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The Relative Residual Effectiveness of Superphosphate Fertilizer and Rock Phosphate in Torripsamments

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TWO SUCCESSIVE pot experiments with Torripsamments soil were conducted to measure the relative residual effectiveness (RRE) of superphosphate fertilizer and rock phosphate deposits.

Bioavailability experiment was achieved by growing two indicator plant species (Wheat, Sids 6 and Sesame, Giza 32) having different external P requirements.

The RRE of superphosphate was greater than that of rock phosphate. Wheat was most effective in obtaining P from the residues of rock phosphate due to its low external P requirements. The RRE was 0.11-0.52 for wheat and 0.02-0.24 for sesame plants. Values of RRE based on plant P content differ from those based on dry matter yield.

The present work drives a recommendation says that it could be possible to mix rock phosphate deposits with organic manures to be applied in sandy soils as a slow P release fertilizer.

Keywords: Superphosphate, Rock phosphate, Relative residual effectiveness (RRE), External P requirement.

The response of plants to the concentration of phosphate in the root environment has important implications in both soil chemistry and plant physiology.

Phosphorus fertilizers can be classified in three main groups: acidulated, partially acidulated and non acidulated. Acidulated P fertilizers include superphosphate and triple superphosphate, partially acidulated rock phosphate fertilizers are those in which only a portion of the original rock phosphate RP is treated with H_2SO_4. Non acidulated P fertilizers include RP mainly soft RP for direct application (Mengel and Kirby, 1987). Three major factors are generally recognized as influencing P availability from RP: (i) inherent differences among RP sources, (ii) soil properties and (iii) variation among crops in their ability to utilize P from RP (Khasawneh and Doll, 1978).

The present work aims at examining the relative residual effectiveness (RRE) of two P-sources, superphosphate fertilizer and rock phosphate deposits (from Abu Tartor mountain, Western desert, Egypt). Two different organic manures and two indicator plants with different external P requirements (Wheat and Sesame) were used to provide a bioassay of the availability of P in the fertilized sandy soil.

Material and Methods

Soil samples (0-30 cm) were collected from wadi El-Molak, Ismailia Governorate, Egypt. The soil contains 85.5 % sand, 9.5 % silt and 5 % clay. Electrical conductivity was 2.9 dS/m in 1:2.5 soil: water extract, $CaCO_3$ was 3.4 %, cation exchange capacity was 4.4 cmol/kg, and organic matter was 0.11 %. The soil was classified as Typic Torripsamments (Soil Survey Stafl, 1998).

Two different organic material sources were used *i.e.* town refuse compost (TR) obtained from Shobra town refuse compost plant, Cairo city, on November, 1995; and water hyacinth (HC) weeds were collected from the River Nile stream and then composted as described by Dazell (1987).

Two P-bearing materials, i.e. rock phosphate (RP) (from Abo Tartor mountain, El Kharga region, Western desert, Egypt), and superphosphate fertilizer were used in the present work. Some properties of the rock phosphate are given in Table 1.

TABLE 1. Some properties of the rock phosphate RP deposit used.

P_2O_5 %	Ca %	CEC cmol/kg	EC* dS/m	Particle size distribution (%)					
				2-1 mm	1-0.5 mm	0.5-0.25 mm	0.25-0.1 mm	0.1-0.05 mm	< 0.05 mm
20	6.2	9.8	2.38	2.22	0.76	2.76	78.63	11.79	3.84

* Extract 1:2.5

Two successive pot experiments were conducted during the winter and Summer seasons (November, 1995 - May 1996), in the greenhouse. Two indicator plants with different external P requirments (Wheat, Sids 6 and sesame, Giza 32) were used to provide a bioassay of the availability of P in the examined soil prior fertilized by P-agencies.

TR was added at rates of 0 (TR_0), 5 (TR_1), 10 (TR_2) and 15 (TR_3) t/fed. HC was added at rates of 0 (HC_0), 5 (HC_1), 10 (HC_2) and 20 (HC_3) t/fed. The fertilizer treatments were superphosphate 0 (SP_0), 7.5(SP_1), 15(SP_2) and 30(SP_3) kg P_2O_5/fed and rock phosphate 0 (RP_0), 7.5(RP_1), 15(RP_2) and 30(RP_3) kg P_2O_5/fed. .20 kg of the soil was placed into a-polyethene pot. Triplicate pots were used for each treatment. All treatments were received the recommended dose of N 100 kg N/fed and K (20 kg K_2O/fed). All pots were watered to a field capacity limit and were sowing with seeds of wheat (Sids 6) on 20[th] of November, 1995.

Plants were thinned to 10 plants per pot 20 days after sowing. Moisture losses from the soil during growth were renewed daily by addition of water. Plants were harvested 170 days afier sowing, dried at 70°C and dry weigh were recorded. The dry matter was digested using a mixture solution of sulphoric and perchloric acids (Jackson, 1967) and analyzed for total P. Surface soil samples (0-15 cm) were collected, air dried and available P was extracted using NH_4 HCO_3-DTPA method (Soltanpour, 1985).

The same previously used pots were cultivated with sesame (Giza 32). One month after sowing, plants were thinned to 10 seedlings per pot. Irrigation being again performed to keep soil moisture content at field capacity. Plants were harvested 120 days after sowing. Dry materials and surface soil samples were analysed for phosphours as previously mentioned.

The relative residual effectiveness (RRE) of superphosphate and rock phosphate (RP) were determined for the different application rates of TR and HC for each plant species, by measuring and comparing the slopes of the following relationships: a) dry weight yield versus phosphorus applied and b) P content of dried plant versus phosphorus applied. P content is the P concentration in dried plants multiplied by the yield of the dried plants. The RRE was determined by dividing the linear slope values for rock phosphate by the slope values for superphosphate (Barrow and Campbell, 1972; Bolland *et al.*, 1988). This is a standard and preferred method of estimating the residual value as a basis for economic decisions. It is more appropriate to compare the residual effectiveness of P fertilizers as a basis for ranking the effeciency of a fertilizer on the bases of P release (or desorption).

Results and Discussion

Data presented in Table 2 showed that the application of superphosphate and rock phosphate resulted in a positive balance of P after the successive harvest of the two crops (Wheat -Sesame). The positive balance was more pronounced with rock phosphate than superphosphate fertilizer. This suggests that RP has two different characteristics or regions of dissolution. Apparently the more soluble portion dissolved in the first weeks, whereas a less soluble portion controlled by years. The more soluble portion of RP represents only a very small fraction of RP < 7% of the weight of RP (Chien and Black 1976), 5-40 % (Smyth and Sanchez, 1982, Ftugkes and Crilkes 1986).

TABLE 2. Phosphorus content (kg P_2O_5/fed) of the soil after the successive harvest of the two crops (Wheat -Sesame).

Treatment	Added	Removed	Balance
SP_1	7.5	6.6	+ 0.90
SP_2	15	10.0	+ 4.50
SP_3	30	17.0	+ 13.0
RP_1	7.5	2.5	+ 5.0
RP_2	15	4.5	+ 10.5
RP_3	30	5	+ 25

The relationship between yield of dry weight from pot experiment and level of phosphorus applied in the field (Fig. 1) shows that residues of superphosphate were most effective and those of rock phosphate were least effective for the two crops. The RRE of superphosphate was greater than that of rock phosphate. The

RRE based on the relationship between P content (P concentration x yield) and levels of P applied (Fig 2), showed similar findings. The results for both yield and P content indicate that the RRE of superphosphate was much greater than for rock phosphate (Table 3). RP can not supply adequate amounts of P to meet the external P requirement for maximum growth of both wheat and sesame crops.

The residual relative effectiveness (RRE) of rock phosphate depends mainly on crop type. Wheat was presumably most effective in obtaining P from the residues of superphosphate fertilizer and rock phosphate than that sesame due to its low external P requirement.

The RRE of wheat was 0.11-0.52 while it was 0.02-0.24 for sesame. This trend is consistent with the P requirement of these two crops which are ranked sesame > wheat (Nishimoto *et al.*, 1977; Fox, 1979, 1981 and 1988).

The concentration of P in soil solution associated with 75% of maximum yield of wheat was in the range of 0.03-0.15 mg P/l (Asher and Loneragon, 1967). It is hypothesized that continuously dissolving RP maintains a low but steady concentration of P in soil solution. It is possible that crop type with a relatively low external P requirement will be most suited to this situation. The residues of P from rock phosphate deposit will be most effectively exploited by plants of low external P requirement. A number of plants can appreciable growth at low concentrations of phosphate. For example, clover, silvergrass, barley, sorghum, corn gave their maximum growth at 0.155 mg P/l in soil solution (Asher and Loneragon, 1967). On the other hand, P from superphosphate dissolved rapidly and sorbed by soil constituents within days of its application to the soil. This form of sorbed P is more readily released to soil solution and hence to plants than P from RP which will be partly present as P sorbed onto soil constituents and partly as residual RP.

Values of RRE based on plant P content may differ from those based on yield (Table 3). This may due to the differences in internal efficiency of P utilization by plants supplied as different P fertilizers. The relationship between yield and P content of plants is an indication of internal efficiency of P utilization by plant (Black and Scott, 1956; Palmer and Gilkex, 1982). Wheat showed apparently higher internal effeciency of P applied from RP than sesame.

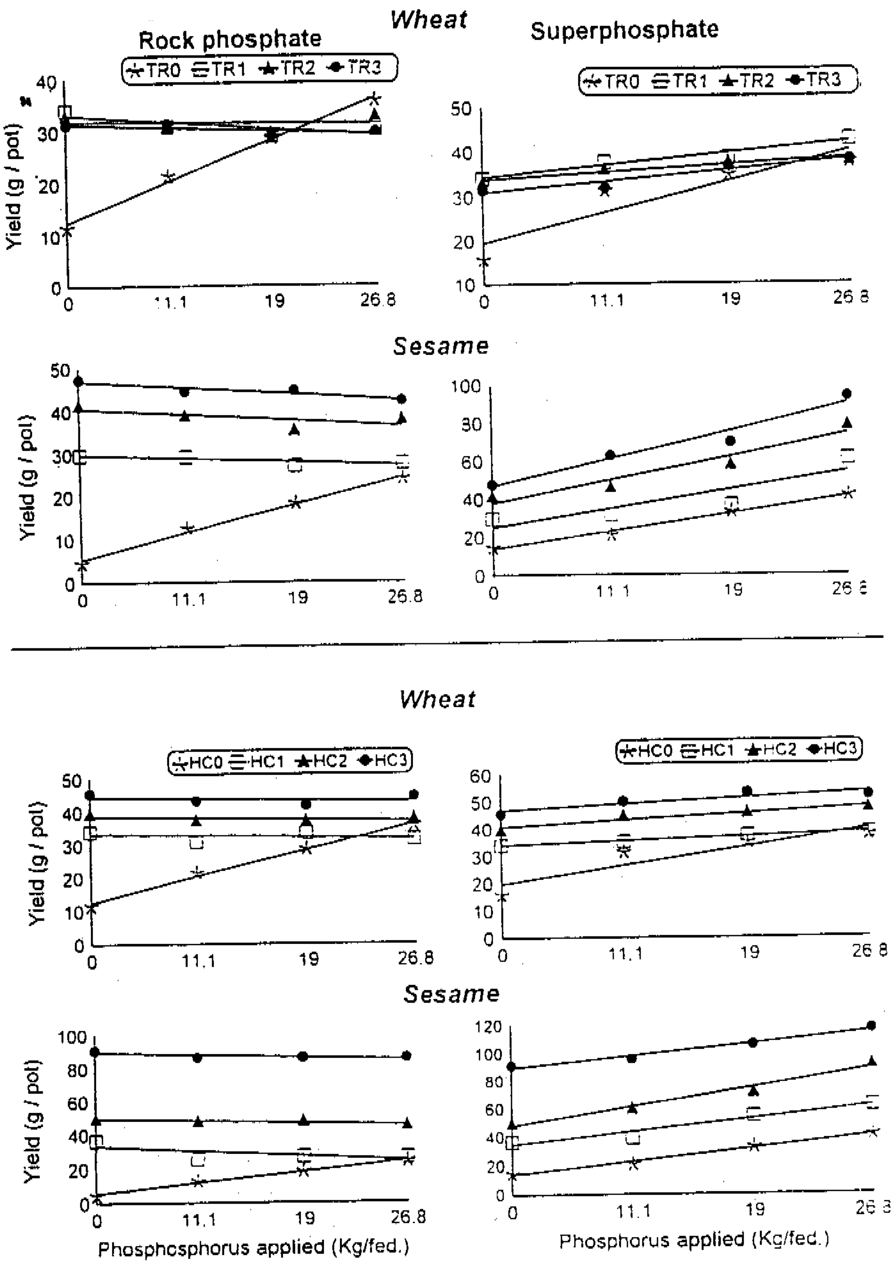

Fig. 1. Relationship between dry matter production of wheat and sesame crops and phosphorus applied as rock phosphate or superphosphate.

TABLE 3. Relative residual effectiveness (RRE) of rock phosphate and superphosphate calculated on the basis of yield and p content for the two crops grown in the greenhouse experiment.

Treat.	Wheat		Sesame	
	Rock Phosphate	Super Phosphate	Rock Phosphate	Super Phosphate
	Yield basis			
HC_0	0.13	1.00	0.08	1.00
HC_1	0.35	1.00	0.31	1.00
HC_2	0.23	1.00	0.11	1.00
HC_3	0.21	1.00	0.18	1.00
TR_0	0.13	1.00	0.08	1.00
TR_1	0.52	1.00	0.09	1.00
TR_2	0.11	1.00	0.12	1.00
TR_3	0.29	1.00	0.11	1.00
	P content basis			
HC_0	0.18	1.00	0.10	1.00
HC_1	0.26	1.00	0.02	1.00
HC_2	0.30	1.00	0.23	1.00
HC_3	0.43	1.00	0.19	1.00
TR_0	0.18	1.00	0.10	1.00
TR_1	0.27	1.00	0.12	1.00
TR_2	0.24	1.00	0.24	1.00
TR_3	0.35	1.00	0.20	1.00

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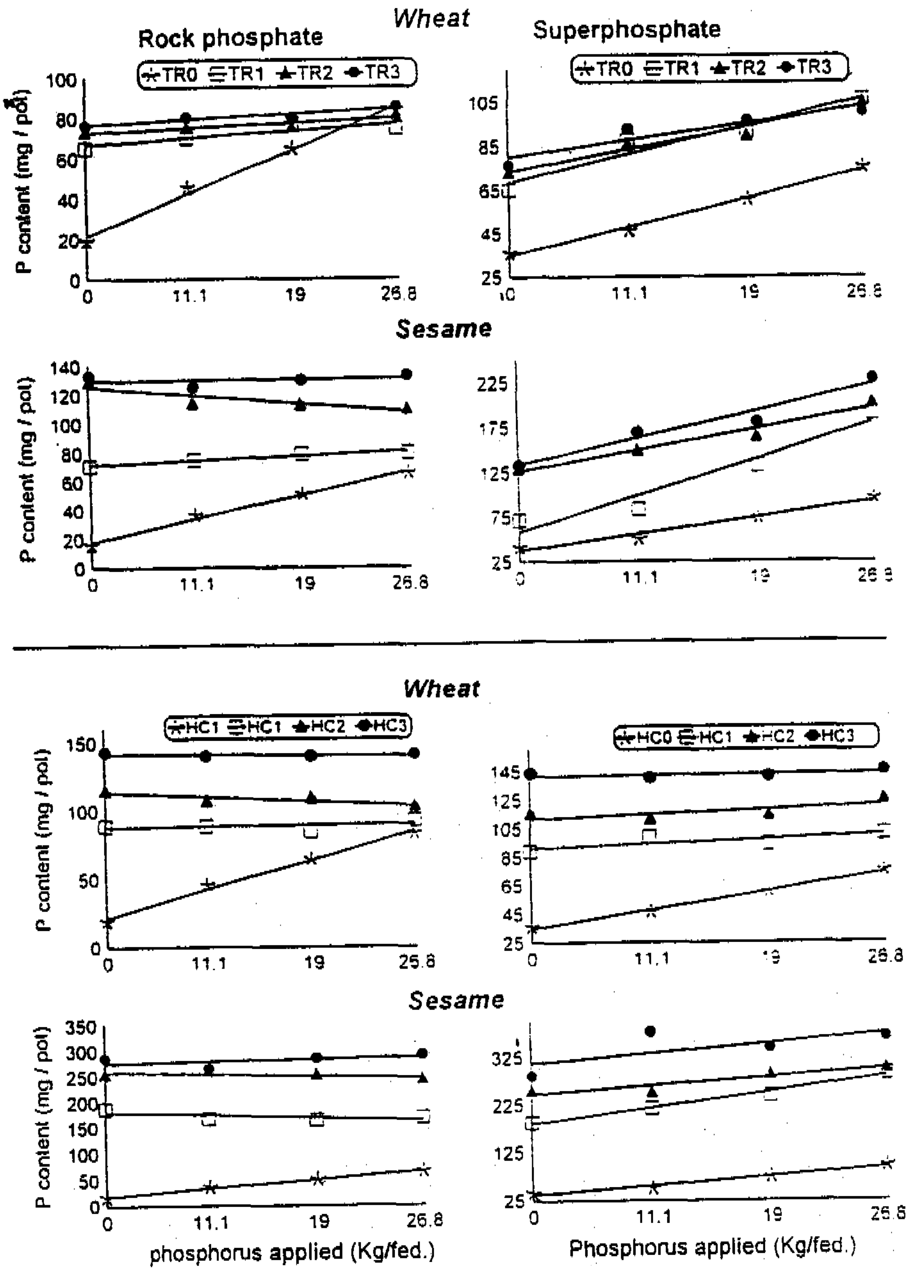

Fig. 2. Relationship between phosphorus uptake by bothwheat and sesame crops and phosphorus applied as rockphosphate or superphosphate.

The relative residual effectiveness of rock phosphate depends on the organic manure applied to the soil. RRE of organic treated soil were higher than that of untreated ones (Table 3). The relative greater RRE for organic treated soils may be attributed to the enrichement of the soil system by organic byproducts through the biodegradation processes. In this concern, Mackay and Syers (1986) mentioned that the low pH and low level of exchangeable Ca^{++} are believed to increase the solubility of RP. It could be proper to apply RP mixed with organic manures to sandy soils to work as a slow release fertilizer for P from rock phosphate and to give a steady concentration of P in the soil solution.

Conclusion

The RRE of superphosphate was generally greater than for rock phosphate for the two plant species (wheat-sesame).

Soil that have been fertilized with RP deposits still enriched with the continuation support of P release for many seasons because only a very small portion dissolved quickly (weeks) and the remainder dissolved slowly (year). The continuously dissolved RP at a low rate give a steady concentration of P in the soil solution. Plant species with low external P requirement will be most suited to this situation, such as clover, barley, sorghum,...

The RRE for wheat was presumably higher due to the low external P requirement of this species, a result which indicates that in general resdeuies of P from RP fertilizers will be most effectively exploited by plants of low external P requirement. From the application point of view, it could be proper to apply RP mixed with organic fertilizers to sandy soils to work as a slow release fertilizers for P in sandy soils.

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الأثر النسبي المتبقي لسماد السوبر فوسفات وصخر الفوسفات في الأراضي الرملية (Torripsamments)

ماهر عبد المحسن عبد الحميد، *شفيق إبراهيم عبد العال، **على عبد الفتاح ، *سعد عبد الجواد و أحمد سيد تعلب**

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أجريت تجربتين من تجارب الاصص بإستخدام نوعين من النباتات (القمح - Sids 6 السمسم Giza 32) والتى تختلف فى إحتياجاتها لعنصر الفوسفور وذلك من أجل دراسة الأثر النسبى المتبقي RRE من استخدام السوبر فوسفات وصخر الفوسفات كأسمدة فوسفاتية فى الأراضى الصحراوية الرملية Torripsamment.

أوضحت النتائج أن قيم الأثر النسبى المتبقي RRE من السوبر فوسفات أعلى من قيمها في صخر الفوسفات وأن التربة التى تحتوى على صخر الفوسفات تحتوى على أثر متبقي لسنوات طويلة بعد الإضافة أى أن هناك إمداد متواصل من هذا العنصر. وأظهر القمح قدرة أعلى في الحصول على الفوسفور من صخر الفوسفات نتيجة الاحتياجات القليلة من الفوسفور مقارنة بالسمسم حيث كانت قيم RRE ١١,٠ -٥٢,٠ للقمح, ٢,٠ - ٢٤,٠ للسمسم.

وتشير النتائج إلى إمكانية استخدام صخر الفوسفات كمصدر للفوسفور للمحاصيل ذات الاحتياجات الفوسفاتية القليلة حيث يحتوى صخر الفوسفات على أثر متبقى لسنوات أى إمداد متواصل وبطيء من العنصر. كما أنه يمكن خلط صخر الفوسفات مع البقايا العضوية فى الأراضى الرملية حتى تعطى إمداد مستمر للفوسفات.