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Determination of the Phosphorus Fixation of the Wheat-growing Soils in the Lake Van Basin

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Abstract: The aim of this study was to assess phosphorus fixation and impinging factors on wheat cultivated fields around the Lake Van region. Main soil groups were taken into account according to their folding areas representing the province, namely Calcisol Cambisol, Kastanozem, Fluvisol and Regosol, in two levels of depth, 0-20 cm and 20-40 cm. A total of 52 soil samples were taken from different areas. Phosphorus fixation capacity was calculated by adding three level of phosphorus, 25 ppm, 50 ppm, 150 ppm; half an hour, twenty-four hours and seventy two hours. Phosphorus fixations were found to be 51.2% in Calcisols, 45.2% in Cambisols, 50.8% in Kastanozems, 47.8% in Fluvisols and 45.1% in Regosol groups. It was also recorded that the big proportion of phosphorus fixations at all soil group occurred in half an hour's time. There were significant correlations between characteristics of soil groups and phosphorus fixation. These correlations with phosphorus fixation, within Calcisol soils, CEC and organic matter, within Cambisols, clay, silt, sand, organic matter and CEC, within Fluvisols, clay, sand, $CaCO_3$ and pH, within regosols, clay and $CaCO_3$ and pH were detected positively. However, within Cambisol and Fluvisol, negative correlations between phosphorus fixation and sand were detected.

Key words: Soil phosphorus, phosphorus fixation capacity, plant nutrients

INTRODUCTION

Phosphorus is the most prominent nutrient that is scrutinized on the studies pertaining to absorbable nutrients in culture soils. It is the fact that phosphorus in soil has got composite and complicated interactions contrary to the others, which makes the subject more fascinating (Çimrin, 1996). It is more common that plants utilize a little amount from phosphorus provided by fertilization. Research results show that the plants make use of 10-30% of P, notwithstanding the rest of phosphorus with a proportion of 70-90% has been make fixation in the soil (Canzler, 1958; Klapp, 1964; Kacar and Katkat, 1997). Ingredients as segment magnitude distribution, type and amount of clay, pH, proportion of organic matter and lime assign phosphorus fixation in agricultural areas (Perkins, 1945; Aydeniz, 1969; Richardson, 1985). P retention transpires discrepant in acidic and alkaline soils. In acidic conditions, Fe, Al, Mn and insolvable hydrate oxides of these elements and in alkaline conditions, Ca and Mg react with soil phosphorus, rendering the nutrient inconvenient. Therefore, the act of phosphorus deserves a convincing interest for obtaining efficient fertilization (Kacar and Katkat, 1997; Velayutham, 1980; Martini and Mutters, 1985). Tisdale and Nelson (1966) asserted that the plants can utilize calcium phosphate in a range of 6.0-7.5 pH degree; however, its utilization declines due to the phosphate retention which causes tri-calcium phosphate in a range of pH 7.5-8.2; fixation occurs in a form of clay-Ca-H_2PO_4 bound within calcium among saturated clays.

MATERIALS AND METHODS

In this study the research area comprises agricultural regions along Van lake basin involving 26 plots. Fifty two soil samples were taken from two levels of depth, 0-20 cm and 20-40 cm, representing main soil groups around the province. Soil locations were determined as UTM by using Garmin- 38 Model GSP and soil samples were collected according to soil map published by General Directorate of Rural Services (Topraksu, 1971) (Table 1).

Soil texture was depicted with Bouyoucous hydrometer method (Bouyoucous, 1951); soil reaction (pH) was assessed with glass electrode pH meter (Jackson, 1962) within two repeated measures; lime with Scheibler calcimeter (Hizalan and Ünal, 1966) organic matter with organic carbon oxidation based on the

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Table 1: Locations and UTM coordinates according to main soil groups

Sample No.	Location	UTM coordinates	Main soil groups (FAO-WRB, 1998)
1	Van Agriculture high school area	(0351188-4276710)	Calcisol
2	Göllü village	(0353699-4287644)	Calcisol
3	Adilcevaz downtown	(0297469-4296222)	Calcisol
4	Kuşhane village	(0292329-4295461)	Calcisol
5	Gölyazi village	(0366036-4269866)	Calcisol
6	Göveçli village	(0352631-4290053)	Cambisol
7	Köy village	(0367849-4302978)	Cambisol
8	Alkasnak Village	(0381746-4314016)	Cambisol
9	Heybeli village	(0311059-4295437)	Cambisol
10	Sarikum village	(0273058-4276740)	Cambisol
11	Tatvan downtown	(0264795-4268314)	Cambisol
12	Çölpan village	(0373414-4305682)	Kastanozem
13	Köşk village	(0383726-4309477)	Kastanozem
14	Erçek downtown	(0373749-4273512)	Kastanozem
15	Kaymakli village	(0388214-4279372)	Kastanozem
16	Aktaş village	(0380332-4277276)	Kastanozem
17	Çelebibağ village	(0354157-4317958)	Fluvisol
18	Arnos brook (nearby 500m)	(0334703-4312623)	Fluvisol
19	Tevekli village	(0352540-4280453)	Fluvisol
20	Van downtown	(0357401-4263642)	Fluvisol
21	Kara gündüz village	(0382717-4281110)	Fluvisol
22	Gürpinar downtown	(0361369-4242151)	Fluvisol
23	Yolçati village	(0311075-4295484)	Regosol
24	Ahlat downtown	(0280246-4291715)	Regosol
25	Yeni Köprü village	(0275784-4287071)	Regosol
26	Bardakçi village	(0349584-4270937)	Regosol

modified Walkley-Black method (Walkley, 1947), caution change capacity (Jackson, 1962), Olsen P, asserted by Olsen *et al.* (1954), was assessed with spectrophotometer, The phosphorus blue color method resolving with 0.5 N sodium bicarbonate $Na(HCO)_3$ into extract was used in soil samples from the research area.

Three different concentrations of P solvents (25, 50 and 150 ppm), from KH_2PO_4, were carried out within discrepant time periods (½, 24 and 72 h) to appraise phosphorus retention influenced by time and the proportion of the P solvent. P fixation capacity was evaluated based on the tenets asserted by Haslep and Black (1954), the amount of phosphorus in the solvent descending in the soil was detected in respect of molibdophosphoricacid blue color method by measuring with a spectrophotometer.

Phosphorus Fixation = Ep – Sp/ Ep x 100
Ep: Bulk of phosphorus mixed with soil (ppm)
Sp: Measured phosphorus in the filter (ppm)

Interactions between phosphorus fixation and soil characteristics have been evaluated statistically with the least square method. Discrepancy between interaction averages was depicted by the orthogonal polynomial method (Düzgünes *et al.*, 1987). SAS (1998) programme was used for statistical analysis.

RESULTS AND DISCUSSION

Range of measured amounts for clay, 16.52 -35.80%, silt 14.52-29.60%, sand 34.60-68.74%, lime 1.13-19.36%, pH 7.38-8.06, organic matter 0.41-4.41%, CEC 20-35 meg/100 g, olsen-P 4-16 ppm were observed in calcisol soils (Table 2). Value spans depicting soil characteristics for clay 3.09- 43.12%, silt 1.84-23.70%, sand 41.06-91.54%, lime 0.00-0.50%, pH 6.52-7.89, organic matter 0.72-2.99%, CEC 8.5-34 meg/100, Olsen-P 5.27-20 ppm were detected in cambisol soils. Range of measured amounts for clay, 22.56-49.50%, silt 15.00-25.22%, sand 28.14-62.44%, lime 1.93-15.63%, pH 7.59-8.16, organic matter 2.15-2.77%, CEC 22.50-35.00 meg/100 g, Olsen-P 3.30-16.00 ppm were observed in Kastanozems. Range of measured amounts for clay, 10.92-48.40%, silt 11.30-28.82%, sand 23.92-76.16%, lime 2.60-21.45%, pH 7.38-8.20, organic matter 0.56-3.88%, CEC 13.00-34.00 meg/100g, olsen-P 3.82-15.00 ppm were detected observed in fluvisol soils. Range of measured amounts for clay, 10.28-35.08%, silt 10.74-20.95%, sand 43.97-77.76%, lime 0.34-21.41%, pH 7.71-8.16, organic matter 1.52-2.49%, CEC 11.50-17.00 meg/100 g, olsen-P 4.00-11.50 ppm were observed in regosol soils.

There were significant differences between variances for all samples, excluding discrepancy among main soil groups, on the proportion of fixation at different time periods and phosphorus dosages ($p<0.01$). Hence, each soil group was evaluated *per se* (Table 3).

There were significant effects of increasing doses of phosphorus ($p<0.01$) and time ($p<0.01$) on the fixed amounts of phosphorus in soil. However, phosphorus x time interaction had a lower significance ($p<0.05$) on P fixation among brown soils (Table 3). The proportion of fixation was aggravated due to the enhancement of applied phosphorus doses; nevertheless, time had comparable effects in the process.

At a time period of ½ h phosphorus retention transpired with a proportion of 43.4% (Table 4). Kacar *et al.* (1975) asserted that phosphorus in a range of 45-55% was fixed in an hour and prportion of phosphorus was balanced after a time of 4 days in all agents. Turan *et al.* (1976) Studied 25 soil samples in a time span of 1 minute to 4 weeks; 2/3 of fixation occurred in a minute during one day time period. In the study at the Izmir region, Kiliç (1978) observed that the amount of fixation increased at four days shaking periods, though increasing rate after this period is of little worthy. Kirmizi (1990), on his study, among main soil groups in Büyük Menderes Basin, detected phosphorus fixation in Calcisol soils, changing within a range of 42.6-51.5%.

The phosphorus doses and time interaction were statistically non-significant; however, time had a

Table 2: Some physical and chemical properties of the soil studied

Main soil group	Sample No.	Depth (cm)	Clay (%)	Silt (%)	Sand (%)	$CaCO_3$ (%)	pH	Org. Mat (%)	CEC (meg/100 g)	Olsen-P (ppm)
Calcisol	1	0-20	29.08	20.56	50.36	1.27	7.51	4.41	33.50	16.00
		20-40	32.48	19.12	48.40	1.13	7.38	4.00	33.50	10.00
	2	0-20	23.48	19.40	57.12	7.52	7.59	1.51	35.00	10.00
		20-40	24.30	20.16	55.54	8.75	7.76	0.41	31.00	4.81
	3	0-20	17.54	14.52	67.94	17.98	7.94	2.13	20.00	4.00
		20-40	16.52	14.74	68.74	19.36	7.99	2.49	20.00	4.30
	4	0-20	20.80	20.68	58.52	7.32	8.06	2.66	21.50	6.30
		20-40	22.00	19.76	58.24	6.73	7.94	2.16	20.50	4.90
	5	0-20	35.16	28.18	36.66	8.18	7.80	2.77	32.00	13.50
		20-40	35.80	29.60	34.60	8.85	7.82	2.63	34.50	13.40
	6	0-20	32.42	23.78	43.80	15.31	7.73	2.05	33.00	8.19
		20-40	33.54	21.66	44.80	14.64	7.86	2.49	32.00	5.82
Cambisol	7	0-20	18.92	17.64	63.44	0.00	6.69	2.66	16.00	20.00
		20-40	18.18	18.12	63.70	0.00	6.52	2.55	16.00	20.00
	8	0-20	7.32	6.68	86.00	0.37	7.89	0.72	9.00	6.30
		20-40	7.34	7.08	85.58	0.00	7.64	1.11	9.50	7.30
	9	0-20	6.02	2.56	91.42	0.20	7.64	1.25	8.50	8.20
		20-40	3.96	2.56	91.54	0.00	6.94	1.25	9.00	8.00
	10	0-20	43.12	2.12	54.76	0.40	7.20	2.99	18.00	19.25
		20-40	42.98	1.84	55.18	0.50	7.08	2.72	17.50	15.40
	11	0-20	35.24	23.70	41.06	0.10	7.52	2.73	33.50	11.60
		20-40	35.22	17.62	47.16	0.00	7.44	2.81	34.00	5.27
Kastanozem	12	0-20	28.62	19.62	51.76	14.64	7.69	2.30	25.00	16.00
		20-40	28.44	18.60	52.76	15.38	7.99	2.15	24.00	14.00
	13	0-20	32.84	21.48	45.68	1.93	7.59	2.57	34.50	10.45
		20-40	32.56	18.52	48.92	2.00	7.78	2.49	35.00	4.01
	14	0-20	48.60	23.26	28.14	15.63	7.72	2.77	35.00	3.30
		20-40	45.16	25.22	29.62	15.04	7.79	2.77	32.50	3.60
	15	0-20	49.50	17.70	32.80	14.76	7.95	2.60	34.00	6.47
		20-40	49.50	21.00	33.00	14.09	8.14	2.27	34.50	3.30
	16	0-20	22.56	15.00	62.44	6.12	7.99	2.45	23.00	11.60
		20-40	23.16	19.68	57.16	10.22	8.16	2.24	22.50	8.90
Fluvisol	17	0-20	31.60	26.16	42.24	6.35	7.83	0.56	26.50	6.37
		20-40	29.68	22.96	47.36	2.34	7.68	0.83	26.00	3.82
	18	0-20	12.54	11.30	76.16	2.60	7.55	0.83	14.00	9.60
		20-40	10.92	13.70	75.38	2.33	7.61	0.56	13.00	7.80
	19	0-20	43.64	26.30	30.06	12.51	7.64	3.88	34.00	12.00
		20-40	43.72	26.20	30.08	12.78	7.93	2.99	25.00	6.90
	20	0-20	28.58	28.82	42.60	11.00	7.65	2.42	30.00	8.19
		20-40	26.36	24.90	48.74	10.27	7.38	2.33	29.00	7.60
	21	0-20	26.12	18.40	55.48	5.88	8.08	2.05	19.50	6.37
		20-40	27.76	20.04	52.20	6.51	7.83	2.16	20.50	4.55
	22	0-20	47.40	27.16	25.44	21.20	8.20	2.16	22.50	15.00
		20-40	48.44	27.64	23.92	21.45	8.19	2.50	21.50	7.46
Regosol	23	0-20	10.28	14.96	74.76	4.35	7.86	1.94	16.50	5.95
		20-40	10.28	11.96	77.76	4.88	7.88	1.86	11.50	5.25
	24	0-20	11.20	13.76	75.04	3.00	7.71	1.80	15.00	10.60
		20-40	14.22	10.74	75.04	2.47	7.73	2.24	15.00	11.50
	25	0-20	12.44	17.24	70.32	0.34	7.74	2.49	17.00	11.30
		20-40	14.20	16.34	70.32	0.68	7.77	1.52	17.00	6.47
	26	0-20	35.08	20.95	43.97	21.06	7.94	1.87	16.00	7.00
		20-40	31.76	18.88	49.36	21.41	8.16	1.69	17.00	4.00

Table 3: Variance analysis of soils of fixed phosphorus at the different doses and time periods

Source of variance		df.	MS	F-value
Main soil groups		4	792.4	8.01**
Source of variances	Main soil groups	df	M Sf	F-value
P doses	Calcisol	2	864.8	15.2**
	Cambisol	2	353.0	2.0
	Kastanozem	2	150.1	2.5
	Fluvisol	2	190.1	1.7
	Regosol	2	647.9	13.2**
Time	Calcisol	2	1558.5	27.4**
	Cambisol	2	3175.7	18.3**
	Kastanozem	2	3354.9	55.0**
	Fluvisol	2	2223.0	20.4**
	Regosol	2	1213.5	24.8**
P x Time	Calcisol	4	155.1	2.7*
	Cambisol	4	250.5	1.4
	Kastanozem	4	307.6	5.0**
	Fluvisol	4	327.2	3.0*
	Regosol	4	11.7	2.3

*, **; Significant at $p<0.05$ and $p<0.01$, respectively

significant effect on P fixation in the cambisol soil group ($p<0.01$; Table 3). The percentage and amount of fixation was aggravated as a consequence of the increasing time period (Table 4). In a similar study with 32 soil samples from Erzurum Plain, Öğüş (1973) observed that after ½ and 20 h, the balance period for the fixed amount of phosphorus was, 37.5 and 91.3%, respectively.

In the Kastanozem apart from the P doses, the time and phosphorus interactions significant effects ($p<0.01$) (Table 3). The amount and percentage of P fixation increasing time period. The largest proportion of P is fixed at the prior ½ h time period (Table 4).

In the Fluvisol soils implemented P doses had non-significant effects. However, the time ($p<0.01$) and P x time interaction ($p<0.05$) contributed to the fixation significantly (Table 3). The amount and percentage of P

Table 4: Percentages and amounts of fixed P at different time periods and P doses based on the main soil groups

		P doses							
		25 ppm		50 ppm		150 ppm		Average	
Main Soil Groups	Time period (h)	%	ppm	%	Ppm	%	ppm	%	ppm
Calcisol	½	52.6	13.2	42.4	21.2	35.2	52.8	43.4	29.1
	24	56.9	14.2	55.2	27.6	45.5	68.3	52.5	36.7
	72	59.5	14.8	57.2	28.6	56.2	84.3	57.6	42.6
Average		56.3	14.1	51.6	25.8	45.6	68.5	51.2	
Cambisol	½	41.1	10.3	37.2	18.6	29.4	44.1	35.9	24.3
	24	45.1	11.3	49.4	24.7	41.0	61.5	45.2	32.5
	72	49.9	12.5	58.2	29.1	55.6	83.4	54.6	41.7
Average		45.4	11.4	48.3	24.1	42.0	63.0	45.2	
Kastanozem	½	46.3	11.6	38.2	19.1	36.6	54.9	40.4	28.5
	24	49.2	12.3	45.1	22.6	58.0	87	50.8	40.6
	72	58.4	14.6	61.2	30.6	64.2	96.3	61.3	47.2
Average		51.3	11.6	48.2	24.1	52.9	79.4	50.8	
Fluvisol	½	43.3	10.8	31.6	15.8	46.3	69.5	40.4	32.0
	24	48.7	12.2	45.1	22.6	47.4	71.1	47.1	35.3
	72	55.2	27.6	58.9	29.5	54.0	81.0	56.0	46.0
Average		49.1	12.6	45.2	22.6	49.2	73.9	47.8	
Regosol	½	43.6	21.8	32.2	16.1	39.5	59.3	38.4	32.4
	24	51.5	27.8	41.6	20.8	39.6	59.4	44.2	36.0
	72	55.8	27.9	46.6	23.3	55.8	83.7	52.7	45.0
Average		50.3	28.8	40.1	20.1	45.0	67.5	45.1	

Table 5: Correlation coefficients (r) pertaining to the relationships between some physical and chemical properties and P fixation in the studied soils

	Calcisols P Fixation	Cambisols P Fixation	Kastanozems P Fixation	Fluvisol P Fixation	Regosols P Fixation
Clay	0.13	0.43**	0.12	0.30*	0.26*
Silt	0.03	0.33**	0.02	0.26	0.11
Sand	-0.09	-0.44**	0.08	-0.30*	-0.25*
Lime	-0.06	0.16	-0.01	0.30*	0.27*
pH	-0.18	-0.05	-0.01	0.27*	0.24*
Org. Mat.	-0.19*	0.40**	0.02	-0.01	-0.06
CEC	0.26*	0.31**	-0.09	-0.03	0.05
Olsen-P	0.03	0.28*	0.07	0.21*	-0.14*,

**; Significant at the 0.05 and 0.01 probability levels, respectively

fixation elevated due to increasing time period. The largest proportion of P was fixed at the prior ½ h time period (Table 4). Accordingly, Kacar (1965) stated that the P fixation was 75.3% after 4 days in Çukurova region.

P doses ($p<0.01$) and time ($p<0.01$) had an significant effect on fixation statistically *per se;* however, the interaction between P and time was not significant in the Regosol soils. The amount and percentage of P fixation was irregular due to increasing P doses. Amount and percentage of P fixation increased in account of the increasing time. The largest proportion of P fixation, with a percentage of 38.4% occurred at the ½ h time period (Table 4).

Relationships between some soil characteristics and P fixation: There was a negative correlation with organic matter (r:-0. 19; $p<0.05$) and positive correlation with cation change capacity (r:0. 26; $p<0.05$) and fixed P in the Calcisol soils. In the Cambisol soils, correlations between fixed P and clay (r:0. 43; $p<0.01$), silt (r:0. 33; $p<0.01$), organic matter (r:0. 40; $p<0.01$), CEC (r:0. 31; $p<0.01$) and Olsen-P (r:0. 28; $p<0.05$) were positive (Table 5). These relations were also determined in early studies by Kilinç (1978), Kirmizi (1990), Kacar (1965), Kacar (1967), Bayrakli and Akay (1992). Correlations between fixed P and clay (r:0. 30; $p<0.05$), $CaCO_3$ (r:0. 30; $p<0.05$), pH (r:0. 27; $p<0.05$) and Olsen-P (r:0. 21; $p<0.05$) were positive, (r:-0. 30, $p<0.05$) was negative and significant in sand fraction of the Fluvisol soils. There were positive correlations between P fixation and clay (r: 0.26; p<0,05), $CaCO_3$ (r:0.27; $p<0.05$), pH (r:0.24; $p<0.05$) while negative sand (r:-0.25; $p<0.05$) in the regosol soils.

CONCLUSIONS

A considerable phosphorus fixation capacity appeared within the folding areas. Phosphorus fixation was depicted in Calcisols, Cambisols, Kastanozem, Fluvisols and Regosols, 51.2, 45.2, 50.8, 47.8 and 45.1%, respectively. There were significant relationships between some characteristics of soil groups and phosphorus fixation. There was a negative correlation between P fixation and organic material, positive correlation with caution change capacity in the calcisol group; positive correlations with clay, silt, organic matter, caution change capacity, Olsen-P and negative correlation with sand in the lime cambisol group. Clay, $CaCO_3$, pH, Olsen-P had positive and sand had negative correlations within the fluvisol group; clay, $CaCO_3$, pH had positive and sand had negative correlations with P fixation in the regosol group.

Consequently, into taking account of strength of phosphorus fixation in this region, it is recommended that the computing amount of phosphorus fertile and surface area of touchment space on fertilization to be declined be recommended. Therefore, especially granular form of phosphorus should be used in fertilization and banding application should be preferred.

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