ROLE OF FUNGI ON THE SOLUBILIZATION OF ROCKPHOSPHATE AND ON GROWTH OF CORN (*Zea mays*)

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ABSTRACT

A pot experiment was conducted to study the role of different genera of fungi on the solubilization of rock phosphate using a loamy clay calcareous soil , classified as typic claciorthid . A pure culture of each of three genera [*Aspergillus* (2 species) , *Penicillium* , (2 species) , and *Cephalosporium*sp] . and their mixture were used , in the presence and absence of organic fertilizer (chicken manure) . Rock phosphate was added at a fixed rate (88 kg p ha $^{-1}$) . Vegetative growth of corn was used as an indicator . The duration of the experiment was 60 days , during which, phosphorus availability solubilized from the added rock phosphate by the action of the specific fungus was measured at a 2-week intervals. Dry weight of shoots and roots and the amount of p absorbed by the corn plant for each treatment was also measured and a P balance was obtained . Results indicated that the total amount of P solubilzed , expressed as percentages of the added rock phosphate in the presence of organic fertilizer was 41.5 in the soil inoculated with the mixture of fungi , followed by *Penicillium* (37.3) , then followed by *Aspergillus* and *Cephalosporium*(36.6) for each , with an increase of 31.8% , 22.5% and 20% over the control , respectively. Less than that was obtained for the treatments without organic fertilizer .

INTRODUCTION

Phosphorus is one of the major nutrient for plant growth. It may be added to the soil in the form of organic and inorganic chemical fertilizers. Most of the available phosphorus added to calcareous soils may become unavailable within a short period of time after its addition (Tisdale and Nelson , 1975). Due to the high fixing ability of calcareous soils and the high cost of producing phosphorus fertilizers, scientists suggested adding phosphorus to the soils as raw material (rockphosphate) after pulverizing it, (Antonio and David, 1997;Terry, 1997; Didiek et al., 2000) , taking benefits of the phosphate dissolving microorganisms (specially fungi) (Schinner and Illmer, 2000) and their abilities in increasing the availability of phosphorus throughout the whole growing season. (Nikolay et al., 1997; Gyaneshwar et al., 2002). Chemoheterophilc microorganisms excrete different types and amounts of organic acids depending on the organic status of the soil and chemoautotrophic bacteria oxidize sulfur and ammonium to inorganic acids. The result is a temporarily and some time a permanent decreases in the pH of the soil, so enhancing the solubilization of rockphosphate making phosphorus and other nutrients more available to the growing plants. The main objectives of this **research** is to study the ability of pure culture of fungi in solubilizing rockphosphate in the presence of organic fertilizer.

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MATERIALS AND METHODS

1. Preparation of the soil: A bulk of soil samples was taken from the surface(0-30cm), ground to pass a 2mm sieve . some of it's chemical and physical properties are listed in table (1) (Page *et al*, 1982).

Table (1): Some of the chemical and physical properties of the soil .

$CaCO_3$ $Gm.kg^{-1}$	O.M. $Gm.kg^{-1}$	Soil pH	Ec $ds.m^{-1}$	B.d. $Gm.cm^3$	Ava.k ppmK	Ava.p ppmP	Total N %	Text.
220	9	7.65	0.04	1.4	151	2.8	0.04	Clay loam

A 5kgs portions equal to the number of the treatment combinations were weighed in pots (16x20cm) . Half of the pots were treated with 1% chicken manure (40% C , 2.1% N) while the other half was left without . The fungi included in this experiment belonge to three genera, namely [*Aspergillus* (2 species) , *Penicillium* (2species) , and *Cephalosporium sp.*] and a mixture .P as rock phosphate was applied at a fixed rate (88 kg $P.ha^{-1}$) . Each treatment replicated three times in a RCBD experiment.

2. Isolation of the Phosphate Dissolving Fungi (PDF): The PDF genera were isolated in pure culture using a sterile Martin's medium (Martin,1950) , composed of : 10 g glucose, 5g peptone, 0.5g magnesium sulfate , 33mg rose bengal , 18g agar-agar dissolved in 1 L . of distilled H_2O . Dipotassium phosphate was replaced by rock phosphate (1g. $L.^{-1}$). The genera of fungi used in this experiment were isolated and classified according to Barnett and Hunter , 1972.

3. Seeding: Three seeds of hybrid corn were sown in each pot on march , 28/2005 .The treated soil of each pot was irrigated to 90% of it's field capacity and maintained at this level of moisture by weighing . After two weeks the number of plants were thinned to one per pot.

4. Inoculation: The soil of each pot was heavily inoculated with pure culture of each of the three genera of fungi or their mixture by making holes (5-7cm) in diameters around the plant directly after thinning.

Duration of the experiment: The duration of the experiment was sixty days, during which, plant heights, number of leaves, dry weight of shoots and roots , and their P contents were measured . Also the changes in soil P^H and the amount of soil available P solubilized from the added rock phosphate by the action of the organic acids secreted by each of the genera of fungi were measured at a 2-week intervals and a P balance was obtained .

RESULTS AND DISCUSSION

Table (2) showed the effect of inoculating the soil with different genera of fungi on the amount of phosphorus absorbed and plant dry weight in the

presence and absence of organic fertilizer. The data indicated that the average amount of phosphorus absorbed by plant from the added rockphosphate , soil mineral phosphate, and from that available in the soil was arround 92mg p.pot^{-1} for the treatment without organic fertilizer regardless of the type of inoculum (singly or mixed), in comparison with just 70mg p.pot^{-1} for the uninoculated treatment (with rockphosphate but without organic fertilizer) and about 60mg p.pot^{-1} for the control. Addition of 1% organic fertilizer increased that to around 115mg p.pot^{-1}, in comparison with a 100mg p.pot^{-1} for the uninoculted treatment .

Table (2): Effect of fungal inoculation on dry weight and amount of phosphorus absorbed in the presence and absence of organic fertilizer

Genus name	Organic fertilizer	Shoots gm.pot^{-1}	P %	Roots gm.pot^{-1}	P %	Total P mg.pot^{-1}	pH of soil
*Aspergillus**	-	18.20	0.43	4.99	0.27	91.73	7.38
	+	20.96	0.46	5.80	0.30	113.81	7.32
*Penicillium**	-	18.00	0.42	5.50	0.29	91.55	7.37
	+	21.6	0.46	6.22	0.31	118.64	7.35
Cephalosporium	-	18.02	0.42	5.25	0.28	90.38	7.41
	+	23.66	0.40	6.75	0.29	119.76	7.31
Mixture	-	19.32	0.40	4.95	0.28	91.14	7.38
	+	25.62	0.41	5.26	0.28	119.76	7.31
Uninoculated	-	16.18	0.35	4.95	0.28	70.49	7.58
	+	18.60	0.47	4.80	0.29	101.34	7.35
Control	-	14.80	0.32	4.90	0.26	60.1	7.60

Uninoculated = with rockphosphate only,
Control = no organic fertilizer and no rockphosphate
* = avarage of two species

Phosphate dissolving fungi are chemoheterotrophs and require organic fertilizer as a source of nutrients and energy, and its decomposition will lead to the formation of different amounts and types of organic acids, which will be secreted to the surrounding soil, lowering the pH and making more phosphorus available to the plant (Adrian, 2001; Akande, *et al.*, 2005; Aziz & Narayanasamy, 1999). This may be observed from table(2) which showed that the pH of the soil decreased 2 to 3 decimal points due to inoculation and the addition of organic fertilizer. The decreases in soil pH may be temporarily due to the buffering capacity of the soil. Many papers have confirmed that (Kirk *et al.*, 1999; Gyanneshwar *et al.*, 2002). They also showed the formation of chelating compounds as a reaction between the organic acids with calcium and magnesium which is present in the soil, decreasing the phosphate fixing surfaces, rendering phosphorus more available to the plant.

The amounts and percentage of phosphorus solubilized from the added rockphosphate only is shown in table (3). The average percent was around 23.5 for the soil inoculated with pure culture of each of the genera of fungi and their mixture without organic fertilizer. More than that (41.5%) was obtained for the treatment with organic fertilizer. The percentages of phosphorus solubilized from the rockphosphate by the indigenous microorganisms were 11.6 and 28.3 respectively.

Statistical analysis (table 4) indicated no significant differences between the genera of fungi when considered individually .

Table(3): Effect of fungal inoculation on the total soluble phosphorus (TSP) and its percentage from the added rockphosphate only* ($mg.pot^{-1}$) in the presence and absence of organic fertilizer after 60 days of growth

Treatment	Without organic fertilizer		With organic fertilizer***	
Genus name	Quantity** $mg.pot^{-1}$	% Of added	Quantity $mg.pot^{-1}$	% Of added
*Aspergillus**	52.6	24.5	78.7	36.6
*Penicillium**	51.0	23.7	81.0	37.7
Cephalosporium	50.0	23.2	78.6	36.6
Mixed	50.5	23.5	89.2	41.5
Uninoculated	24.9	11.6	60.7	28.3

TSP* = Soil P +Plant absorbed P (roots and shoots).

** = After subtracting the quantity of P absorbed by corn plant and soil P without RP (control=56.6)

*** = After subtracting the quantity of P obtained from the organic fertilizer.

Table (4) : Statistical analysis of the effect of different genera of fungi on the total available P using Duncan´s multiple range test .

Genus name	Total available P	
	+ O.M	- O.M
Uninoculated	117.349	81.499
Aspergillus	135.31b	109.23b
Penicillium	137.64b	107.55b
Cephalosporium	135.21b	106.38b
Mixture	145.76c	107.14b

Conclusion:

Fungi may play an important role in the solubilization of rockphosphate especially in soils rich in its organic matter contents.

دور الفطريات في إذابة الصخر الفوسفاتي وتأثير ذلك في نمو محصول الذرة (*Zea mays*)

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الخلاصة

تم اجراء تجربة سنادين الهدف منها دراسة دور اجناس مختلفة من الفطريات في اذابة الصخر الفوسفاتي باستعمال تربة كلسية مزيجية طينية مصنفة تحت (Typic Calciorthid). تم في هذه التجربة استعمال مزارع نقية تابعة لكل من الجنس *Aspergillus* (نوعين) و *Penicillium* (نوعين) و *Cephalospoium* (نوع واحد) وخليط منهما بوجود السماد العضوي (مخلفات دواجن ١%) او عدم وجوده . اضيف الصخر الفوسفاتي لجميع المعاملات بتركيز ثابت (٨٨ كغم P / هكتار) . تم زراعة الذرة الصفراء لمدة ٦٠ يوم لكي تعتبر كمؤشر تم خلالها قياس التغير في الـ P^H والفسفور الجاهز المذاب من الصخر الفوسفاتي بتأثير كل جنس من الفطريات كل اسبوعين . اضافة الى ذلك فقد تم قياس الوزن الجاف للجذور والنمو الخضري والفسفور الممتص من قبل كل منهما لكل معاملة للحصول على الموازنة الفوسفورية (P balance) . بينت النتائج ان الكمية الكلية للفسفور المذاب من الصخر الفوسفاتي معبر عنهما كنسبة مئوية من المضاف بوجود السماد العضوي كانت (٤١.٥%) في التربة الملقحة بخليط من الفطريات الثلاثة تبعها الملقحة بالفطر *Penicillium* (٣٧.٧%) تبعتها تلك الملقحة بكل من الفطر *Aspergillus* و الـ *Cephalosporium*(٣٦.٦%) بزيادة قدرها ٣١.٨% ، ٢٢.٥% ، ٢٠% عن المقارنة بالتتابع . وكانت المعاملات من دون سماد عضوي اقل من ذلك .

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