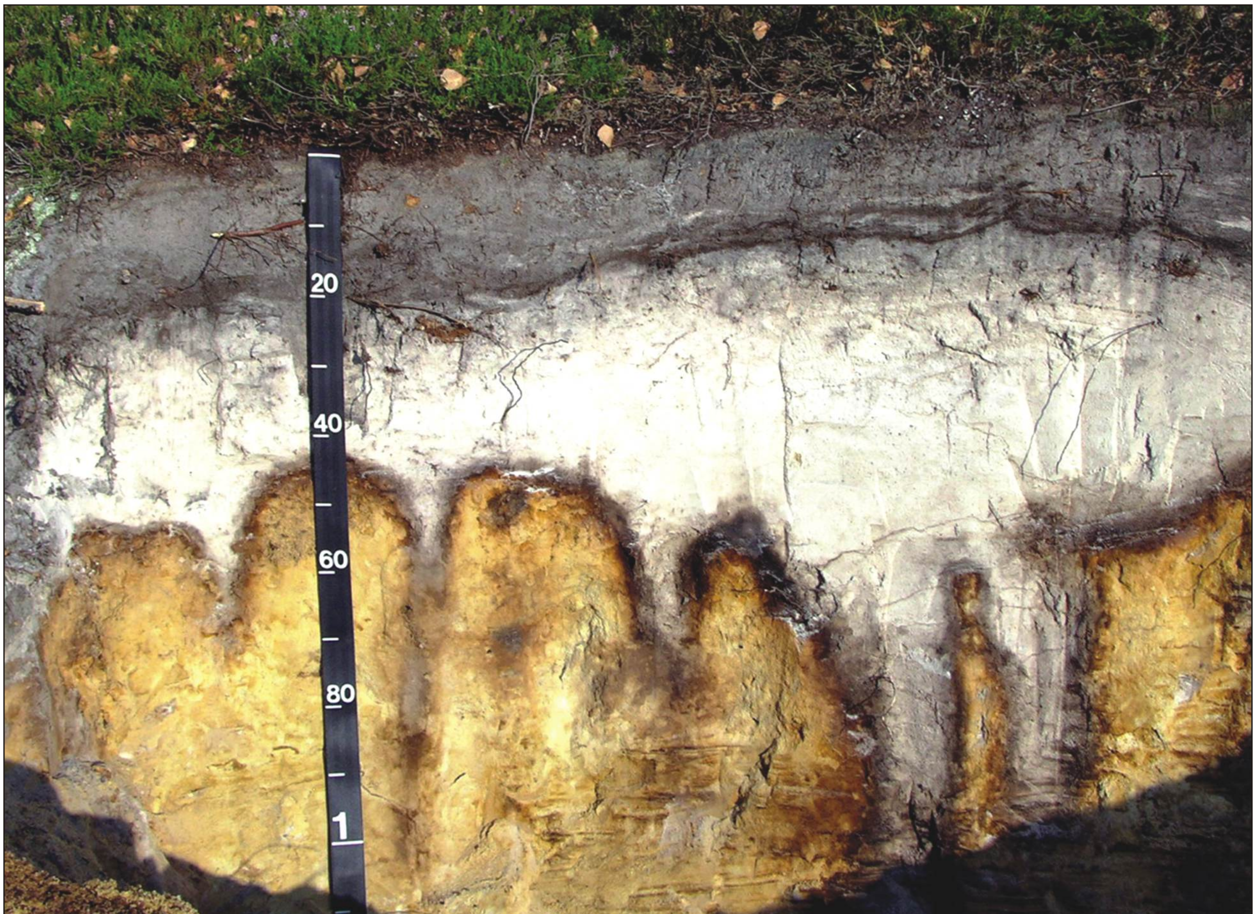

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Release of P from Natural Syrian Rock Phosphate in Acidic Soils

[1]B. Dib, [2]A.I. Rezk and [2]Mohamed M. El-Fouly
[1]Faculty of Agriculture, University of Damascus, Damascus, Syria
[2]Department of Fertilization Technology, National Research Centre, Cairo-Dokki, Egypt

Abstract: Syrian Arab Republic is one of the producing and exporting countries of the natural rock phosphate. Its stock is about one billion tons. However, inspite of the existence of this huge amounts, no study has been done on the possibility of using this raw material as P-source for acidic soils, which covers more than 7% of Syrian agricultural areas. These areas are located in the humid and semi-humid regions and severely suffering from phosphorus deficiency. Powdered or dust natural rock phosphate were added to the soils at different rates (700, 1400, 2100 kg ha^{-1}) and compared with Triple Super Phosphate (TSP) as control. Rye Grass was used as a test plant. P content in plants was determined after each cut. Phosphorus absorbed by ray grass plants was maximum by using natural rock phosphate compared with dust phosphate and control. Moreover, the available amounts of residual P_2O_5 in the soil after harvest give enough stock to the following crop. The addition of natural rock phosphate increased the soil pH with different values depending on kind and rate of the added phosphates, while the TSP reduced it.

Key words: Acidic soil, phosphorus, rock phosphate

Introduction

Application of phosphate fertilizers to the soil is an essential management practice for all crops (Arvieu, 1972; Olsen and Sommer; 1982; Dib, 1985). The P of phosphate fertilizers changes in the soil to non-soluble compounds and becomes unavailable and cannot be absorbed by plants. In calcareous soils, in which calcite ($CaCO_3$), dolomite ($CaMg\ CO_3$) and argonite are dominate carbonates, reactions with phosphates take place giving compounds rich in Ca or Mg. In addition, phosphate ions combined with Fe and Al hydroxides in acid soils forming unsoluble compounds.

Natural phosphate (Apatite) cannot be used in calcareous or alkaline soils, but can be used in acid soils (Black and Kempthorne, 1956). Many researchers studied the application of natural phosphates in acid soils and confirmed it's importance in increasing both available-P in these soils and crop response (Dib, 1986; Rajan *et al.*, 1991a, b; Haque and Lupwayi, 1998). Black and Kempthorne (1956) stated that addition of natural phosphate to acid soils is more effective than triple supper phosphate.

The importance of using natural rock phosphate in Syrian acidic soils is due to: the abundance of acid soils areas which reach 20, 0000 ha, their very low soil-phosphorus content, the availability of huge amounts of natural phosphate (one billion tons) in the country and the fact that local production of phosphate fertilizer is not meeting the increasing demand. Moreover, the use of natural rock phosphate is cheap and saves the sulfur which is used in the manufacture of phosphate fertilizers. However, the available information on using Syrian rock phosphate in Syrian acidic soils is very scarce.

The objective of this study was to follow the behavior of the added natural phosphate to Syrian acidic soils, its effect on plant and the possibility of using it as a source of phosphate, for these soils.

Corresponding Author: Mohamed M. El-Fouly, Department of Fertilization Technology, National Research Centre, Cairo-Dokki, Egypt

Materials and Methods

Soils of west part of Homs governorate were selected. The soil of this region in under lithic Haploxerolls sub-group which follows Haploxerolls group which is located under xerolls sub-order which follows Mollisols order which has volcanic origin. Nine locations were selected which have acidic pH. Surface soil samples (0-30 cm) were collected and prepared for physico-chemical analyses. Ranges of soil characteristics are given in Table 1.

Soil texture is ranged from sandy to sandy clay and sometimes sandy clay loam. All soils have acidic pH values, ranging from 4.98 to 6.36 in H_2O extract and from 4.04 to 5.76 in KCl extract. All soils have high organic matter content (2.43-4.24) except one site (0.95%). The soils have poor C/N ratio and good values for both cation exchange capacity and saturation percentage with cations. Mg ions are predominant and have antagonistic effects on absorption of K and Ca, whereas Ca/Mg ranged from 1.06 to 2.02. Similarly, K/Mg ratios were very low in these soils. Both ratios are calculated from Table 1. Therefore, calcium and potassium malnutrition are expected. P_2O_5 content is relatively low. A representative soil of this area (Thahr El-Koseer site) with low phosphate content was used in this study (Table 1).

Ray Grass D Italy (*Lolium* sp.) plant was selected as a test plant due to its good growth in different soil types, resistance for diseases and insects, rapid emergence and ability for cutting more than once and finally for its high depletion of the nutrients from soil.

Natural and dust phosphates from Khnefes mines and Triple Super Phosphate (TSP) were used in the experiment:

- Natural phosphate (30.96% P_2O_5) which was prepared for export or for manufacture of TSP.
- Dust phosphate (25.2% P_2O_5) which produced from treatments of concentrated natural phosphate in concentration unit.
- TSP (46% P_2O_5) as control.

Table 1: Range values of soil physico-chemical characteristics of the nine locations representing acid soils and of the soil used in the experiment (depth 0-30 cm)

	Mechanical analysis			pH (1:2.5)				
Location	Sand (%)	Silt (%)	Clay (%)	H_2O	KCl	EC ($dS\ m^{-1}$)	$CaCO_3$ (%)	Soluble salts (%)
Range	38-64	22-30	14-36	4.98-6.36	0.04-5.76	0.04-0.28	0	0.028-0.185
Thahr elkoseer	41	30	29	5.23	5.17	0.043	0	0.028

					Exchangeable cations (meq./100 g soil)				
Location	C (%)	N (%)	OM (%)	C/N	Ca	Mg	Na	K	P_2O_5 (ppm)
Range	0.55-2.46	0.07-0.26	0.95-4.24	7.85-9.48	9.3-13.2	6.23-9.09	0.06-0.15	0.42-0.51	13-70
Thahr elkoseer	1.84	0.20	3.18	9.27	9.7	8.21	0.08	0.51	15

Table 2: Phosphate rates used in the experiment*

		P_2O_5			
Raw phosphate rate		Natural rock phosphate 30.96% P_2O_5		Dust phosphate 25.20% P_2O_5	
($kg\ ha^{-1}$)	mg/pot	($kg\ ha^{-1}$)	mg/pot	($kg\ ha^{-1}$)	mg/pot
700	350	210	108.36	175	88.20
1400	700	420	216.72	350	176.40
2100	1050	630	325.08	525	264.6

* The control treatment contains: 200 kg P_2O_5 ha^{-1} as TSP (46% P_2O_5) = 100 mg P_2O_5/pot

Pot experiment was designed in completely randomized plot with four replicates in glasshouse at temperature of 28°C±2. Pots of 1.8 kg air-dried soil per each one were used and three rates of natural and dust phosphates: 700, 1400 and 2100 kg ha^{-1} and one rate of TSP; i.e., 200 kg ha $^{-1}$ as control were used (Table 2). N and K fertilizers were used as follows:

- N as NH_4 NO_3 38% : 100 kg N ha $^{-1}$ = 180 mg/pot.
- K_2O as K_2SO_4 54.02% : 150 kg K_2O ha $^{-1}$ = 74.88 mg/pot.

All fertilizers were mixed with the soil, prior to sowing. Three gram of rye grass seeds per pot were seeded 11 days after the addition of natural phosphate and other fertilizers to the soil. The pots were watered to reach the field capacity. Two cuts were taken, the first 20 days after sowing and the second 17 days later.

Available amounts of P_2O_5 in soil solution and pH of the soil of each treatment, in addition to total amount of P absorbed by rye grass after each cut were determined.

Chemical Analyses

- Phosphorus in the raw material was determined using ammonium citrate after digestion with nitric acid.
- Available P in the soil was determined by Dyer method (Gervy, 1970).
- Exchangeable Ca, Mg, Na and K were extracted by ammonium acetate. Ca and Mg were determined by EDTA method. Na and K were photometrically measured.
- pH in soil solution was measured in 1:2.5 water or KCl suspension.
- Plant P was determined by ammonium vandate-molybdate method after drying at 500°C and wet digestion.
- Plant Ca was determined by using Chelating method (Chapman and Pratt, 1961).

Results and Discussion

Chemical Composition of Natural Phosphates

The type of Syrian phosphate is Flouro-Apatite CO_{10} $(PO_4)_6$ F_2 contains calcium carbonate and silica as impurities. The chemical analyses indicate also that Syrian phosphate has low contents of iron (0.225%) and aluminum (0.3%) oxides whereas, it contains high amount of calcium oxide (50%). On the other hand, P_2O_5 content differ according to the product, it ranges from 25.2% in the dust phosphate to 30.96% in natural phosphate.

Calcium is present as impurity of natural and dust phosphates. Accordingly, the importance of natural phosphate in fertilizing the acidic soil is to enrich these soils with orthophosphates ions in addition to increase calcium concentration which improves the physicochemical properties and the fertility of these acidic soils.

Effect on P absorbed by Plant

The response of plant to the addition of both natural and dust phosphates was highly significant compared with control. The phosphate absorption by plants was in the following order: natural phosphate > dust phosphate > control (Table 3).

On the other hand, by comparing the absorbed amounts of P by rye grass plants of each cut as affected by increasing amounts of natural and dust phosphates, it was found that using higher rates of both phosphates resulted in increasing the absorbed amount of P over the lower rates and control (Table 4).

Table 3: Total amount of P_2O_5 absorbed by rye grass (mg P_2O_5 g^{-1} dry matter)

Treatment	Control (TSP)	Natural phosphate	Dust phosphate
1st cut	0.296	6.670	4.798
2nd cut	0.869	5.896	5.565
Total	1.165	12.566	10.363

Table 4: Effect of phosphate application on absorption of phosphorus by rye grass (mg P_2O_5 g^{-1} dry matter)

		Natural rock phosphate (kg ha^{-1})			Dust phosphate (kg ha^{-1})		
Treatment	Control TSP	700	1400	2100	700	1400	2100
1st	0.064	0.072	0.218	0.776	0.067	0.170	0.599
2nd cut	0.180	0.280	0.351	0.450	0.235	0.581	0.591
Total	0.244	0.352	0.569	1.226	0.302	0.751	1.190

It was, also, found that there is a significant difference between the types of phosphate. F test showed that the calculated F was 197.9, whereas the tabulated F was 3.89 and 6.93 for the natural and dust phosphates, respectively. On the other hand, the LSD for differences between the cuts was 0.076 and 0.11 at 5 and 1% levels, respectively and between the control and both phosphate treatments were 0.098 and 0.138 for natural and dust phosphates, respectively, for the first cut. Whereas for the second cut, the LSD between natural and dust phosphates was 0.0872 and 0.122 at 5 and 1% levels, respectively.

It might be concluded that there are significant differences between the different phosphates and between each of them and the control and also between the two cuts.

Movement of added phosphorus compounds in the soil differs than that in soil solution. These compounds remain in the surface layer and do not move to the deeper layers as nitrogenous fertilizers. This behavior results in decreasing available phosphorus concentration during plant growth stages. In addition, when P-concentration decreases in the soil solution, the absorbed phosphorus ions are released from colloids to make a balance between the soluble and absorbed parts of P in the soil.

Effect on Soil pH

The results showed that the addition of both natural and dust phosphates to acidic soils increased the pH with different degrees according to the rate and type of phosphates used. Dust phosphate was more effective in increasing the soil pH than natural phosphate (Table 5). This is due to high calcium carbonate content of dust phosphate and its content of high percent of particles with less than 40 micron which increase area of the particles and then increase the release of phosphate ions from the dust compared with the natural phosphate.

Effect on P and Ca Balance in Soil

Soil samples were taken after the second cut of the rye grass from all treatments and P_2O_5 contents were determined. The initial concentration of P in soil before addition of phosphates was 150 ppm as P_2O_5. The results showed that both dust and natural phosphates released high amounts of P_2O_5 but there is no significant difference between type or rates of phosphate used (Fig. 1).

The used soil contains calcium carbonate and very low content of exchangeable Ca (9.7 meq/100 g soil) with very low ratio of Ca/Mg (1:18) have bad effect on calcium deficiency in apple crops found in these areas which also followed by Bitter pit disease. The data of pot experiment with rye grass indicated that addition of natural or dust phosphorus to these soils increased the phosphates, $CaCO_3$ and the exchangeable Ca but there was no significant difference between type or rate of phosphates used (Table 6 and Fig. 2).

It can be concluded that application of natural or dust phosphate to the Syrian acidic soils improves their chemical properties through increasing the soil pH and exchangeable Ca, in addition to

Table 5: Effect of natural rock phosphate on soil pH after cutting the rye grass

		Natural rock phosphate (kg ha^{-1})			Dust phosphate (kg ha^{-1})		
Treatment	Initial	700	1400	2100	700	1400	2100
pH-H_2O	5.53	5.74	6.20	6.15	6.18	6.34	6.46
pH-KCl	5.17	5.12	5.65	5.58	5.59	5.74	5.80

Table 6: Phosphate, $CaCO_3$ and exchangeable Ca content in soils after application of phosphate

	Natural rock phosphate (kg ha^{-1})			Dust phosphate (kg ha^{-1})		
Phosphate rate kg ha^{-1}	$Ca_3(PO_4)_2$	$CaCO_3$	Ca	$Ca_3(PO_4)_2$	$CaCO_3$	Ca
700	494	140	56	484	162	188
1400	988	280	112	969	323	375
2100	1482	420	168	1453	485	563

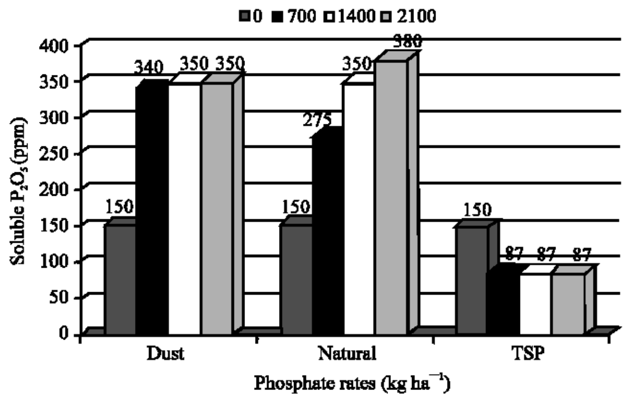

Fig. 1: Effect of rates and types of phosphates on soil P after cutting the rye grass

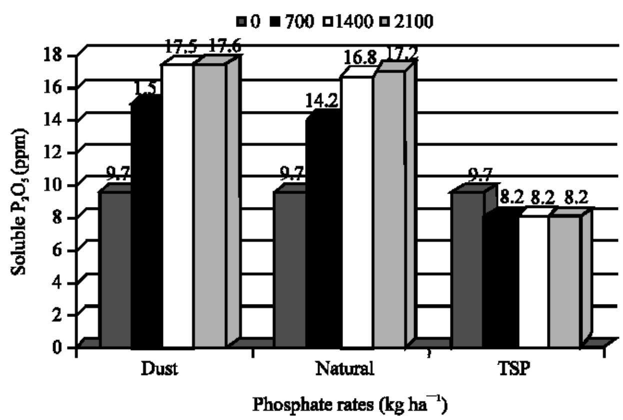

Fig. 2: Effect of rates and types of phosphate on exchangeable-Ca after cutting the rye grass

increasing, the available amount of phosphorus. Moreover, the available amount of residual P in the soil after harvest gives enough stock to the following crops in the soil treated with natural or dust phosphates.

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