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RESEARCH ARTICLE

Investigation of Relationships between Available Phosphorus, Potassium and Some Soil Properties in Agricultural Lands of Varamin - Iran

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ABSTRACT

Potassium (K) and phosphorus (P) are essential nutrient for plants which are found in different forms in the soil. Their significance influence on crop production that is controlling by available form of these two primary elements specifies importance of study through chemical and physical analysis. In this study, fifty surface samples collected from agricultural soils were mainly under cultivation of wheat, alfalfa, canola and barley in south eastern part of Tehran province, Varamin. The amount of available Phosphorus (P_a) and Potassium (K_a), organic carbon (OC), percentage of clay, silt and sand of the soil, pH and calcium carbonate equivalent (CCE) in collected samples were measured and their correlation was evaluated. Moreover, five profiles were selected to study distribution of highlighted parameters along depth of the soil. The results showed that amount of silt, clay and OC positively correlated with K_a and were the most important factors influencing potassium availability. P_a showed negative correlation with CCE and positive with OC. Soil profiles classified in Aridisols (Haplocambids). Depth distribution of available P indicated that surface horizons due to more fertilization and organic matter had more P while deeper horizons had less P mainly organic matter and fertilizer are not mixed with the soil. The amount of available K in the surface horizons were higher but deeper horizons showed considerable amount, too that can be related to minerals containing high potassium in studied soils. According to the results, in soils with a high amount of clay, silt and lime, application of K and P should be regulated by soil conditions to optimize elements intake by plants.

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INTRODUCTION

Potassium (K) and phosphorus (P) are essential elements in plant nutrition. P after nitrogen (N) is one of the most important elements required by the plant and in processes such as photosynthesis, cell respiration and cell division plays a key role (Whiteny, 1988). Mineral forms of phosphorus in soils usually exist as primary mineral like apatite, hydroxyapatite and oxy-apatite and hydrated oxides of iron, aluminum and manganese where P is insoluble (Grant *et al*., 2005). Several factors, can affect the amount of available P to plants. Organic matter, soil pH, lime, calcium, presence of iron and aluminum oxides are the main factors affecting available P for plant (Freeman and Rowell., 1981). It is noteworthy to mention that even sandy soils are able to fix high amounts of P because of quick reaction of P with Fe, Al and Ca which precipitate as insoluble forms (Sarhadi-saroudi *et al*., 2003). Havlin *et al*. 1999 demonstrated that by adding lime to the soil the amount of available P reduced, thus the availability of phosphorus in calcareous soils is a challenge for plant nutrition. Westerman, (1992) found that crop production decreased in calcareous soils. Also, soil organic matter plays an important role in the supply of phosphorus. Microbial decomposition of organic matter in the soil has a very important impact on cycle of P and distribution of its different forms (samadi *et al*., 1999). Whalen *et al*. (2001) observed that decomposition of plant tissue and soil organisms consequently mineralization of organic phosphorus supplies main part of available P for plant. Also positive effect of organic matter on P availability has been reported (Delgado *et al*., 2002). Miraki and samadi (2011) observed the amount of available P increased by adding organic fertilizers to the soil. Since every year large amounts of phosphorus fertilizer is added in calcareous soils of Iran, studying effective factors on P availability is highly required.

The third important element after N and P is potassium (K). K is involved in nearly all metabolic processes of plants. K as ion by using energy absorbed from soil and has functions to maintain osmotic potential, activating enzymes, protein synthesis, stomata movement, cell expansion, photosynthesis, and anionic balance in plant (Yawson *et al*., 2011). There are four different forms of K in the soil: (1) soluble K which is consumed by the plant as the primary source; (2) exchangeable K that conserved through negative charge of clay surfaces; (3) non- exchangeable K which stabilized in the mineral structure as a part of mineral; and (4) mineral K that exists in the structure of primary minerals (Pal *et al*., 1999). Most of K exists in minerals and only a small amount is available as soluble and exchangeable for the plant. K because of low hydrated radius can be fixed by soil minerals, mica, vermiculite and illite particularly (Schinder, 1997). One hectare of soil in an area may contain hundreds ton of K which by different ways placed in soil minerals (Sparks and Haung, 1985). Applying fixed and non-exchangeable form of K depending on type of plant and environmental conditions can be used by plant gradually (Tisdale *et al*., 1993). The main factor affecting the availability of K is clay minerals in the soil and the relative percentage of sand, silt and clay. In fact, the relationship between mineralogical characteristics, texture characteristics and biological processes control final forms of K (Wang *et al.*, 2000; Hisinger *et al*., 1993). Liu *et al*. (2002) found that clay coats and generally clay has a high ability to adsorb K. Release of K from clay minerals are largely dependent on size and chemical composition of clay (Bouabid *et al*.,1991). Soils with a high cation exchange capacity can hold K on their surface which is equal to increase in the amount of exchangeable K (Askegaard *et al*., 2003). Generally, K consistently is shifting to exchangeable, fixed and soluble forms (Figure 1) (Haung, 2005). pH can also be involved in the stabilization and availability of K, indirectly. Low pH by decreasing soil negative charge and influencing aluminum hydroxyl reduces K stabilization; thereby leaching of K will be increasing. Alkaline pH increases the negative charges on the clay surface that enhance level of exchangeable K (Khaled and Stucki, 1991). Therefore changes of K in different soils in various conditions should receive more attention. The purpose of this study was to investigate the effect of soil properties on available form of K and P and depth distribution of these elements in some agricultural soils of Varamin, Iran.

MATERIALS AND METHODS

Studied area is located in around Varamin city, Pishva, (Eastern longtitude 51^{o} 48' Northern latitude 35^{o} 20' ') .Mean annual precipitation and temperature are 140 mm and 17^{0}C respectively. Fifty surface samples (0-30cm) from land under cultivation of wheat, alfalfa, canola and barley were picked. Also, After investigating land situation, location of Five soil profiles were determined and sampling were performed according to the field book for describing and sampling of soil (USDA-NRSC, 2002). Then they were classified according to soil taxonomy system (soil survey staff, 2010). Available phosphorus (P_a) and potassium (K_a), soil texture, pH, calcium carbonate equivalent (CCE) and organic carbon (OC) were measured. All standard analyses were performed on air-dried, < 2-mm soil. P_a was extracted by sodium bicarbonate (pH=8.5) and determined by spectrophotometer (Carter and Gregorich, 2008). Extraction of K_a were performed by ammonium acetate (pH=7) and determined by flamephotometer (Carter and Gregorich, 2008). Soil texture was measured by hydrometer method (sparks, 1966). Organic carbon (OC) was determined using wet oxidation (Carter and Gregorich, 2008). Calcimetric method used for measurement of CCE (Carter and Gregorich, 2008). pH was measured in saturated paste (Sparks,1996). Statistical analysis was performed by SPSS, 18 software.

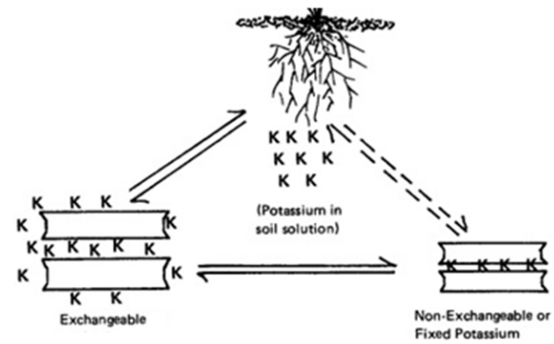

Fig.1: Potassium reactions in soil

Fig. 2: Geographical position of varamin city

RESULTS

P_a showed significant and positive correlation with OC whereas there was negative and significant relationship between CCE, pH and P_a. There was no significant relationship between P_a, clay and silt. K_a positively and significantly correlated with silt and clay. K_a showed insignificant correlation with CCE and pH (Table 1).

All soil profiles classified in Aridisols (Haplo-cambids). P_a range changed between 37(mg/kg) and 7(mg/kg) in soil profiles (Table 2). The Amount of P_a reduced with increasing depth (Figure 3). Similar trends were observed for K_a (Figure 4). K_a varied between

Table 1: Correlation between K_a, P_a and some soil properties

	K_a	P_a	OC	clay	silt	sand	CCE	PH
K_a	1							
P_a	0.22	1						
OC	0.45*	0.63**	1					
clay	0.59**	0.165	0.40*	1				
silt	0.43*	-0.131	0.17	0.30*	1			
sand	0.149	-.086	0.043	-0.2	-0.11	1		
CCE	0.19	-0.58**	-0.226	-0.14	-0.164	-0.055	1	
PH	0.21	-0.31*	-0.176	-0.11	0.126	0.133	0.32*	1

**, * Correlation is significant at the 0.01 and 0.05 level, respectively

Table 2: Studied parameters in soil profiles

		K(mg/kg)	P (mg/kg)	OC (%)	Clay (%)	Silt (%)	Sand (%)	pH	CCE (%)
				Profile1: Typic Haplocambids					
Horizon	Depth(cm)								
Ap	0-22	340	21.5	0.97	40	38	22	8	16.6
Bw1	22-65	202	19.8	0.41	41	42	17	8.1	18.1
Bw2	65-100	190	10	0.4	41	37	22	8.1	18.4
				Profile2: Typic Haplocambids					
Ap	0-20	348	22.7	1.06	41	36	23	7.8	15
Bw1	20-75	224	8.9	0.4	43	36	21	8	16.8
Bw2	75-100	200	8	0.4	44	32	23	8	17
				Profile3: Typic Haplocambids					
Ap	0-20	428	37	1.01	44	39	17	8	16.9
Bw1	20-60	332	18	0.52	49	35	16	7.9	17.8
Bw2	60-100	234	10	0.4	48	39	13	8	17.9
				Profile4: Typic Haplocambids					
Ap	0-25	246	26.7	0.75	30	41	29	7.8	13.3
Bw1	25-70	200	13.9	0.47	36	40	24	8	15.5
Bw2	70-100	150	7	0.41	40	38	22	8.1	15.8
				Profile5: Typic Haplocambids					
Ap	0-20	386	26	0.81	35	44	21	7.6	14
Bw1	20-65	164	15	0.28	39	39	22	7.9	16.8
Bw2	65-100	155	10	0.21	39	40	21	7.9	17

428(mg/kg) and 150 (mg/kg) in soil profiles (Table 2). Vertical clay variation was inappreciable. Also, Silt and sand showed constant trends in soil profiles. Clay and clayloam were predominant textures in studied soil samples. Calcium carbonate (CCE) slightly increased in subsoil horizons. Maximum amount of OC was observed in surface horizons.Soil samples showed alkaline pH (Table 2).

DISCUSSION

As mentioned previously, K showed a significant correlation with clay which is in consistence with results provided by Simonsson *et al.* (2009). They stated that correlation of clay and K is because of presence of clay minerals such as illite and vermiculite which can fix and release K. The soil texture in the studied area was mainly clay and clay loam that are likely to existence of Phyllosilicates which are able to fix and release K. Phyllosilicates probably are the main source of K release in most of agricultural soils including Entisols, mollisols, and inceptisols in northern and southern part of Sweden (Andrist-rangel *et al*., 2006). On the other hand, a significant positive correlation observed between silt and K. The reason can be the presence of minerals in size of silt that can keep exchangeable K. Simonsson *et al*. 2007 by studying Haplaquept soils reported that the highest rate of K release are from silt and clay particles. Morishkina *et al*. (2007) found that in soils with high silt content, considerable part of fixation and release of K processes is carried out in silt fraction. In many cases clay minerals like vermiculite and illite which are able to release K found in silt particle (Zeng and Brown, 2000). Unlike our expectation, K showed positive correlation with organic carbon content which can be in result of relevancy of clay particles with organic matter. Clay particles due to their surface negative charge are capable of adsorbing organic substances (Stum *et al*., 1985). Also, organic matter, by releasing carbon dioxide and compounds such as organic acids accelerate K release from the soil minerals (Tu *et al*., 2007). Oliva *et al*. (1999) demonstrated that adding organic matter to the soil result higher weathering of soil minerals that consequently release elements such as K, Al, and Si. Wang *et al*. (2005) reported that organic acids can release elements found in Kaolinite. However, another factor that affects correlations is rate of fertilization and type of plant. Some plants such as canola consume more K. Moreover, change of soil minerals and as a result variation in available K by fertilization has been reported by many researchers (Liu *et al*., 1997; Velde *et al*., 2002)

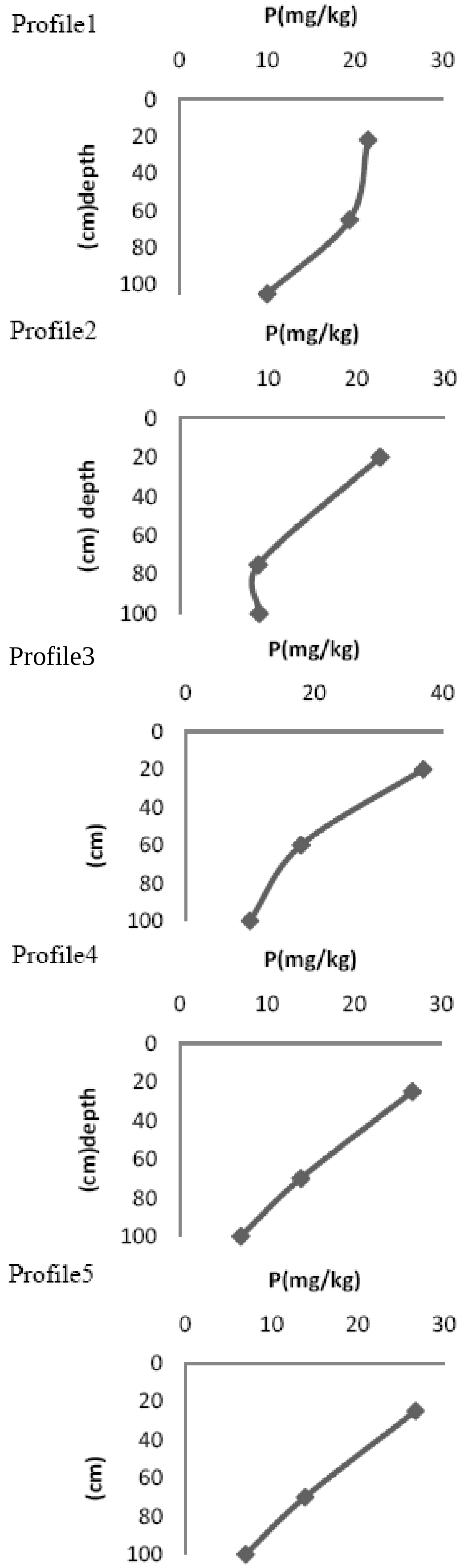

Fig. 3: Distribution of available phosphorus in soil profiles

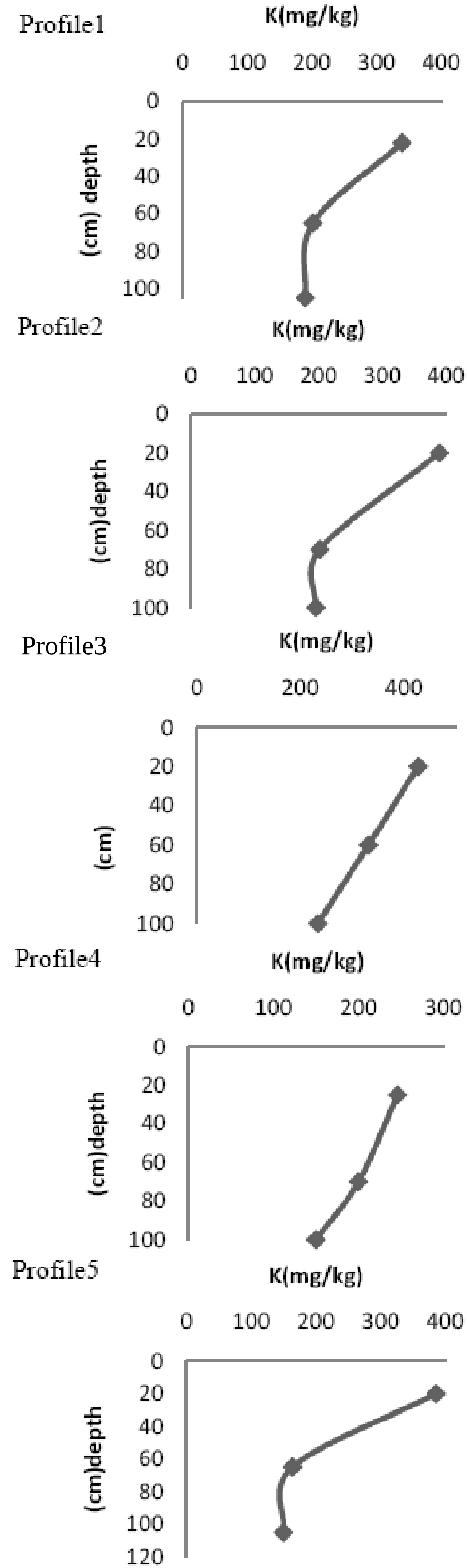

Fig. 4: Distribution of available potassium in soil profiles

but others did not obtain such similar results (Singh and Goudling, 1997).

P_a was negatively correlated with soil calcium carbonate. P by adsorption and precipitation stopped in surface of carbonate minerals. Reduced availability of P can be related to activity of Ca ion that combines with phosphate ions and form compounds with low solubility. Also, calcium carbonate particles covering soil P and decrease its availability (Govere *et al*., 2004). On the other hand, positive correlation of P with organic matter observed. The positive effect of organic matter on P availability has been reported by several researchers (Aziz *et al*., 2010). Unlike K, organic P has a basic role on level of available P. P mineralization of organic compounds can provide a part of plant demand for P. Burt *et al*. (2006) reported the highest correlation between non-crystalline P and organic matter and stated that organic matter by inhibiting crystallization of lime and iron minerals increasing P availability. As stated, the decomposition of organic matter produce carbon dioxide which increase solubility of lime (Singh and dahiya,1976).The production of organic acids resulting higher availability of low soluble forms of P is another reason for the positive relationship between organic carbon and P_a (Yusran, 2010).

Depth distribution

Evaluation of soil profiles confirm the results obtained by surface samples. The largest amount of P in surface horizons was observed that could be due to higher P fertilization and organic matter in soil surface. Similar trend reported by Simonsson *et al*. (2007). Deeper horizons of the soils which are poor in organic matter have less amount of P. It should be noted that in some depth of the soil profiles, P levels were lower than desired level which demonstrated that P fertilization was mostly on the surface and also organic matter has not mixed very well in the lower depths. High amount of available K in surface horizons was because of fertilization but deeper horizons showed relative abundance which confirms that soil minerals have significant role on K availability. khormali and abtahi (2003) found that aridisols naturally have high level of K due to presence of K enriched minerals. Also, higher K content in surface horizons can be related to activity of plant roots. Blake *et al*. 1999 reported that continuous cultivation of crops transfer K from deeper to the surface horizions.

Conclusion

Our results suggested that the amount of clay and silt were the most important factors affecting available K for plants. Therefore, in soils with high clay and silt content, applying elements such K should be based on soil conditions, exchangeable, and storage phase of K. Negative correlation between lime and P showed that proper management of P in calcareous soils is essential. Practices to reduce pH in calcareous soils can be used to optimize P availability. Organic carbon had a positive influence on availability of K and P. Due to the low amount of organic matter in Iranian soils, in order to reduce fertilization and sustain availability of nutrients measurements, increasing soil organic matter should be planned.

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