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Website: https://www.aun.edu.eg/agriculture/ar *E-mail: ajas@aun.edu.eg*

Effect of Some Soil Properties on Available Phosphorus in El-Kharga Oasis, New Valley

Thabet, Entsar A.; H.H. Gomah; M.A. Ahmed and M.A. El- Desoky

Department of soils and water sciences, Faculty of Agriculture, Assiut University
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Abstract

El-Kharga oasis, New Valley governorate is a promising area for increasing the cultivated areas in Upper Egypt. This area has variations in soil physical .i.e. soil texture and chemical properties. Therefore, its contents of plant essential nutrients may become concerned. The aim of this study is to investigate the available phosphorus content of some soils of El- Kharga oasis and its relation with soil texture and some other soil properties. Thirty nine soil samples were collected from 13 soil profiles representing 5 different locations. Three soil samples from three layers (0-20, 20-40 and 40-60 cm) were collected from each profile.

The results showed that the available soil phosphorus ranged from 4.40 to 34.54 mg kg^{-1}. Levels of available P were low (< 6 $mgkg^{-1}$), medium (6 -10 mg kg^{-1}) and high (>10 mg kg^{-1}) in 10.26, 35.90 and 53.84% of the soil samples, respectively .The average available P level differed with soil texture. It was 16.38, 13.41, 12.13, 9.25 and 7.66 mg kg^{-1} in sand, loamy sand, sandy loam, sand clay loam and clay textured soil samples respectively. Insignificant negative correlations were obtained between the available P and most of the discussed soil properties (clay fraction, OM, SP, ECe, $CaCO_3$, soluble Ca and soil depth) with r values of (-0.2729,-0.2074, -0.3257,-0.2121,-0.0985, -0.2047 and -0.3905) respectively, except soil pH, sand andsilt fractions which had positive significant correlation with available P (r= 0.0095, 0.2877 and 0.0055 respectively).

Keywords: *Available phosphorus, clay fraction, texture, New Valley.*

Introduction

Soils of El-Kharga oasis, (New Valley governorate, west desert) have different textures and chemical composition as well as plant essential nutrient contents. Consequently, evaluating these soils and their properties from the agriculture point of view is necessary. So, the soils of this oasis and their properties such as texture, salinity and $CaCO_3$ content as well as some nutrients like phosphorus (P) should be assessed for the agriculture use.

El-Kharga soils are generally poor in organic matter. In the cultivated soils, the organic matter content is higher than in the uncultivated ones (Hammad and Hussein, 1993). According to Metwally and Beshay (1997), organic matter presence is mostly associated with the uppermost surface layers and tends to decrease with depth. El-Sayed *et al.*; (2016) indicated that soils of Gharb El-Mawhob, El-Dakhla oasis, had pH values that were near neutral to strongly alkaline. The cation exchange capacity (CEC) of these soils ranged from 6.58to 57.49 cmol /kg. The high soil CEC values in some locations are attributed to the high levels of clay, pH and organic matter as well as the elevated PH values (Foth and Ellis, 1988). Calcium carbonate ($CaCO_3$) is the most active sorbent of P in alkaline soils (Lopez-Pineiro and Navarro, 2001).

Phosphorus is one of the most important macronutrients. It is often the potential limiting nutrient in many of arid and semiarid regions (Zhao *et al*., 2008). Plants absorb phosphorus mainly as phosphate forms of $H_2PO_4^-$ and HPO_4^{-2}. However, the soil solution contains very low levels of these forms in spite of the great soil total content of P. Large number of methods that evaluate the available phosphorus indicates the complexity of this P nutrient in the soil, mainly due to its strong interaction with soil colloids and other element. That are present in soil solution Silva and van Raij, (1999), showed that soil texture, salinity, $CaCO_3$, organic matter, pH and CEC are the mainfactors that affect the soil available phosphorus.

Swify *et al*. (2017) recorded and mapped the variability of the available P in coarse-textured soils of El-Kharga and El-Dakhla oases using geostatistic techniques. They found that the concentrations of available P ranged from 0.35 to 85.02mgkg^{-1}. Abd El-Rehim *et al*. (2016) reported that the texture of most soil samples collected from Gharb El-Mawhob, El-Dakhla oasis, were loamy sand, sandy clay loam and clay with high $NaHCO^{-3}$ extractable P that varied from 2.25 to 65.35 mg/kg in the surface layer and from 3.34 to 42.49 mg/kg in the subsurface one.

Compared with their virgin analogues, Samadi and Gilkes (1998) displayed that the agricultural development of soils resulted in increases in the total P, inorganic P, organic P, Olsen P and Colwell P with average increases by 105,154, 49, 200 and 100%, respectively. The agronomic effectiveness of phosphate fertilizers is strongly affected by the reactions of the added P with soil constituents (Samadi and Gilkes, 1999).

Sodium bicarbonate-extractable P markedly decreases with time after peat application to un-cropped and cropped soils which it has been attributed to plant uptake and rapid reaction of P with soil constituents (Rasheed *et al*., 2017). Over time, there was a decrease in the soluble, plant-available P fractions indicating a shift of P from extractable to non-extractable forms (Hooker *et al.,* 2017).

This study aims to assess the correlation of the available phosphorus content of some El-Kharga oasis soils with some soil properties.

Materials and Methods

Study area

El-Kharga Oasis lies in the South east of the Western Desert of Egypt. It covers an area of about 4500 km. It is located at 140 km to the east of El-Dakhla Oasis and 220 km^2 south of Assiut city. It is bounded by longitudes 30° 27' and30° 47' E and latitudes 24° 30' and 26° 00' N.

Soil sampling

Thirteen soil profiles were designated and chosen by GPS from 5 different areas (each area contained two or three profiles) and dug (Fig 1 and Table 1). Thirty nine soil layers were collected from these soil profiles representing three soil samples (0-20, 20-40 and 40-60 cm) for each soil profile to evaluate the available P level and its relation with some properties of these soils. Most of these samples were collected from cultivated soils. All soil samples were airdried, ground, sieved through a 2 mm sieve and then, kept for analysis.

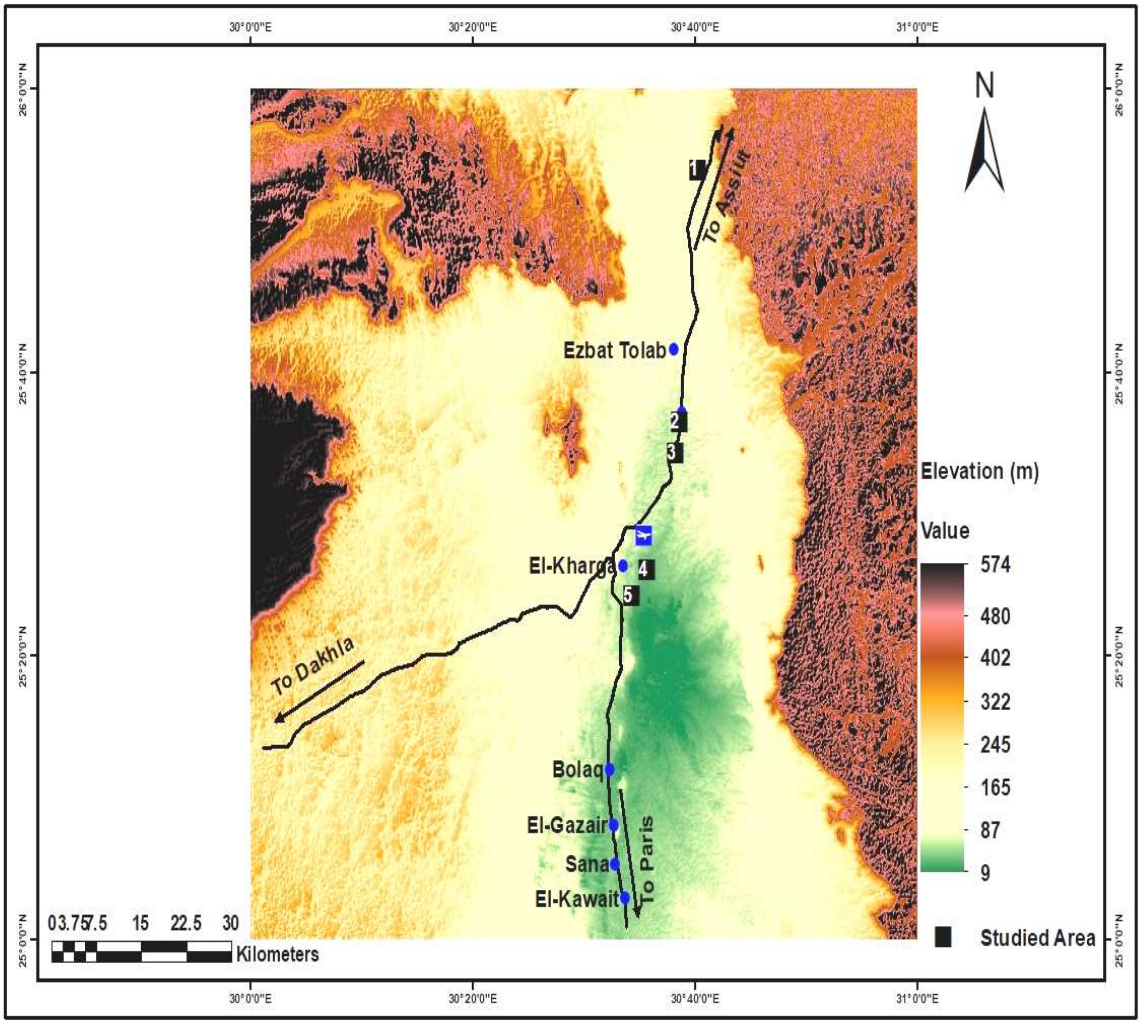

Fig (1): Soil profile locations of the study areas.

Table 1. Location of the investigated soil profiles and land use at the time of soil sampling.

Area	Profile	Latitude (N)			Longitude (E)			Land use
		d	m	s	d	m	s	
A1	P1	25	54	14.71	30	40	19.67	Alfalfa under sprinkler irrigation system
	P2	25	54	9.86	30	40	19.17	Faba bean under drip irrigation system,
	P3	25	54	9.17	30	40	18.75	Faba bean with dill on raised bed 90 cm under drip irrigation system.
A2	P4	25	36	26.77	30	38	35.94	Alfalfa intercropped under fruitful date palm with flood irrigation system
	P5	25	36	25.24	30	38	35.86	Wheat intercropped under fruitful date palm with flood irrigation system
	P6	25	36	24.69	30	38	35.64	Wheat intercropped under fruitful date palm with flood irrigation system
A3	P7	25	34	17.06	30	38	18.95	Barley intercropped under date palm offshoot with flood irrigation system
	P8	25	34	12.01	30	38	19.45	Maize (fodder) under flood irrigation system
A4	P9	25	26	4.40	30	35	41.30	Wheat under flood irrigation system
	P10	25	26	4.30	30	35	44.10	Wheat under flood irrigation system
	P11	25	26	2.90	30	35	47.90	Bare soil
A5	P12	25	24	11.40	30	34	19.00	Wheat under flood irrigation system
	P13	25	24	12.80	30	34	19.20	Alfalfa under flood irrigation system

Soil analysis

The particle size distribution of the soil samples was determined by the international pipette method (Jackson, 1973). The saturation percentage (SP) was Mass base estimated as described by Hesse (1998). Soil pH was measured in a 1:1 of soil to water suspension using pH meter with a glass electrode (Jackson, 1973). Soil organic matter was determined using Walkley and Black method (Jackson, 1973). Total calcium carbonate was estimated using a volumetric calcimeter (Nelson, 1982).

Electrical conductivity (ECe) was measured in the saturated soil paste extract using an electrical conductivity meter according to Jackson (1973). Soluble calcium (Ca^{+2}) in the saturated soil paste extract was determined using the titration method by EDTA (ethylene di-amine tetra acetic acid) solution. Available phosphorus was extracted using 0.5 M $NaHCO_3$ solution at pH 8.5 (Olsen *et al.*, 1954) and then measured calorimetrically.

Results and Discussion

1- Soil physical and chemical properties

The soil texture of the studied soil samples differed from sand (4 samples), loamy sand (12 samples), sandy loam (13 samples), sand clay loam (6 samples), and clay (4 samples) (Table 2). S and, silt and clay fractions of these collected soil samples varied from 28.88 to 90.72%, 2.00 to 30.00% and 3.28 to 65.12 %, respectively. The saturation percentage (SP) of these samples varied between 12.20% and 104.41% (Table 2). The highest SP values were related to the heavy- textured samples and the lowest ones were recorded for the light- textured ones. The highest SP level (104.41%) was found in the deeper layer of profile 8 (area 3) while the lowest level (12.20%) was recorded in surface layer of profile one (area 1) in cultivated soil.

Table 2. Some soil physical Properties of the studied areas.

Area	Profile	Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture	Saturation Percentage (%)
A1	P1	0-20	77.92	16.00	6.08	Loamy sand (LS)	12.20
		20-40	76.72	20.00	3.28	Loamy sand (LS)	34.11
		40-60	62.72	18.00	19.28	Sandy loam (SL)	39.35
	P2	0-20	78.72	16.00	5.28	Loamy sand (LS)	28.52
		20-40	80.72	8.00	11.28	Sandy loam (SL)	27.09
		40-60	64.72	30.00	5.28	Sandy loam (SL)	37.70
	P3	0-20	71.92	24.00	4.08	Sandy loam (SL)	33.62
		20-40	80.72	8.00	11.28	Sandy loam (SL)	26.48
		40-60	84.72	4.00	11.28	Loamy sand (LS)	26.48
A2	P4	0-20	78.72	10.00	11.28	Sandy loam (SL)	34.64
		20-40	86.72	8.00	5.28	Loamy sand (LS)	30.56
		40-60	90.72	4.00	5.28	Sand (S)	38.11
	P5	0-20	70.72	12.00	17.28	Sandy loam (SL)	40.15
		20-40	76.72	18.00	5.28	Loamy sand (LS)	33.01
		40-60	65.72	10.00	24.08	Sandy clay loam (SCL)	24.44
	P6	0-20	66.72	14.00	19.28	Sandy loam (SL)	35.66
		20-40	78.72	10.00	11.28	sandy loam (SL)	26.48
		40-60	86.72	2.00	11.28	Loamy sand (LS)	27.09
A3	P7	0-20	77.92	6.00	16.08	Sandy loam (SL)	28.52
		20-40	63.92	4.00	32.08	Sandy clay loam (SCL)	63.81
		40-60	37.92	6.00	56.08	Clay (C)	87.68
	P8	0-20	42.72	6.00	51.28	Clay (C)	84.02
		20-40	32.88	6.00	61.12	Clay (C)	99.79
		40-60	28.88	6.00	65.12	Clay (C)	104.41
A4	P9	0-20	90.72	2.00	7.28	Sand (S)	24.24
		20-40	90.72	4.00	5.28	Sand (S)	24.44
		40-60	88.72	6.00	5.28	Sand (S)	24.03
	P10	0-20	78.72	12.00	9.28	Sandy loam (SL)	25.87
		20-40	86.72	8.00	5.28	Loamy sand (LS)	26.48
		40-60	84.72	10.00	5.28	Loamy sand (LS)	25.66
	P11	0-20	78.72	14.00	7.28	Loamy sand (LS)	27.50
		20-40	62.72	10.00	27.28	Sandy clay loam (SCL)	37.70
		40-60	48.72	24.00	27.28	Sandy clay loam (SCL)	57.49
A5	P12	0-20	65.72	18.00	25.28	Sandy clay loam (SCL)	44.84
		20-40	72.72	6.00	21.28	Sandy clay loam (SCL)	54.02
		40-60	82.72	10.00	7.28	Loamy sand (LS)	28.11
	P13	0-20	78.72	10.00	11.28	Sandy loam (SL)	32.60
		20-40	86.72	8.00	5.28	Loamy sand (LS)	23.42
		40-60	90.72	4.00	5.28	Sand (S)	23.42

The soil pH of these soil samples ranged between 7.31 and 8.71 (Table 3). According to Brady and Weil (1999), about 21% of these soil samples were mildly alkaline (pH 7.3 to 7.8) and 79% were moderately alkaline (pH 7.9 to 8.7). The highest soil Ph (8.71) was in the surface layer of profile 10 (area 4) and the lowest one (7.71) in surface layer of profile 8 (area 3). Abd El-Rahim *et al*., (2016), reported that the pH of the soils of Gharb El-Mawhob, El-Dakhala oasis ranged from 7.42 to 7.96 and from 7.44 to 7.96 in the surface and subsurface layers, respectively, which represent 79.4% of these soils were mildly alkaline (pH 7.4 to 7.8) and 20.6% were moderately alkaline (pH 7.9 to 8.4).

The electrical conductivity (EC_e) of the investigated soil samples differed between 1.17 and 139.20 dS m^{-1} (Table 3). The highest EC_e level (139.2dSm^{-1}) was recorded in the surface layer of profile 11 (area 4) and the lowest one is (1.17 dSm^{-1}) was found in the subsurface layer of profile 6 (area 2). According to Abrol *et al*., (1988), about 25.64% of these soil samples were non-saline (EC_e< 2 dSm^{-1}), 7.69% were very slightly saline (EC_e 2 -4 dSm^{-1}), 38.46 % were slightly saline (EC_e 4-8 dSm^{-1}), 12.82% were moderately saline (EC_e 8-16 dSm^{-1}) and 15.38 % of them were strongly saline (EC_e> 16 dSm^{-1}). Generally, the ECe of the subsurface layer was higher than that of the surface one. Abd El-Rehim *et al*. (2016), showed that about 14.7% of Gharb El-Mawhob soils were non-saline, 17.64% were very slightly saline, 26.47% were slightly saline, 8.82% were moderately saline and 32.35% were strongly saline with higher ECe values in the subsurface layers compared to those of the surface layer.

The organic matter (OM) content of the collected soil samples ranged from 0.3 to 10.9 g kg^{-1} with an average of 5.6g kg^{-1} (Table 3).The highest organic matter content (10.9 g kg^{-1}) was present in the subsurface layer of profile 7 (area 3) while the lowest one occurred in the subsurface layer of profile 2, 3 (area1) and profile 4 (area2) in the deeper layer of profile 1 (area1) and profile 6 (area2). El-Sayed *et al*., (2016) found that the organic matter content of Gharb El-Mawhob soils was very low and varied from 0.5 to14.1 g kg^{-1}. Moreover, the organic matter of Gharb El-Mawhob soils was also reported to vary from 1.1to 22.7g kg^{-1}(Abd El-Rehim *et al*., 2016).

Table 3. Some soil chemical properties and available P of the investigated areas.

Area	Profile	Depth (cm)	pH (1:1)	ECe (dS m^{-1})	O.M (g\kg)	$CaCO_3$ (g\kg)	Soluble Ca (mmol kg^{-1})	Available P (mg kg^{-1} soil)
A1	P1	0-20	7.77	6.15	2.1	283.5	6.75	21.58
		20-40	7.57	6.39	2.6	292.1	4.59	12.02
		40-60	7.69	5.40	0.3	283.5	6.75	6.15
	P2	0-20	7.83	7.88	0.5	214.8	16.20	19.18
		20-40	7.80	5.20	0.3	292.1	4.86	6.76
		40-60	7.34	7.13	2.6	223.4	8.10	9.78
	P3	0-20	7.77	15.89	2.3	189.0	7.13	7.22
		20-40	7.79	8.39	0.3	223.4	8.10	4.79
		40-60	7.86	7.67	0.8	257.7	4.59	14.12
A2	P4	0-20	8.18	1.96	6.5	128.9	2.97	16.43
		20-40	8.13	1.758	0.3	108.2	3.51	24.11
		40-60	8.04	1.46	1.5	128.9	3.24	12.18
	P5	0-20	8.15	2.88	2.4	128.9	2.70	21.55
		20-40	8.39	1.55	7.0	85.9	1.89	14.61
		40-60	7.82	1.24	6.6	77.3	2.16	18.92
	P6	0-20	8.04	1.52	5.6	120.3	2.43	9.87
		20-40	8.25	1.17	1.8	77.3	0.81	19.31
		40-60	8.22	1.28	0.3	94.5	1.35	5.14
A3	P7	0-20	8.40	3.09	4.6	103.1	3.24	17.11
		20-40	8.25	10.17	10.9	106.5	1.35	4.40
		40-60	7.97	5.09	5.8	173.5	5.94	5.44
	P8	0-20	7.31	6.15	4.7	156.4	4.05	7.35
		20-40	8.04	13.19	0.4	171.8	2.16	7.70
		40-60	8.06	14.51	0.4	171.8	1.35	10.14
A4	P9	0-20	8.25	4.75	0.4	63.6	5.13	34.54
		20-40	8.10	4.75	3.3	72.2	1.89	11.92
		40-60	8.31	4.75	4.0	77.3	16.20	10.98
	P10	0-20	8.71	4.75	4.4	77.3	4.86	12.31
		20-40	8.01	7.37	3.8	68.7	14.85	8.00
		40-60	8.51	27.70	3.3	68.7	15.43	6.95
	P11	0-20	8.40	139.20	4.7	67.0	12.15	6.93
		20-40	8.49	28.30	4.3	68.7	10.61	7.44
		40-60	8.43	19.78	2.8	77.3	11.21	10.17
A5	P12	0-20	7.91	29.10	4.0	60.1	8.10	14.64
		20-40	7.90	17.02	5.1	58.4	11.88	6.67
		40-60	8.03	6.29	5.4	79.0	10.26	8.26
	P13	0-20	7.81	3.86	4.7	94.5	12.15	16.27
		20-40	7.96	1.69	2.5	85.9	9.45	10.98
		40-60	7.85	1.45	5.7	77.3	8.10	8.07

The soil $CaCO_3$ content of the tested soil samples varied from 292.1g kg^{-1} in the subsurface layer of profile 1 and 2 (area 1) to 58.4g kg^{-1} in the subsurface layer of profile 12 (area 5) with an average value of 175.25g kg^{-1} without a regular trend with soil depth (Table 3). According to the classification proposed by FAO (2006), about 48.71% of these soil samples were moderately calcareous ($CaCO_3$ from 20 to 100 g kg^{-1}), 38.46% were strongly calcareous ($CaCO_3$ from 100to 250 g kg^{-1}) and 12.82 % were extremely calcareous ($CaCO_3$ higher than 250 g kg^{-1}).

Tantawy *et al*. (2017), also found that 8.33% of El-Dakhala oasis soils were slightly calcareous, 66.67% were moderately calcareous, 20% were strongly calcareous and only 5% were extremely calcareous. In addition, the soluble Ca^{2+}content of the investigated soil samples varied from 0.81 mmol kg^{-1} in the subsurface layer of profile 6 (area 2) to 16.20 mmol kg^{-1} in the surface layer of profile 2 (area 1) and profile 9 (area 4) in the deeper layer(Table 3).

2- Soil available phosphorus

The $NaHCO_3$–extractable P (Olsen P) is the readily available P for the absorption by plant roots. The available soil phosphorus of the 0-20, 20-40 and 40-60 cm layers of the studied soil profiles varied from 6.93 to 34.54 mg kg^{-1} with an average of 15.78 mg kg^{-1}, 4.40 to 24.11mg kg^{-1} with an average of 10.67 mg kg^{-1} and 5.14 to 18.92 mg kg^{-1} with an average of 9.72 mg kg^{-1}, respectively, (Table 3). In most cases, the available P decreased with increasing the soil depth. According to Olsen and Sommers (1982), about 10% of the studied soil samples containeda low level of available P(< 6 mg kg^{-1}), 36% of them showed a medium level (6 -10 mg kg^{-1}) and 54% had a high level of available P(>10 mg kg^{-1}). The available P decreased with increasing the soil depth. The highest level of available soil phosphorus (34.54 mg kg^{-1}) occurred in the surface layer of profile 9 (area 4) but the lowest level (4.4 mg kg^{-1}) was found in the subsurface layer of profile 7 (area 3).

On the other hand, Abd El-Rehim *et al*., (2016), showed that about 50% of Gharb El-Mawhob soil samples contained a low level of available P(< 6 mg kg^{-1}), 24% of them showed a medium level (6 -10 mg kg-1) and 26% had a high level of available P(>10 mg kg-1), The available P also decreased with depth. In the semi-arid regions, the available P was reported to vary from 1.7 to 8.7 mg kg-1(Bennoah *et al*., 1995). In some soils of Toshka region, Behiry *et al*. (2003) pointed out that the $NaHCO_3$-extractable P varied from 3.00 to 21.20 mg kg^{-1}, 2.90 to 19.50 mg kg^{-1} and 2.50 to 18.90 mg kg^{-1} in the surface, subsurface and deeper soil layers, respectively.

Regarding the soil texture, the available P of the studied soils ranged from 8.07 to 34.54 mg kg^{-1} in the sand samples, 6.93 to 24.11 mg kg^{-1} in the loamy sand samples, 4.79 to 21.55 mg kg^{-1} in the sandy loam samples, 4.40 to 14.64 mg kg^{-1} in the sandy clay loam samples and 5.44 to 10.14 mg kg^{-1} in the clay ones (Tables 2 and 3). The average level of the available P differed with the change in the soil texture. The average levels of the available P were 16.38, 13.41, 12.13, 9.25 and 7.66 mg kg^{-1} in sand, loam sand, sandy loam, sand clay loam and clay soil textured samples, respectively. It is clear that soil- texture has an important effect on the availability of P in these soils. Furthermore, the available P of these soils decreased as the soil texture becomes finer. Contradictly, Tomas and Peaslee (1973) reported that the clay and clay loam- textured soils contained higher levels of the available P compared to the other textured ones.

3- Correlations between available P and the investigated soil properties

The correlation coefficients (r) of the soil available P and some properties of the investigated soil samples are present in Table (4). Insignificant negative correlations were obtained between the available P and all studied soil properties with the exception of soil sand, silt and pH which had insignificantly positive correlations with the available P with r values of0.2877, 0.0055 and 0.0095, respectively. Only, the soil available P of these samples was significantly negatively correlated to the soil depth (Table 4). The results also showed a negative correlation between the available P and clay fraction. Abd El-Rahim *et al*., (2016) found that the available P of El-Dakhala soils was positively correlated to the silt content (r= 0.457) and negatively correlated to the sand content (r= -0.324). Abd El-Alla *et al.* (2007) indicated also that the available P was affected by clay and calcium carbonate contents of some Egyptian soils. However, in El-Dakhala soils Abd El-Rahim *et al*. (2016) found a negative correlation between the available P and the sand content. In addition, they displayed that the correlation between the available P and soil pH of El-Dakhala soils was not significant (r=0.037). Moreover**,** Li *et al.,* (2013), found that the rate of P release increased with the increase of soil pH from 8 to 10.

Table 4. Relationship and correlation coefficient (r) of available P (Av.P) and the investigated soil properties.

Soil property(x)	Equation	R^2	r
Soil depth	Av.P= -0.1513x + 18.103	0.152	-0.3905^{*}
Sand	Av.P= 0.1172x + 3.5489	0.082	0.2877^{ns}
Silt	Av.P= 0.0055x + 11.988	3E-05	0.0055^{ns}
Clay	Av.P= -0.1068x + 13.799	0.074	-0.2729^{ns}
Saturation percentage	Av.P= -0.097x + 15.791	0.106	-0.3257^{ns}
pH	Av.P= 0.1537x + 10.815	0.009	0.0095^{ns}
Soil EC_e	Av.P= 0.0610x + 11.360	0.045	-0.2121^{ns}
O.M	Av.P= -5.4792x + 13.863	0.043	-0.2074^{ns}
$CaCO_3$	Av.P= -0.0848x + 13.179	0.009	-0.0985^{ns}
Soluble Ca	Av.P= -0.2878x + 13.959	0.041	-0.2047^{ns}

The correlation between the EC_e and available P of the studied soil samples was positive and insignificant (r= 0.2121). It may be explained by the precipitation of phosphorus with the dissolved Ca ions occurred at the high EC_e values. On the other hand, the available P of some soils of El-Dakhala oasis was negatively correlated to EC_e, Na^+, $CaCO_3$ and Ca^2 (Abd El-Rahim *et al*., 2016).

The available P of this study was insignificantly negatively correlated to the organic matter content (r=- 0.2074). Abd El-Rahim *et al*. (2016) also found that the correlation between the available P and soil organic matter of El-Dakhala soils was insignificantly negative (r = -0.039). In addition, Qian and Schoenau (2000) indicated that the addition of organic manure did not increase the most soil labile P; instead the initial fate of the P from the manure was mainly moderately labile and stable fractions such as calcium phosphate and organic P forms.

The correlation between the available P and the soil $CaCO_3$ content of these soils was negative and insignificant with r value of =-0.0985. Soluble phosphorus is also very reactive with lime due to its precipitation with $CaCO_3$ as Ca-P forms (Mehmood *et al.,* 2010). Moreover, in calcareous soils, the Ca-saturation clay content exhibits low solution P levels, since P can readily be precipitated by calcium or adsorbed on the clay (Tisdale *et al.,* 1997; Bai *et al.,* 2013). In Egyptian soils, Abd Alla *et al*., (2007) reported that the available P decreased with increasing $CaCO_3$ content. Moreover, in Gharb El-Mawhob soils El-Dakhala oasis, Abd El-Rahim *et al*. (2016) found low available P contents in some locations that may be related to the P fixation due to their high contents of Ca^{+2} and $CaCO_3$. They also observed a negative correlation between the available P and the $CaCO_3$ content of these soils. The soluble Ca of the investigated soil samples exhibited a negative and insignificant correlation with the available P (r= 0.2047). Increasing Na^+ and Ca^{2+} concentrations in the soil solution may lead to an increase in soil ionic strength which may affect the P availability and uptake by plants (Curtin *et al.,* 1993).

Conclusions

Soils of El-Kharga oasis have variations in their physical and chemical characteristics that are attributed to the differences in their formations and nature of parent material. In most studied soils, the available soil P content differed from one profile to another as well as the surface layer showed a higher content of available P than the subsurface one. It may be attributed to the low organic matter content and the light texture (sand, loamy sand, sandy loam and sandy clay loam) of these soils. About 10.26% of the studied soil samples contained a low level of available P (< 6 mg kg^{-1}) and 35.90% showeda medium level (6 -10 mg kg^{-1}). On the other side, 53.84% of these soils exhibited a high level (>10 mg kg^{-1}). These findings confirm that most of El-Kharga soils contain surplus amounts of available P to meet their high potential use in agriculture.

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Website: https://www.aun.edu.eg/agriculture/ar *E-mail: ajas@aun.edu.eg*

تأثير بعض خواص التربة على الفوسفور الميسر في واحة الخارجة، الوادي الجديد

انتصار أحمد ثابت، هالة حسانين جمعة، محمد عبد الرازق أحمد، محمد على الدسوقي

قسم الأراضي والمياه- كلية الزراعة - جامعة أسيوط

الملخص

أجرى هذا البحث في واحة الخارجة، الوادي الجديد، حيث تم جمع ٣٩ عينة تربة من ١٣ قطاع ارضي من خمس مناطق مختلفة لترب مختلفة القوام لتقييم الفوسفور الميسر في هذه الترب وعلاقته بخصائصها. وقد أخذت هذه العينات من ثلاث طبقات (٠-٢٠، ٢٠-٤٠، ٤٠-٦٠سم) لكل قطاع.

أوضحت النتائج أن قيم الفوسفور الميسر قد تراوحت بين ٤,٤٠ إلى ٣٤,٥٤ ملليجرام/كجم تربة. كما اظهرت حوالي ١٠,٢٦% من عينات التربة مستوى منخفض من الفوسفور الميسر(اقل من ٦ ملجم /كجم) وان٣٥,٩٠% من هذه العينات لديها مستوى متوسط من الفوسفور الميسر (٦-١٠ ملجم/كجم) بينما كان ٥٣,٨٤% من هذه العينات تحتوي على مستوى مرتفع من الفوسفور الميسر(اكبر من ١٠ ملجم/كجم). كما أوضحت النتائج اختلاف القيم المتوسطه للفوسفور الميسر باختلاف قوام التربة فقد كانت ١٦,٣٨، ١٣,٤١، ١٢,١٣، ٩,٢٥، ٧,٦٦ ملليجرام/كجم في القوام الرملي، الرملي الطمي، الطمي الرملي، الطمي الطيني الرملي، الطيني على التوالي.

اشارت النتائج الى وجود ارتباط معنوي موجب بين قيم الفوسفور الميسر وكل من الرمل، السلت،pH التربة حيث كانت قيم معامل الارتباط ٠,٢٨٧٧، ٠,٠٠٥٥، ٠,٠٠٩٥ على التوالي. في حين ارتبطت قيم الفوسفور الميسر سلبيا وغير معنويا مع كل من عمق التربة، ملوحه التربة، نسبة الطين، المادة العضوية، وسعة التشبع بالماء، كربونات الكالسيوم، الكالسيوم الذائب.