.43	0.05	3.06	0.38	49.73	6.31	579.42	73.5	155.4	19.7	788	10.6
A_3	31-57	2.25	0.66	0.76	0.22	33.15	9.78	271.40	80.1	23.9	7.1	338	10.4
A_4	57-86	0.17	0.05	0.76	0.24	31.08	10.01	234.77	75.6	35.9	12.8	311	2.3
Guzelkonak II series (Typic Haploxeroll)													
A_P	0-15	3.20	0.80	9.95	2.49	41.44	10.39	256.41	64.3	35.9	9.0	398	11.7
A_d	15-35	0.09	0.02	0.76	0.19	24.86	6.37	251.42	64.5	107.6	27.6	390	2.8
A_3	35-60	0.09	0.02	8.42	2.27	18.65	5.03	201.47	54.3	119.5	32.2	371	0.8
Iskele series (Lithic Xerorhent)													
A_p	0-13	3.46	0.59	15.31	2.62	95.31	16.32	289.71	49.6	179.3	30.7	584	19.8
Mulk series (Typic Xerorhent)													
A_1	0-13	0.09	0.02	21.44	4.28	24.86	4.97	274.73	54.9	167.3	33.5	500	3.1
A_2	13-25	0.17	0.04	19.14	4.71	24.86	6.12	274.73	67.7	71.7	17.7	406	0.8
Minimum		0.09	0.01	0.76	0.13	2.07	0.33	163.17	40.3	23.9	7.1	280	0.3
Maximum		5.00	0.80	52.83	6.84	105.67	16.32	951.12	80.9	611.0	53.7	1732	19.8
Mean		1.14	0.18	12.77	1.95	43.28	6.45	422.08	59.3	210.2	27.4	713	6.2

Some physical and chemical properties and inorganic phosphorus fractions of the study area soils have been determined significant relationships between the Ca-P fractions. Negative between Ca-P and salinity and CEC (Table 3), but positive significant relationships between Ca-P and lime, organic matter, Organic-P, CB-P, CDB-P (Table 4) were determined. On the other hand, negative significant relationships were determined between olsen-P and pH, lime and sand contents of the soils, and positive significant relationships between salinity and organic matter contents. Ahmad et al. (2019) determined positive relationships between the soils olsen-P and organic matter contents.

CDB-P, which are in the second place with an average share of 6.65% after Ca-phosphates in total phosphorus, were found to be average 43.28 mg kg^{-1}, ranging from 2.07 mg kg^{-1} to 105.67 mg kg^{-1}. Significant positive relationships were determined with CDB-P fraction of the study area soils and silt amount of soils and negative values with lime amounts (Table 3). Similar findings to the study were reported by Robertss et al. (1985), Çimrin and Karaçal (1997).

Table 3. Correlation coefficients between soil properties and of soil phosphorus fractions

	Al-P+Fe-P	CB-P	CDB-P	Ca-P	Organic-P	Total-P	Olsen-P
pH	-0.376*	0.077	-0.053	-0.023	0.154	0.053	-0.415*
Salinity	0.412*	-0.411*	-0.269	-0.416*	-0.272	-0.430*	0.362*
CEC	0.222	-0.377*	-0.221	-0.382*	-0.243	-0.397*	0.225
$CaCO_3$	-0.457**	-0.229	-0.347*	0.545**	-0.538**	-0.631**	-0.350*
O.M.	0.310*	0.258	0.250	0.410*	-0.101	0.254	0.364*
Sand	-0.301	0.052	-0.092	-0.034	-0.125	-0.076	-0.218
Silt	0.200	0.182	0.370*	0.125	0.330*	0.284	0.185
Clay	0.125	-0.213	-0.235	-0.077	-0.166	-0.175	0.055

*. **; Correlation values indicated by are important at the level of $P < 0.05$ and $P < 0.01$, respectively.

CB-P, which ranked third among the inorganic phosphorus fractions with an average of 1.95% of the total amount of phosphorus, were found to be average 12.77 mg kg^{-1}, ranging from 0.76 mg kg^{-1} to 52.83 mg kg^{-1}. A significant negative relationship was determined between CB-P fraction and CEC and salinity of soils.

Table 4. Correlation coefficients for soil phosphorus fractions

	Olsen-P	Organic-P	Al-P+Fe-P	CB-P	CDB-P	Ca-P
Organic-P	0.080					
Al-P+Fe-P	0.836**	0.034				
CB-P	0.280	0.199	0.111			
CDB-P	0.444*	0.256	0.224	0.612**		
Ca-P	0.233	0.480**	0.075	0.461**	0.647**	
Total-P	0.233	0.753**	0.105	0.510**	0.643**	0.922**

*. **; Correlation values indicated by are important at the level of $P < 0.05$ and $P < 0.01$, respectively.

The Al-P+Fe-P, which constitutes a very small portion with a share of 0.18% of total phosphorus on average, was found to be average 0.18 mg kg^{-1} between 0.01 mg kg^{-1} and 0.80 mg kg^{-1}. Negative relationships were found between the Al-P+Fe-P fraction of the soil, pH and lime and positive between organic matter (Table 3). In addition, significant positive relationships between the olsen-P phosphorus, which represents the phosphorus available for the plant in the soil, and the Al-P+Fe-P and CDB-P between inorganic phosphorus fractions were determined. This indicates that the greatest contribution to the Olsen-P in the soil is the Al-P+Fe-P and CDB-P fractions in the soil. Samadi (2006) in study, named Contribution of inorganic phosphorus fractions to plant nutrition in alkaline-calcareous soils, stated that The significant positive relationships between the Ca_2-P, Al-P, Fe-P and Ca_{10}-P fractions and plant P uptake may indicate the partial availability of P in these fractions to plants. In addition, multiple regression analysis (stepwise) was performed to determine the contribution of inorganic phosphorus fractions to Olsen-P in these soils and is shown below.

Olsen-P= 0.147 + 3.272 (Al-P+Fe-P) + 0.053 (CDB-P).

As it can be understood from the equation, nonocculuded Al and Fe bound phosphorus (Al+Fe-P), and occluded the phosphate (CBD-P) had effect on the

change of Olsen-P. One-unit increase in Al-P +Fe-P and CDB-P phosphors in soil, and Olsen-P increase by 3.272 and 0.053 units, respectively. As a result of the analysis, these two fractions determine 76.84% (R^2= 0.7684) of Olsen-P. However, the contributions of these two fractions were separately determined as 69.88% (R2= 0.6988) of Al-P + Fe-P and 6.96% (R^2= 0.0696) of CDB-P.

ÖZET

Amaç: Çalışmada, Doğu Anadolu bölgesinde yaygın olarak görülen Mollisol ve Entisol olarak sınıflandırılan toprak profillerinde inorganik fosfor fraksiyonlarının miktar ve dağılımlarının belirlenerek, bunların toprak özellikleri ve biri birleri ile ilişkilerinin belirlenerek, inorganik fosfor fraksiyonlarının bitkiye yarayışlı toprak fosforuna katkılarının değerlendirilmesi amaçlanmıştır.

Yöntem ve Bulgular: Kireçli ve hafif alkalin reaksiyonlu toprakların, toplam fosfor miktarları 280-1713 mg kg^{-1} arasında, ortalama 713 mg kg^{-1} olarak saptanmıştır. Toplam fosforun ortalama % 80.9'unu oluşturan ve bu topraklarda birinci sırada bulunan fosfor fraksiyonu olarak belirlenen kalsiyuma bağlı fosfatlar (Ca-P) 163.2-951.1 mg kg^{-1} arasında belirlenmiştir. Ca-P' den sonra bu topraklarda miktar olarak ikinci sırayı alan hapsedilmiş fosfatlar (CDB-P) 2.07-105.6 mg kg^{-1} arasında, üçüncü olarak ise ilk ekstraksiyon sırasında karbonatlar tarafından tutulan fosfatları (CB-P) 0.76-52.83 mg kg^{-1} arasında bulunmuştur. Dördüncü ve son sırada ise hapsedilmemiş alüminyum ve demir fosfatlar (Al-P+Fe-P) 0.09-5.0 mg kg^{-1} arasında bu topraklarda en az miktarlarda bulunan fosfor fraksiyonları olarak bulunmuştur.

Genel Yorum: Özetle, bu topraklarda inorganik fosfor fraksiyonlarının miktarlarına göre bulunma sırası Ca-P>CDB-P>CB-P>Al-P+Fe-P olarak belirlenmiştir.

Çalışmanın Önemi ve Etkisi: Bu topraklarda bitkiye yarayışlı fosfora (Olsen-P), hapsedilmemiş alüminyum ve demir fosfatlar (Al-P+Fe-P) ve hapsedilmiş fosfatlar (CDB-P) olmak üzere iki fraksiyonun katkıyı yaptığı belirlenmiştir.

Anahtar Kelimeler: İnorganik fosfor fraksiyonları, kireçli topraklar, yarayışlı P, fosfor toprak ilişkileri.

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