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INFLUENCE OF INCUBATION PERIOD ON PHOSPHATE RELEASE IN TWO SOILS OF DISTRICT HYDERABAD

G. M. Kaloi, N. Bhughio, R. N. Panhwar, S. Junejo, A. H. Mari and M. A. Bhutto*

National Sugar Crops Research Institute, PARC Thatta
*Grain Quality Testing Laboratory, SARC, PARC Karachi.
Corresponding author email: gmkaloiparc@gmail.com

ABSTRACT

An experiment was carried out to observe the influence of the incubation period on phosphate release in two soils of District Hyderabad. The samples were treated with the initial phosphorus level of 12.5, 100 and 1000 µg g^{-1} soil as KH_2PO_4 dissolved in 0.01 M Ca CL_2. The soil solution ratio was 1:10. The samples were incubated for 1-60 days and were shaken for six hours daily on an orbital shaker (150 rpm) at room temperature. It was observed that phosphorus release increased, as the incubation period was less. The native soil phosphorus increased the phosphorus release at same initial phosphorus (PI) levels with increase in incubation period. The phosphate release increased where there was less clay content and more native phosphorus along with increasing initial phosphorus (PI) level. The phosphorus release decreased with more clay content and the increasing incubation period as well as the number of extractions. Thus it was recommended that soils bearing more clay content need higher phosphorus additions before sowing of crop. The soils having less clay content and more native phosphorus requires lower doses of phosphorus because soils have less phosphate adsorbing capacity and adsorbed phosphate could easily be released.

Key words: Incubation period, phosphorus, clay content, soil

INTRODUCTION

The importance of maintaining an adequate phosphorus (P) supply to crops in order to maximize agricultural output has long been recognized and the routine application of P fertilizers to agricultural land have become an integral part of agriculture in developed countries (Withers *et al*., 2001). However, continued long term application of fertilizers can lead to P accumulation in surface horizons greater than that required for optimum plant growth, thus increasing the potential for P loss to surface waters and eutrophication (Sui *et al*., 1999 and McDowell *et al*., 2001). Scalenghe *et al*. (2002) indicated that long term repeated applications of fertilizers and livestock wastes have resulted in a general increase in the soil P status. As a consequence, many agricultural soils are now considered to be potential diffuse source of P for surface waters (Kumar *et al*., 1994). Residual P can be an important reservoir of P in soils. Several studies demonstrate that P from reserves makes an important contribution to plant P supply. (Steffens, 1994 and Toor and Bahl, 1999). For optimal nutrition of crop, the replenishment of a P depleted soil solution is affected predominated by the release of residual P from clay minerals, organic matter and Fe and Al hydroxides.

While much research has been done on kinetics of P release by a number of researchers (Tiessen, 1995, Toor and Bahl, 1999, McDowell and Sharpley, 2003 and Nafiu, 2009), limited information on influence of soil properties on kinetics of P release under different land use is available on calcareous soils. Fertilization in excess of crop requirements leads to increasing P content which in turn causes increasing rates of P release.

Soils containing larger amounts of clay will desorb more phosphorus than the soils containing less amounts of clay. Rashid and Rowell (1988) concluded that generally the extracted phosphorus increased with increase in clay content and total surface area of soils because of increased phosphate adsorption under the same conditions. The soils rich in lime content, the solubility of phosphates may be controlled by soil phase dicalcium phosphate (Cole and Olsen, 1959), or by chemisorption of phosphate on calcite, with the formation of a surface complex of $CaCO_3$-phosphorus compound with a well defined chemical composition. Tisdale and Nelson (1975) stated that the addition of organic materials to the mineral soils increase the availability of phosphorus. Raven and Hossner (1994) while working with soil phosphorus desorption kinetic, reported that the acid soils required 72 hours to achieve and approximate steady-state conditions, while the calcareous soils needed about 8 to 48 hours. Lignuist *et al.* (1997) measured the rate of P released from different aggregate size fractions by using a continuous flow system and Mehlich-1 extractable. They found that the rate of P extraction was essentially linear with time to 56 hours and inversely proportion to aggregate size. It was therefore, considered worth while to study the effect of incubation period on phosphate release to soil properties like lime content, clay content, organic matter, electrical conductivity and soil reaction.

MATERIALS AND METHODS

Experiment was undertaken to observe the effect of incubation period of phosphate release in agricultural soils during 1999. For this, soil samples were obtained from two location of District Hyderabad. The samples were air dried ground and passed 2mm sieve.

All the soil samples were run in duplicate. A known weight (25 g) of soil samples were taken into plastic bottles (8 cm in diameter and 12 cm in height) with 300 ml capacity. In each bottle 250 ml of 0.01 M $CaCl_2$ solution was added with various initial P levels from 12.5, 100 and 1000 µg P g^{-1} soils and 5 to 8 drops toluene ($C_6H_5CH_3$) were added in each bottle to check the microbial activity. The samples were incubated for 1, 2, 3, 7, 15, 30 and 60 days. After the determination of phosphorus, the supernatant solution already present in bottles was discarded in such a way to minimize soil loss from the bottles and to reduce the moisture content up to the possible extent.

Plastic bottles containing soil + 250 ml 0.01 M $CaCl_2$ with P weighed during the experiment. After discarding the supernatant solution 0.01 M $CaCl_2$ was again added to the bottles until the pervious weight was obtained. These soil samples were shaken for 6 hours daily on an orbital shaker (150 rpm) at room temperature (25^o C). During the incubation, the bottles were closed with stoppers to reduce the moisture loss from the bottles. The suspensions were then filtered through Whatsman filter paper No. 42. Finally, the P was determined in clear extract. In this way seven extractions were done for each treatment. All the data were analyzed statistically using ANOVA following the procedure of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The data regarding physico-chemical properties of both soils presented in Table-1 reveals that the soils were clayey in texture, moderately alkaline, non saline, highly calcareous in nature, medium in organic matter and low in available phosphorus.

Table-1. Physico–chemical properties of soils in district Hyderabad during 1999.

Properties	Soil-A	Remarks	Soil -B	Remarks
Sand %	19.00	Clayey	22.00	Clayey
Silt %	23.00		37.00	
Clay %	58.00		41.00	
Soil reaction (pH)	7.9	Moderately alkaline	7.8	Moderately alkaline
Line content%	17.90	Highly calcareous	19.90	Highly calcareous
Electrical conductivity (dSm^{-1})	0.45	Non saline	0.42	Non saline
Organic matter %	0.96	Medium	1.08	Medium
Available phosphorus (µg g^{-1} soil)	2.50	Low	3.5	Low

Table-2. Released P during 1-60 days of incubation period for different PI levels in 0.01 M $CaCl_2$.

Treatment µg g^{-1}	Total Sorbed µg g^{-1}	Release (µg g^{-1})					Total release µg g^{-1}
		Days					
		One	Seven	Fifteen	Thirty	Sixty	
12.50 µg g^{-1}	11.90	2.14 c	1.99 c	1.79 c	1.64 c	1.48 c	9.04
100 µg g^{-1}	99.50	14.85 b	14.07 b	12.72 b	12.18 b	10.70 b	64.52
1000 µg g^{-1}	995.60	56.26 a	71.76 a	51.36 a	34.03 a	23.37 a	236.78
CV%		2.82	2.22	0.45	4.87	0.93	-
LSD 0.5%		0.90	0.84	0.13	1.01	0.14	
LSD 0.1%		1.49	1.40	0.21	1.68	0.23	

Means followed by the same letters in a column do not differ significantly at 0.5 and 0.1% levels of probability.

SOIL-A: Soil phosphate release data depicted in Table-2 reveals that phosphate release increased significantly with increase in initial phosphorus levels and decreased with increasing incubation period.

PI= 12.5 µg g^{-1} soil: After the incubation period of one, seven ,fifteen ,thirty and sixty days, the phosphate sorption was 11.90 µg g^{-1} soil , out of this; the phosphate release of total seven extractions was 2.14, 1.99, 1.79, 1.64 and 1.48 µg g^{-1} soil respectively.

It was observed from the data that the phosphate release decreased slowly with the increasing number of the extraction as well as with increase in time. The highest phosphate release was noted on first extraction of one day, the lowest was noted on last (seventh) extraction of sixty days of the incubation period (Table-2). The results are in agreement with findings of Jalali and Zinli (2011), who reported that kinetics of P release from soils can be described as an initial rapid rate followed by a slower rate, same pattern of P release was also observed by Horta and Torrent (2007) and Nafiu (2009).

PI= 100 µg g^{-1} soil: After the incubation period of one, seven, fifteen, thirty and sixty days, the phosphate sorption was 66.20, 88.10, 91.00 , 93.20 and 99.50 µg g^{-1} soil, out of that; the released phosphate for total seven extractions was 14.85, 14.07, 12.72, 12.18 and 10.70 µg g^{-1} soil respectively.

It was observed from the data that phosphate release decreased slowly with the increasing number of the extraction as well as with the increasing time. The highest phosphate release was noted on first extraction of one day, the lowest was noted on last (seventh) extraction of sixty days of the incubation period (Table-2). The results are in agreement with findings of Jalali and Zinli (2011), who reported that kinetics of P release from soils can be described as a initial rapid rate followed by a slower rate, same pattern of P release was also observed by Horta and Torrent (2007) and Nafiu (2009).

PI= 1000 µg g^{-1} soil: After the incubation period of one, seven, fifteen, thirty and sixty days, the phosphate sorption was 362.00, 740.20 , 953.00, 988.70 and 995.60 µg g^{-1} soil, out of that; the released phosphate for total seven extractions was 56.26, 71.76, 51.36, 34.03 and 23.37 µg g^{-1} soil respectively.

It was observed from the data that phosphate release decreased slowly with the increasing number of the extraction as well as with the increasing time, except the first extraction of one-day incubation, where the phosphate desorption was less. The less desorption was due to more positively phosphate carried over (PCO) that was carried over in solution. The highest phosphate release was noted on first extraction of second day, the lowest was noted on last (seventh) extraction and sixty days of the incubation period (Table-2). The results are in agreement with findings of Jalali and Zinli (2011), who reported that kinetics of P release from soils can be described as an initial rapid rate followed by a slower rate, same pattern of P release was also observed by Horta and Torrent (2007) and Nafiu (2009).

Soil-BPI= 12.5 µg g^{-1} soil: After the incubation period of one, seven, fifteen, thirty and sixty days, the phosphate release for total seven extraction was 13.49, 12.67, 11.70, 9.32 and 7.05 µg g^{-1} soil out of the sorbed phosphate 5.80, 7.62, 8.00, 8.54 and 9.80 µg g^{-1} soil respectively. It indicated that -7.69.-5.05, -3.7 and -0.78 µg g^{-1} soil for one, seven, fifteen and thirty days respectively was desorbed from the native soil.

Table-3 Released P during 1-60 days of incubation period for different PI levels in 0.01M $CaCl_2$

Treatment µg g^{-1}	Total Sorbed P µg g^{-1}	Release (µg g^{-1}) Days: One	Seven	Fifteen	Thirty	Sixty	Total release µg g^{-1}
12.50 µg g^{-1}	9.80	13.49	12.67	11.70	9.32	7.05	54.23
100 µg g^{-1}	96.50	25.89	22.09	15.35	12.20	7.03	82.56
1000 µg g^{-1}	994.80	139.13	98.26	67.98	49.11	23.62	378.10

It was observed from the data that the phosphate release decreased slowly with the increasing number of the extraction as well as with increase in time. The highest phosphate release was noted on first extraction of one day, the lowest was noted on lost (seventh) extraction of sixty days of the incubation period (Table-3). The results are in agreement with findings of Jalali and Zinli (2011), who reported that kinetics of P release from soils can be described as a initial rapid rate followed by a slower rate, same pattern of P release was also observed by Horta and Torrent (2007) and Nafiu (2009).

PI= 100 µg g^{-1} soil: After the incubation period of one, seven, fifteen, thirty and sixty days, the phosphate sorption was 53.70, 86.22, 91.60 , 94.00 and 96.50 µg g^{-1} soil, out of that; the released phosphate for total seven extractions was 25.89, 22.09, 15.35, 12.20 and 7.03 µg g^{-1} soil respectively.

It was observed from the data that phosphate release decreased slowly with the increasing number of the extraction as well as with the increasing time. The highest phosphate release was noted on first extraction of one day, the lowest was noted on last (seventh) extraction of sixty days of the incubation period (Table-3). The results are in agreement with findings of Jalali and Zinli (2011), who reported that kinetics of P release from soils can be described as an initial rapid rate followed by a slower rate same pattern of P release was also observed by Horta and Torrent (2007) and Nafiu (2009).

PI= 1000 µg g^{-1} soil: After the incubation period of one, seven, fifteen, thirty and sixty days, the phosphate sorption was 300.0, 772.40, 938.30, 989.00 and 994.80 µg g^{-1} soil, out of that; the released phosphate for total seven extractions was 139.13, 98.26, 67.98, 49.11 and 23.62 µg g^{-1} soil respectively.

It was observed from the data that phosphate release decreased slowly with the increasing number of the extraction as well as with the increasing time, except the first extraction of one-day incubation, where the phosphate was less. The less desorption was due to more positively phosphate carried over (PCO) that was carried over in solution. The highest phosphate release was noted on first extraction of second day and the lowest was noted on last (seventh) extraction of sixty days of the incubation period (Table-3). The results are in agreement with findings of Jalali and Zinli (2011), who reported that kinetics of P release from soils can be described as an initial rapid rate followed by a slower rate, same pattern of P release was also observed by Horta and Torrent (2007) and Nafiu (2009).

COMPRSION OF SOIL–A WITH SOIL-B

PI= 12.5 µg g^{-1} soil: The data on Soil-A and Soil-B at the initial phosphorus level of 12.50 µg g^{-1} soil showed that the soil-B desorbed 11.35, 10.68, 9.91, 7.68 and 5.57 µg g^{-1} soil more phosphate than the soil-A at all incubation periods of one, seven, fifteen, thirty and sixty days respectively (Fig-1).

The greater quantity of phosphate desorption by soil-B than Soil-A might be due to less clay content and more native phosphorus, or adsorbed phosphate might be loosely held by the soil particles that was easily released. On other hand, in case of soil-A, the adsorbed phosphate was tightly held by the soil particles and tends to release slowly due to more sorbing energy. These results were in agreements with those of Horta and Trorrent (2007), who reported that the ratio of fast desorbable P or total desorbable P to sorbed P increased with increasing degree of P saturation in the soil.

PI= 100 µg g^{-1} soil: The data on Soil-A and Soil-B at the initial phosphorus level of 100 µg g^{-1} soil showed that the soil-B desorbed 11.04, 8.02, 2.63 and 0.02 µg g^{-1} soil phosphate more than the soil-A, after all the incubation periods of one, seven, fifteen and thirty days respectively, except sixty days incubation period , where soil-A desorbed 3.67 µg g^{-1} soil more than soil-B (Fig-2). This might be due to the weather of that day or might be an error.

At the PI level of 100 µg g^{-1} soil, the more quantity of phosphate desorption by soil –B than soil-A might be due to less clay content and more native soil phosphorus, or adsorbed phosphate might be loosely held by soil particles (Soil-B) and was easily released. On other hand, in case of soil-A, the adsorbed phosphate was tightly held by the soil particles and tends to release slowly due to more sorbing energy. These results were in agreements with those of These results were in agreements with those of Horta and Trorrent (2007), who reported that the ratio of fast desorbable P or total desorbable P to sorbed P increased with increasing degree of P saturation in the soil.

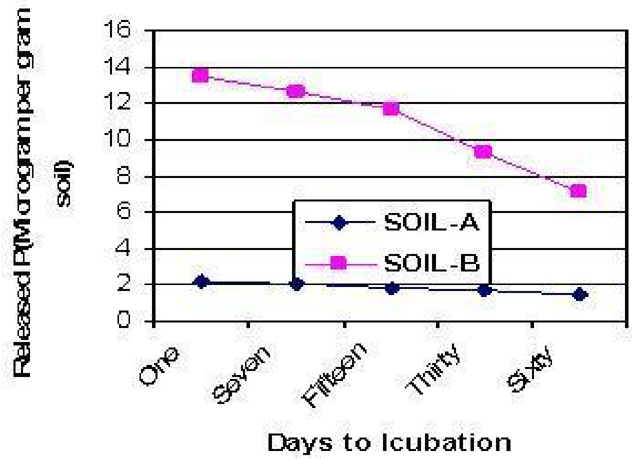

Figure 1. Released P of 12.5 ug g^{-1} soil during 1-60 days of incubation in 0.01 M CaCl

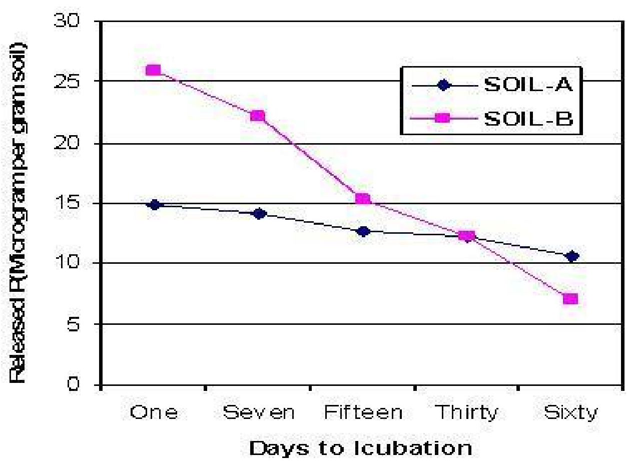

Figure-2. Released P of 100.0 µg g^{-1} soil during 1-60 days of incubation in 0.01 M CaCl

PI= 1000 µg g^{-1} soil: At initial phosphorus level of 1000 µg g^{-1} soil, soil-B desorbed 82.87, 26.50, 16.62, 5.08 and 0.25 µg g^{-1} soil more phosphate than the soil-A at all incubation periods (Fig-3). The more quantity of phosphate desorption by soil-B than soil-A, might be due to less clay content and more native soil phosphorus or adsorbed phosphate might be loosely held on surface of the soil particles and was easily released. On other hand, in the case of soil-A the adsorbed phosphate was tightly held by the soil particles and tends to release slowly due to more sorbing energy. These results were in agreements with those of These results were in agreements with those of Horta and Trorrent (2007), who reported that the ratio of fast desorbable P or total desorbable P to sorbed P increased with increasing degree of P saturation in the soil.

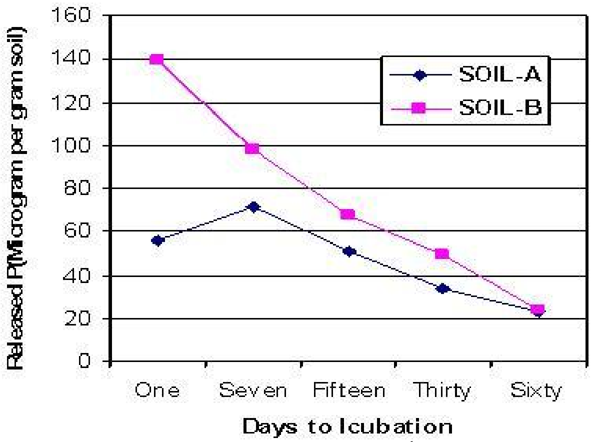

Figure-3. Released P of 1000.0 μg g^{-1} soil during 1-60 days of incubation in 0.01 M CaCl

The results showed that at all PI levels, soil B sorbed more phosphate than soil A. This might be due to less clay content and more native phosphorus in soil B as compared to soil A, thereby phosphorus might has loosely held by the soil particles in case of soil B, while, in case of soil A, it might has held tightly. These results were in agreements with those of Saha *et al.* (2004), who reported that the two phases of P release can be due to the heterogeneity of the adsorption sites with different adsorption affinities. Toor and Bhal (1999) also stated that fast phase and the slower second phase may be related to the desorption of surface labile P and slow dissolution of the crystalline phosphate compounds in the soils.

Conclusion: It was obtained from the results that phosphate release was increased, where; there was less clay content and more native phosphate along with increasing initial phosphate levels. The phosphate release was decreased with more clay content and also decreased with increasing incubation period as well as the number of extractions.

Recommendations: The soil having more clay content (like Soil-A) require higher phosphorus addition before the sowing of crop. These high doses could enrich labile pool and will maintain the equilibrium in soil solution, which might furnish phosphate to growing crops as well as future crops. The soils containing less clay content and more native phosphate (like Soil-B) requires lower doses of phosphorus because soils have less phosphate adsorbing capacity and adsorbing phosphate could easily be released. The phosphorus adsorption could be reduced with the application of organic matter and change of texture from heavy to medium.

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